FLANDERS ENVIRONMENT REPORT 2009

MIRA 2009

Environment Outlook 2030 Flanders

FLANDERS ENVIRONMENT REPORT

VLAAMSE MILIEUMAATSCHAPPIJ

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FLANDERS ENVIRONMENT REPORT

Environment Outlook 2030

Presented on 11 December 2009
to Joke Schauvliege,
Flemish Minister for the Environment, Nature and Culture

Marleen Van Steertegem, *final editing*

A future outlook is necessary

Issues concerning the environment and nature require an outlook to the future. Sometimes it takes years before problems truly become clear and for that reason looking ahead is a must. Climate change is an excellent example of this. The transition to a low carbon economy through drastically changing our production and consumer processes is not a sinecure and requires (a lot of) time.

The long-term nature of environmental problems and the uncertainty as regards its impact must not be an excuse for delaying policy measures. After all, the generally accepted principle of sustainable development entails that the current generation is (jointly) responsible for the well-being of future generations. A cohesive vision of the future is therefore also essential.

The Environmental Outlook 2030 and the Nature Outlook 2030 want to support this long-term perspective. They describe – in an independent and scientific manner – how the environment and nature in Flanders may look in the future. The road to tomorrow is open but the choices made in the policy of today also define the future of (the day after) tomorrow.

The task of the Environment Report and the Nature Report Flanders (MIRA and NARA) is threefold and was defined respectively in the decree containing general provisions regarding environmental policy (DABM, 5 April 1995) and the decree relating to nature conservation and the natural environment (Nature decree, 21 October 1997). In addition a description of the state of the environment and nature and an evaluation of the current environmental policy and nature policy, the reports must 'give a description of the expected development of the environment and nature in case of an unchanged policy as well as in case of a changed policy according to a number of scenarios considered relevant'.

Outlooks require an open mind; they require more abstract thought and the loosening of up-to-date policy details. The focus shifts from problems from the past to solutions for the future. The compilers of both reports faced a difficult task that could only be brought to a successful conclusion through the active collaboration of a large group of people. We would therefore like to thank everyone who contributed to this ambitious task.

We wish the Environment Outlook 2030 and the Nature Outlook 2030 a fantastic future.

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November 2009

TABLE OF CONTENTS

Summary

Marleen Van Steertegem, MIRA team, Flemish Environment Agency

The future depends on the choices made today. The Environment Outlook 2030 investigates how the environment in Flanders might look in a few decades. The aim is to show policy makers and interested citizens how the quality of the environment might develop in Flanders and what impact policy could have on this.

The future developments have been depicted using three policy scenarios with increasing levels of ambition:

- The *reference scenario* investigates how far the current environmental policy reaches.
- The *Europe scenario* investigates what may be required to realise the European ambitions concerning climate change, air quality and water quality in the medium term.
- The *visionary scenario* investigates how the environment may be safeguarded for present and future generations.

The results of the scenarios outline the area for the environmental policy and indicate what may be required to realise certain ambitions. The Environment Outlook 2030 may not in any event be seen as a forecast of the future. The report describes multiple developments that may arise in the future under certain circumstances. The exploration offers new insights that help to anticipate undesirable developments and thereby to make adjustments to the future.

The Environment Outlook 2030 describes developments in the economical sectors, the consequences thereof to the pressure on the environment and the quality of the environment. The Nature Outlook 2030 by the Research Institute for Nature and Forest concentrates on the consequences of the environmental quality and the land use for biodiversity.

Socio-economic outlook

The environmental status is the result of the socio-economic developments and the (environmental) policy implemented. The three policy scenarios are linked to a common set of steering environmental variables drawn up by the Federal Planning Bureau:

- Between 2005 and 2030 the population in Flanders have grown by 12 %, to 6 785 000 inhabitants. The ageing and dejuvenation continues. By 2030 nearly a third of the population is over 60 years of age and less than one fifth below 18 years of age. Family shrinkage trends will continue.

- The price of coal rises by 32 %, of crude oil by 63 % and natural gas by 98 % by 2030 (at constant prices from 2005). The price estimates are the average between the assumptions of the European Commission for the 2020 Energy and Climate package and that of the International Energy Agency. The energy prices affect the choice of energy carrier, the quantity used and the efforts for innovations.

- With an average annual growth of 2.0 % between 2010 and 2030 the growth of the gross domestic product is slightly lower than the growth trend over the last 25 years. The service economy grows further to the expense of industry and agriculture.

Challenges for the environmental policy

In the reference scenario, the current environmental policy *(as of 1 April 2008)* continues unchanged without any additional measures. Testing against the future targets indicates the challenges for the future (environmental) policy:

- The gross domestic energy use is 13 % higher in 2030 than in 2006. The total emissions of greenhouse gases increases by 12 % in 2020 and even by 31 % by 2030 compared to 2006. In 2006 the proportion of renewable energy in the gross end consumption was only 0.8 %. If the policy remains unchanged this will increase to 4 % by 2020 and 6 % by 2030. The use of renewable energy sources is beneficial both for the security of the supply and the emissions of greenhouse gases.

- The energy quality of homes in Flanders is low. Due to the population growth and smaller families, the number of homes grows further. The current energy performance standards for new construction and conversions/renovations are insufficient for decreasing the energy requirements. Industrial activities grow by 43 % between 2006 and 2030. As a result industrial energy consumption increases by 32 %, greenhouse gas emissions by 30 %. Transport flows continue to rise, with a 10 % increase in greenhouse gas emissions. Transport also fails to reach the European target of 10 % renewable energy by 2020.

- The annual average ozone concentration shows a gradual, but significant, rising trend. This is partly due to the increase in the background concentration due to long distance transport of ozone to Europe but primarily due to a decreased ozone breakdown due to the expected NO_x reduction of emissions. The annual excess falls because the ozone peaks decrease but not enough to achieve the long-term European target.

- The current policy fails to realise the target for particulate matter of the Pact 2020 for Flanders – a drop of the annual average PM10 concentration by 25 % by 2020 compared to 2007. In 2030, 15 % of the population will still be exposed to daily average PM10 concentrations greater than 50 µg/m^3 for more than 35 days. Furthermore unfavourable meteorological conditions for air pollution occur more frequently due to climate change.

- The acidifying deposition drops by a quarter by 2030 but the long-term target of 1 400 Aeq/ha will not be reached. Approximately 20 % of the nature area in Flanders will receive an excessive acidifying deposition in 2030.

- The pollutant loads to the surface water decrease further, for instance in 2015 by 12 % for nitrogen and by 23 % for COD compared to 2006. The pollutant loads by households and businesses decrease due to the further expansion and improvement of the public waste water treatment infrastructure. Businesses also decrease their pollutant loads themselves. However pollutant loads from the use of manure by agriculture will not fall. The lower pollutant loads will improve the physico-chemical quality of the water but nitrogen and phosphorus remain problematic. The biological quality of the water also improves but primarily due to shifts from poor to moderate quality.

- The population growth steers the future land use in Flanders to a considerable extent. The increased demand for houses and business premises ensures a further expansion of urbanised areas, by 17 % in the period from 2005 to 2030, or almost 7 ha/day. This is primarily at the expense of agriculture.

- The building primarily increases along the major roads. In this respect the developments for housing and trade within a distance of 450 m from major roads is 21 % higher in 2030 than in 2005. As a result exposure to air pollution and road traffic noise increases. In general, exposure to road traffic noise and the number of people potentially experiencing severe nuisance increase for Flanders.

- New climate scenarios for Flanders to 2100 unanimously indicate an increase in temperatures (winter: +1.5 to 4.4 °C, summer: +2.4 to 7.2 °C), and of precipitation during the winter. The summers will be drier and the river flows will drop, which increases the probability of severe water shortage. The summer storms will be fiercer with a higher chance of flooding of sewers. The sea level at the Flemish coast may rise by 20 to 200 cm this century.

European ambitions

The Europe scenario researches the effects of additional measures aimed at the European ambitions in the field of climate change, air quality and surface water quality.

The targets of the European 2020 Energy and Climate package take action on energy efficiency, the use of renewable energy sources and greenhouse gas emissions:

- The gross domestic energy use continues to fluctuate around the 2006 level. As a result Flanders cannot fulfil the energy efficiency target of a 20 % increase by 2020 in relation to an unchanged policy.

- Approximately 9 % of the gross final energy consumption is from renewable energy sources by 2020. Belgium had a target of 13 % imposed by Europe but the regions have not yet reached any further agreements regarding burden sharing. The share of green power in electricity production grows to 22 %. There is sufficient potential for renewable energy sources in Flanders to meet the demand. Transport increases the use of biofuels (including from the second generation) and reaches the target of 10 % renewable energy by 2020.

- Through measures regarding space heating the households succeed in almost halving their energy consumption by 2030. Trade & services can reduce their energy consumption by over one fifth. Industry does not succeed in decreasing its energy consumption in the Europe scenario.

- Europe implements a dual approach for the reduction of greenhouse gases by 20 % in 2020 compared to 1990. A national target is applicable for sectors that do not fall under the emission trading system (ETS). For Belgium this is -15 % for the 2005-2020 period. Installations from sectors that do fall under emission trading, must submit emission rights for their CO_2 emissions. The non-ETS sectors (households and the majority of trade & services, agriculture and transport) succeed in decreasing their greenhouse gas emissions by 23 % in 2020. The falling trend continues until 2030. The ETS sectors (industry and energy production) do not succeed in reducing their joint greenhouse gas emissions. Insufficient cost efficiency measures are available with the expected CO_2 prices. These sectors may rely on the acquisition of emission rights.

- With the same electricity production in the period between 2015 and 2020 the greenhouse gas emissions in the Europe scenario are noticeably lower than in the reference scenario. This is due to a larger use of renewable energy. From 2025 the difference is even more considerable due to the use of carbon capture and storage (CCS) with the new coal power stations. This technology will then be ready for the market.

- The scenario results indicate that when phasing-out the nuclear power stations the national power production may further be harmonised with the national power demand without any major negative repercussions on climate change, acidification and photochemical air pollution. A crucial condition is a strong and thorough effort for renewable energy sources (wind and solar energy as well as biomass) and after 2020 for underground CO_2 storage at coal and gas power stations.

- The greenhouse gas emissions from agriculture drop by almost a quarter between 2006 and 2030 due to the decrease of the cattle stock and measures in greenhouse farming. The introduction of road-pricing in the transport sector decreases motorised road traffic. But primarily due to technological measures transport may decrease its emissions by a quarter by 2030 in comparison to 2006. A condition is that consumers and companies increasingly choose energy efficient vehicles.

Europe imposes limit and target values for air pollutants on member states. In the context of the National Emission Ceilings Directive (NEC) stricter targets are expected for 2020. These decreases in emissions must allow the achievement of good air quality in Europe and Flanders:

- In the Europe scenario the annual average ozone concentration increases more greatly than in the reference scenario, up to 54 µg/m³ in 2030. The lower NO concentration (as a result of the expected Flemish and European NO_x emission reductions) ensures that less ozone is broken down. But also the increasing background concentrations, amongst others due to increased emissions in China and India, ensure that the ozone concentration remains high. Due to a lack of threshold values, lower 'every day' ozone concentrations are also harmful to health. However, the annual excess (ozone peak concentrations) shows a significant drop by 37 % between 2007 and 2030. But with drier and warmer weather in the future, for instance as a result of climate change, the positive effect of emission reductions on the ozone peak concentrations largely disappears.

- A decrease in the annual average of PM10 concentration by 25 % by 2020 compared to 2007, as stated in the Pact 2020 for Flanders, is only feasible with extra measures in the Europe scenario. The annual average PM2.5 concentration will probably reach the indicative limit value of 20 µg/m² in 2020. The target for the daily average PM10 concentration, i.e. a maximum of 35 days higher than 50 µg/m³, may only be achieved with local measures, such as low emission zones in cities and industrial areas.

- In almost 30 % of Flemish nature (70 000 ha) the nitrogen deposition remains too high to protect biodiversity.

- The industrial growth between 2006 and 2030 ensures an increase in the emissions of air pollutants. The stricter energy and climate policy also has positive effects on air quality, but is inadequate for achieving the air quality targets. Particularly the emission of particulate matter (PM2.5) rises significantly after 2015.

- Agriculture succeeds in decreasing its emissions of acidifying substances and particulate matter (PM2.5) by over 15 % in 2030 compared to 2006. This is a result of the decrease in livestock and extra environmental measures in stock-breeding and greenhouse farming. In 2030 the soil-bound cattle stock will have decreased by 28 % compared to 2006. Landless stock-breeding (pigs and poultry) may maintain its position thanks to manure processing.

- Transport is able to control its emissions of acidifying substances and ozone precursors with additional measures but does not succeed for particulate matter (PM2.5). The non-exhaust emissions must especially be tackled for this. Exposure to road noise may be decreased, for instance by choosing noise-friendly road surfaces and through speed limits. The drafting and execution of noise action plans in the context of the European Environmental Noise Directive provides opportunities for this.

The European Water Framework Directive puts a good status of the water first:

- Additional measures make it possible to decrease the impact on the surface water by households, business and agriculture. In comparison to 2006 the nitrogen and phosphorus load falls by about 35 % in 2027, by 49 % for COD. The execution of zoning plans is a precondition for the decrease in the pollutant loads from households. In addition to the further development of collective waste water treatment, agriculture contributes to this decrease by fertilizing according recommendation, by sowing winter green cover and by decreasing the livestock through government incentives.

- Despite the improvement of the physico-chemical water quality, only 1.5 % of the modelled waterbodies fulfil the quality standards for all modelled variables. Phosphorus remains especially problematic. There are particularly shifts from moderate to good biological quality but less than half of the measurement sites fulfil the quality standard. Under the assumption that the watercourses that flow into Flanders also fulfil the standards, a little below 60 % achieve a good biological quality.

- Water managers will have to take account of the consequences of climate change. Because the changes are uncertain, it must be possible to adapt measures flexibly depending on the changes observed. A lot of attention is paid to flooding but low water problems may become more important this century.

- In the Europe scenario the urbanised surface area also expands, by 13 % between 2005 and 2030. Smaller building plots ensure greater density with greater opportunities to preserve open spaces. The risk of flooding as a result of climate change is at the same level as with current land use. The Europe scenario absorbs the increase in population and additional housing needs better than the reference scenario.

Vision for Flanders

The starting point for the visionary scenario is the need for drastic measures with a view to a sustainable future. This scenario is based on the global challenge of climate change. The visionary scenario assumes additional measures aimed at reducing the greenhouse gas emissions by 60 to 80 % by 2050, with a halving of emissions by 2030. In order not to exceed the global temperature increase of 2 °C an 80 to 95 % reduction in emissions in industrialised countries is required by 2050 according to the IPCC. This implies an evolution to a sustainable low carbon economy:

- The gross domestic energy use falls by 20.6 % by 2020 compared to the reference scenario. As a result, Flanders meets the European energy efficiency target. The share of renewable energy in the gross final energy consumption stagnates at 9.2 % in 2020. The target for Belgium is 13 %. The share increases to 26.4 % by 2030.

- The non-ETS sectors succeed in reducing their greenhouse gas emissions by 32 % by 2020 and halving them by 2030, compared to 1990. After 2020 the ETS sectors also succeed in bringing their emissions under the 2006 level through national measures by 21 %. This decrease must to a great extent be attributed to the energy sector.

- Wind energy (primarily at sea), solar energy and biomass may be used cost-efficiently approximately to a 70 % share of the power production. Adjustments to the electricity grid to a so-called smart grid will require major investments.

- The ambitious targets for the energy and climate policy may be achieved if the housing and work system is drastically changed. The concept of living centres, striving for 'energy neutrality' fits within this.

- If industry wants to limit its greenhouse gas emissions greatly, the production and consumption processes must change fundamentally and structurally. Technological innovations and pricing instruments are important but insufficient. A transitional approach may help to realise the green economy of the 2009-2014 Flemish Coalition Agreement.

- Biofuels do not fit in a visionary scenario for transport because biomass may be used more efficiently as a energy source in other sectors. The breakthrough of electric cars is expected after 2020: by 2030 90 % of new cars will use electricity but this is only 15 % by 2020. Electric cars are more energy efficient and have better environmental performance, even if the emissions of the electricity production are taken into account. Citizens must be prepared to buy more energy-efficient cars, if necessary encouraged through support measures.

The road to transition

Even with far-reaching measures all the sectors will not always succeed in reaching the European targets, let alone the higher ambitions of the visionary scenario. There is a need for transitions: the systems that fulfil social needs, such as the energy system, the housing system and the mobility system must change fundamentally. Transitions generally take place over a period of multiple generations. In order to realise a sustainable low carbon economy by 2050, the transition must be started now. Leadership is expected from the government by stimulating policy integration, by creating spaces for experimentation and by investing in networks.

Introduction

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Myriam Dumortier, NARA, Research Institute for Nature and Forest

Objective

Society is becoming more complex and changing at an ever-faster pace. Policy cannot be solely based on figures that evaluate the past. It also needs a view of the future. How will the environment and nature in Flanders evolve over the coming decades? What impact can policy have on this? These are questions that the Environment Outlook 2030 and Nature Outlook 2030 try to answer.

The environment and nature are subject to autonomous and policy-led changes in society. The Environment Outlook 2030 describes developments in the sectors of the economy and the consequences thereof for the pressure on the environment and environmental quality. The Nature Outlook 2030 focuses on the consequences of environmental quality and land use on biodiversity.

The Environment Outlook 2030 and Nature Outlook 2030 primarily support the Environment, Nature and Energy policy field of the Flemish government. However they are also an aid to other policy fields, authorities and business, organisations and citizens in their contribution to a sustainable society. These outlooks help estimate the impact of the choices made today on the environment and nature of tomorrow. They facilitate long-term thinking and stimulate debate. Amongst others, they offer support to the 2011-2015 Environmental Policy Plan (MINA-plan 4).

The Environment Outlook 2030 analyses the extent by which alternative policy strategies allow the achievement of European and Flemish targets concerning climate change, air quality and water quality:

- the medium-term targets of the European 2020 Energy and Climate Package;
- the long-term target of 60 to 80 % reduction of greenhouse gas emissions by 2050, with a halving of the emissions by 2030, compared to 1990;
- the stricter European emission ceilings for air pollutants;
- the targets of the European Water Framework Directive.

The Environment Outlook 2030 and the Nature Outlook 2030 are not predictions of the future. They describe developments that could occur in the future under specific circumstances. The outlooks offer new insights that help to anticipate unwanted developments and thereby to adjust the future.

Approach

Scenarios are an integral part of outlooks. The European Environment Agency defines scenarios as 'plausible descriptions of the future on the basis of 'if-then' assumptions'. Outlooks on the basis of alternative scenarios are much more interesting than simple prognoses because they allow a comparison of alternative solutions. They also give an idea of the bandwidth within which future developments might vary. They form an attractive approach for dealing with complexity and uncertainty.

The Environment Outlook 2030 outlines the options for the future environmental policy on the basis of three policy scenarios:

- The *reference scenario* investigates the scope of the current environmental policy.
- The *Europe scenario* investigates what may be needed to realise the European ambitions concerning climate change, air quality and water quality.
- The *visionary scenario* investigates how the environment could be safeguarded for present and future generations.

The Nature Outlook 2030 builds further on the reference scenario and the Europe scenario of the Environment Outlook 2030. It describes the possible development of nature in Flanders for both environmental scenarios on the basis of three land use scenarios: the reference scenario, the 'separated land use' scenario and the 'multifunctional land use' scenario.

The Environment Outlook 2030 and the Nature Outlook 2030 found the scenarios on the basis of quantitative calculations. With adapted mathematical models they translate the causes of change for each scenario to their anticipated effects on nature and the environment. The scenarios in the Environment Outlook 2030 are calculated in consultation with experts and the policy. Both measures within the environmental policy and within other policy fields are considered.

Limitations

The future is uncertain, especially when looking forward multiple decades and when it relates to complex subjects like the environment and nature. The Environment Outlook 2030 and the Nature Outlook 2030 both model a chain of cause and effect relations. The results are consequently subject to a sum of uncertainties. There are also very many gaps in the knowledge.

In any event, figures about the future imply assumptions:

- The Environment Outlook 2030 and the Nature Outlook 2030 are based on one socio-economic outlook in the field of demography, energy prices and economic growth. The medium and long-term projections of the Federal Planning Bureau have been used for this. Such projections are rectilinear in use and disregard unpredictable political, financial, technological or other developments. The social basis for environment and nature may of course also experience changes and are not taken into account.

- The Environment Outlook 2030 and the Nature Outlook 2030 are limited to a number of developments that can be modelled. Every burden on the environment and nature could not be analysed, for instance the waste production of households and business. All cause-effect relations could not be included either. For example, the impact of climate change on the flow rates in watercourses and consequently also the water quality could not be calculated. Finally there was no feedback of the impact that the resulting developments might, in their turn, have on the cause.

Structure

The MIRA reports over the last years and the environmental indicators suggest that climate change, air quality and water quality constitute major challenges to future environmental policy. The Environment Outlook 2030 consequently also particularly focuses on these environmental themes.

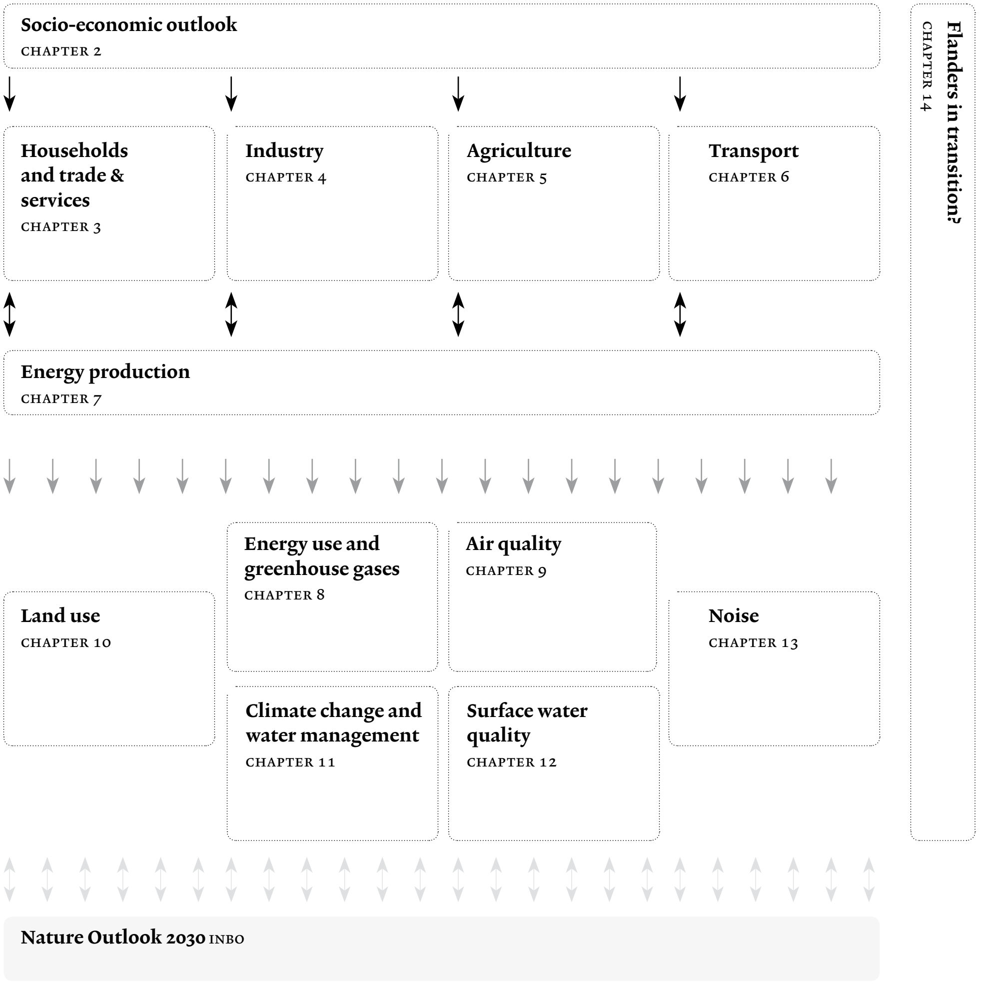
The structure of the Environment Outlook 2030 follows the DPSIR chain. Chapter 1 describes the context of outlooks and the three policy scenarios. The complexity of the exercise is also considered. The external developments in demography, economy and energy prices are considered in Chapter 2 Socio-economic outlook. Chapters 3 to 7 describe the emissions and energy consumption of the main sectors for the three policy scenarios. Chapter 8 brings together the results from the energy consumption and greenhouse gas emissions for Flanders. Chapter 9 explores the future air quality on the basis of the total emissions of acidifying substances, ozone-damaging substances and particulate matter. Chapter 10 describes the spatial consequences of the policy scenarios on the basis of the new Land Use Model. Chapter 11 gives the results of new climate scenarios for Flanders until 2100 and the impact of climate change on water management. Chapter 12 analyses the future quality of the surface water on the basis of measures in the draft river basin management plans. Chapter 13 studies the effects of traffic noise (road, rail, air) on the population.

Chapters 3 to 13 describe how far Flanders develops towards the intended environmental quality with the various scenarios. The most drastic is the visionary scenario that aims at an evolution to a low carbon economy. Chapter 14 is the concluding section of the Environment Outlook 2030. It examines how the transition to a sustainable low carbon economy may be initiated and what role the government and other stakeholders may play in it.

Each chapter of the Environment Outlook starts by outlining a number of main points as an introduction and ends with conclusions for policy.

FIGURE 1 illustrates how the report was realised and what data flows form its basis. External developments in demography, economy and energy prices define the activities of the sectors. The output of the scenarios is a set of pressure indicators. The total environmental pressure from the sectors then proceeds to the environmental themes. The figure also shows the flow of information to the Nature Outlook 2030.

FIG. 1 *Relationship between the scenario calculations in the Environment Outlook 2030*

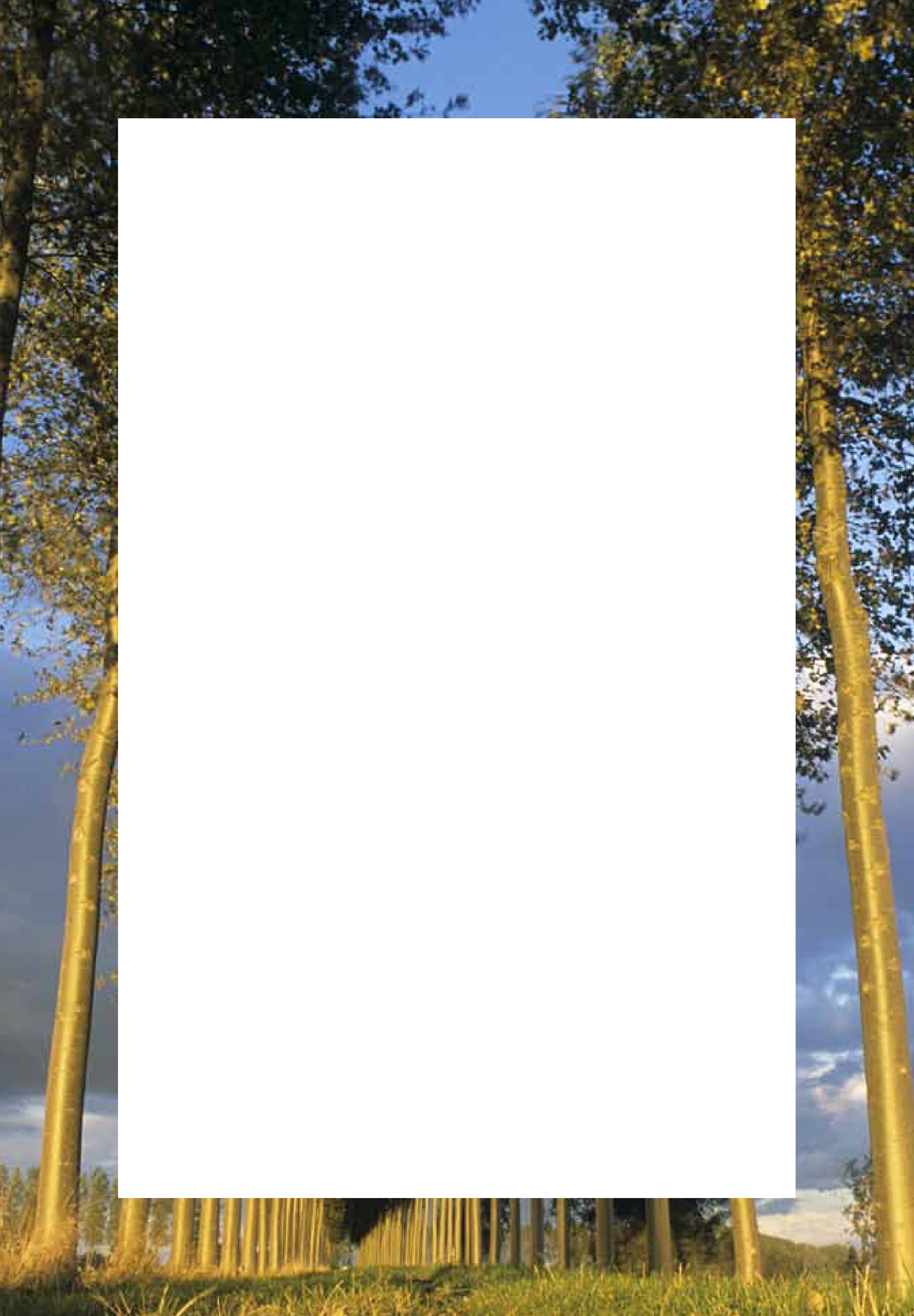


Information cascade

To make it easier to read this outlook, the cover has foldout flaps. These give the reader a brief summary of the three scenarios in words and pictures.

The chapters in the Environment Outlook 2030 and the Nature Outlook 2030 only include the most relevant results of the calculations. A detailed description of the methods, models, measurement packages and scenario results can be found in the scientific reports (*in Dutch*) available from www.milieurapport.be or www.nara.be.

The calculations for preparing the Environment Outlook 2030 and the Nature Outlook 2030 resulted in exceptionally numerous results. They cannot all be summarised in a report but are useful for specific applications. A lot more maps and data may be consulted per scenario at www.milieuverkenning.be and www.natuurverkenning.be.



1 Policy scenarios

Saskia Opdebeeck, Fre Maes, Stijn Overloop, Johan Brouwers, MIRA team, Flemish Environment Agency

OUTLINES

- The Environment Outlook 2030 is an outlook based on three policy scenarios. An outlook is not a prediction but analyses complex systems and tests various policy options. Policy scenarios are paths to possible ideas of the future that are aimed specifically at the impact policy choices have on these ideas.

- The reference scenario (REF) examines the future effects of unchanged (environmental) policy. The Europe scenario (EUR) investigates what might be needed to realise the European ambitions with regard to climate change, air quality and water quality. The visionary scenario (VISI) examines how our environment may be safeguarded for present and future generations.

- The Environment Outlook 2030 aims to support the Flemish decision-making process and to strengthen the government's strategic capacity. Furthermore it is intended to serve as a basis to explore the future in an open dialogue with the stakeholders. Finally it aims to function as a tool to map the complexity of policy questions.

Introduction

Policymakers are expected to formulate answers to social issues, such as environmental problems. However it is not always easy to identify an issue, let alone to put all the various policy options as possible solutions together and compare them.

A good scientific basis with strategic information and indicators *(evidence based policy)* helps tackle the uncertainty characteristic of policy questions. An outlook, like the Environment Outlook 2030, fits within this context.

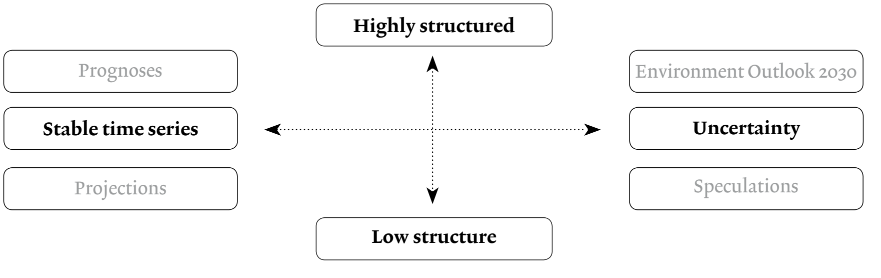
This chapter outlines the aim of this publication by considering the concepts 'outlook' and 'policy scenarios' in more detail. The three scenarios developed for this Environment Outlook 2030 are then explained. Finally this chapter considers the interaction between outlooks and the policy process, the complexity of this exercise and how the policy level can respond to it.

1.1 Outlook using policy scenarios

An outlook is a thinking exercise about an, as yet, non-existent reality which clearly differs from observable reality. It is not a predictive method. Outlooks are intended to analyse complex systems and test policy options. Evolutions and changes are systematically outlined on the basis of possible outlooks and paths. The time horizon (10 to 50 years) depends on the aim and the policy context.

An outlook is one of the techniques used to give shape to the possible future. Dammers (2000) defines four different approaches. FIGURE 1.1 positions the various techniques in relation to the structural level of the analysis and the level of uncertainty of the result.

FIG. 1.1 *Overview of the various concepts for viewing the future*



Source: Research Centre of the Flemish Government

This Environment Outlook 2030 bases its statements on the future on an analysis of complex and dynamic systems. This is highly structured as the statements about the future are based on data and an explanatory model. Models translate developments in the system and the impact they have on each other in a large number of variables and relations that are expressed through mathematical equations. The model consequently provides time lines concerning the status of a number of variables after x number of years as a result of the variation of one or more other variable(s). The high level of uncertainty is the result of the complexity that characterises each environmental problem.

Scenarios are an integral part of outlooks. They are paths to possible images of the future in the form of storylines that reflect different interpretations of the present and the future. A scenario describes changes, actions, unexpected events and their consequences. It indicates which elements are important in the future and how they interconnect.

In this Environment Outlook the strategic-explorative scenarios were primarily considered. They attempt to chart an uncertain future by exploring the various possible future images (explorative). In addition they focus on the consequences of own decisions (strategic).

The scenarios in this Environment Outlook 2030 are moreover described as policy scenarios. Such a scenario is explicitly aimed at charting the impact of policy choices and changes in relation to the current policy. More specifically the scenarios in this Environment Outlook explore the possible developments of the environment in Flanders in the long term for different packages of measures.

1.2 Three policy scenarios

The Environment Outlook 2030 outlines the options for the future environment on the basis of three policy scenarios: the reference scenario, the Europe scenario and the visionary scenario. The level of ambition and corresponding measures and costs vary considerably between the three environmental scenarios. Autonomous developments such as demographic shifts or the economy also define the development of the environmental pressure in the various sectors. These external environmental factors can all be kept equal for all policy scenarios (see Chapter 2 Socio-economic outlook). The evolution of environmental factors is not set in reality but equal points of departure for their evolution offers the benefits that the difference in the scenario results purely shows the effect of the various packages of measures. This allows an unequivocal comparison of the various policy options.

FIG. 1.2 *Graph of the REF, EUR and VISI scenarios in the Environment Outlook 2030*

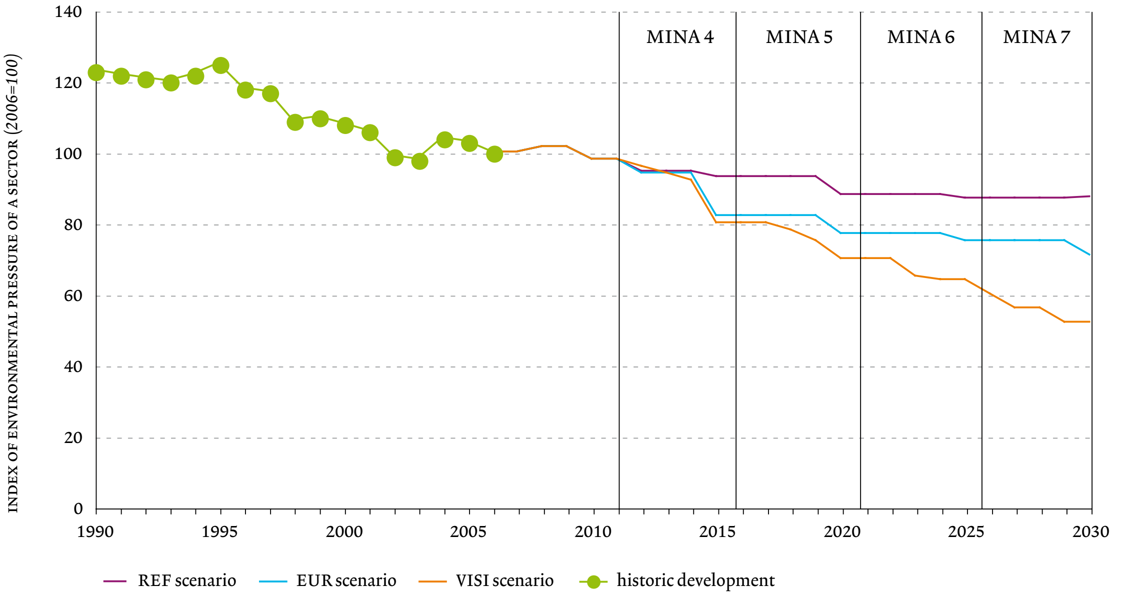


FIGURE 1.2 shows a fictive progress of the environmental pressure of an undefined sector. The figure illustrates the level of ambition of the three policy scenarios across the four environmental planning periods. The figure indicates that the future quality of our environment depends on the choices made today.

The reference scenario

In the *reference scenario* (REF), the current environmental policy (as of 1 April 2008) is continued unchanged without any additional measures. This scenario comprises all legislation and regulation already in force, planning already budgeted, the achievement of product standards and the sector specific autonomous developments. The targets set in the legislation are not imposed in the scenario calculations. Measures in the various sectors to achieve targets have been included.

The Europe scenario

The *Europe scenario* (EUR) comprises measures and instruments aimed at the following medium-term targets of the European environmental policy:

- the 20-20-20 targets in the Energy and Climate package;
- the stricter emissions ceilings for air pollutants;
- the targets formulated in the European Water Framework Directive (WFD).

In the European Energy and Climate package the European Union presents the following ambitious 20-20-20 targets for 2020 for the EU-27:

- a reduction in energy consumption by 20 % through more efficient use in relation to the expected level in 2020 if the policy remains unchanged;
- an increase in the share of renewable sources of energy in the gross end consumption to 20 %. Europe sets this target at 13 % for Belgium. A specific target of at least 10 % renewable energy on the total energy consumption is applicable to transport.
- a decrease in greenhouse gas emissions by at least 20 % compared to 1990. Europe sets the target for Belgium at a minimum 15 % reduction of greenhouse gas emissions compared to 2005 for sectors not falling under emissions trading.

There are no explicit Flemish targets regarding energy consumption, renewable energy sources and greenhouse gas emissions for 2020 but indicative targets were derived of the Belgian or European targets for the EUR scenario.

The emission of acidifying substances, ozone precursors and particulate matter were decreased in the EUR scenario to the levels in preparatory studies for a new European emission policy for the 2010-2020 period (Amann *et al.*, 2008). Emission reduction percentages were derived for Flanders as indicative emission targets for 2020 on the basis of these IIASA emission scenarios (successor for the 2010 NEC emission ceilings). This decrease in emissions is intended to fulfil the Flemish and European targets for achieving good air quality.

A good condition of the surface and groundwater by 2015 is the central objective of the WFD. For bodies of surface water this entails that they must be in a good ecological condition and a good chemical condition. However the WFD foresees certain circumstances by which deviations are possible to this target. The draft river basin management plans justify an extension of the period because it is technically not feasible to achieve the targets by 2015. The EUR scenario includes measures aimed at achieving the targets of the WFD by 2017 specifically the standards as represented in the draft river basin management plans.

The targets listed are an inspiration for the choice of measures, which clearly go further than the package of measures in the reference scenario. Furthermore they may go further than current economic capacity.

The visionary scenario

The starting point for the *visionary scenario* (*VISI*) is the need for drastic measures with a view to a sustainable future. This scenario is based on the challenge of climate change. Like the Europe scenario this scenario considers the extent by which a defined package of measures may achieve long-term targets without the pressure being shifted to other environmental themes. The long-term target is defined as follows:

- 60 to 80 % reduction of greenhouse gas emissions by 2050, with a halving of the emissions in 2030 compared to 1990. This reduction must result in a low carbon economy.

The evolution to a low carbon economy is part of a broader transition to a sustainable society. This transition cannot be realised with product and process optimisation alone. Structural changes are needed in the systems that fulfil social functions, such as the energy, material, mobility, food and housing system (see also Chapter 14 Flanders in transition?).

1.3 Interaction between the outlook and the decision-making process

A decision-making process is often described as a process in which interactions between the government and other social stakeholders (e.g. experts, interest groups, civil society organisations) are central. Via these interactions an outlook may also influence the decision-making. The role of an outlook in the decision-making process is threefold. This Environment Outlook 2030 explicitly strives to fulfil these three functions:

- An outlook helps to strengthen the strategic capacity of the government. The government strives to achieve the set targets. Defining the targets and policy instruments is preferably realised in a justified way. Outlooks may consequently also be used at various phases of the policy cycle and thereby contribute to forming the complete decision-making process.
- An outlook benefits the democratic process. It may serve as a basis to explore the future in an open dialogue with the stakeholders. As a result it increases the legitimacy of the choices of decision-makers.
- An outlook is a tool to map the complexity of policy questions. Outlooks consequently also help policymakers deal with uncertainties. Outlooks offer support in the first two phases of the policy cycle, namely agenda setting and policy preparation.

Environment Outlook 2030 and complexity

The unpredictable interaction between the various components of natural systems makes it very complex to plumb the depths of environmental issues.

Despite the fact that it is possible to research systems independently of each other and thereby to understand them relatively well, the conviction is growing within the scientific community that we will never understand the natural systems in their entirety. This makes it hard to measure the impact of a single environmentally hazardous substance on public health, let alone a combined effect of multiple substances. Furthermore due to a lack of proof, black-and-white conclusions can never be drawn.
This scientific complexity makes any type of research more difficult and consequently also the drafting of outlooks. In addition social complexity creates additional difficulties. For instance, each researcher handles uncertainty in a different way and social groups interpret environmental issues from their own assumptions and interests.
This twofold complexity raises many questions. In the first place it appears that the value of scientific knowledge is questioned. Is there any point constantly wanting to understand more in the traditional scientific way? The risk of mirage certainties is waiting around the corner, rather than truly useful insight. In addition this complexity also has consequences for the ability to control environmental problems. Should all aspects of a problem be understood before action is taken? Or is specific information sufficient? When is there sufficient evidence to act? And who decides that?

The Environment Outlook 2030 takes account of these considerations insofar as possible. The complexity of environmental issues cannot ever be grasped by a single type of expertise. For that reason MIRA decided to involve the largest possible number of researchers from different disciplines in this outlook – either as an expert or a reader. After all, the quality of the knowledge stands or falls to a considerable extent with the quality of the discussion between all the stakeholders.
The policy role of an Environment Outlook is placed in a different light due to the complexity of environmental issues. Policymakers cannot automatically derive a blueprint for future environmental policy from this Environment Outlook 2030. After all, the definition of the policy and weighing up the costs and benefits are ultimately a social and political task. Different considerations and interpretations are important. Consequently it is also useful to invest in a top quality evaluation of the consequences of environmental problems to society. Despite the complexity, this Environment Outlook 2030 aims to give policymakers a useful insight without any pretension of being the single scientific truth. The intention is to offer support for making well-informed policy choices and for defining a coherent environmental policy. The complexity of environmental issues and the presence of various interests should not paralyse the decision-making process.

If you would like to know more, you can consult the scientific report, which forms the basis for this framework text:

Keunen H., Morren B. & Loots I. (2009). Hoe omgaan met de complexiteit van milieuvraagstukken? Scientific report, MIRA 2009, VMM, www.milieurapport.be.

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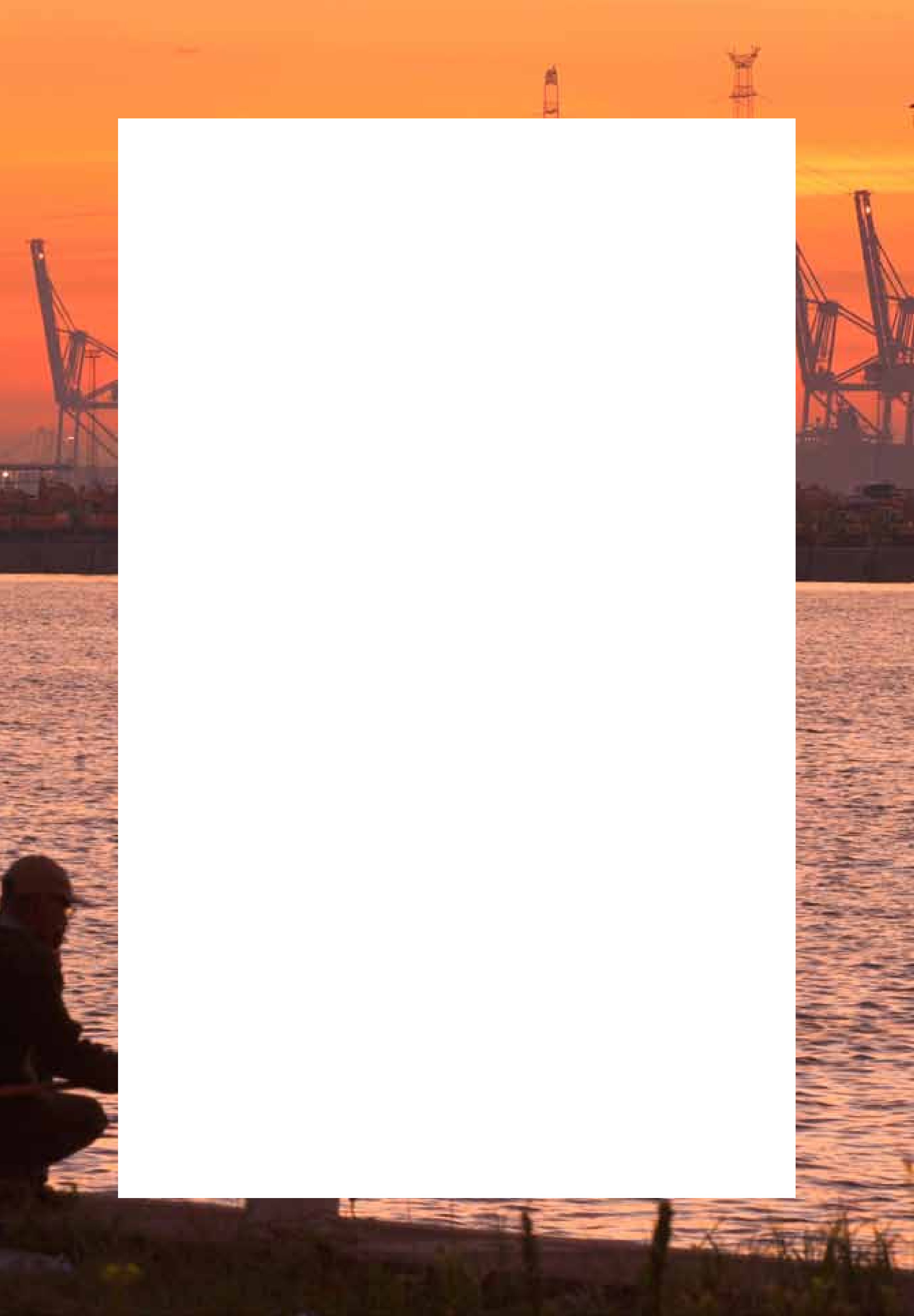

2 Socio-economic outlook

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OUTLINES

- The population of Flanders will grow by 12 % between 2005 and 2030 to 6 785 000 inhabitants. This is primarily the result of immigration and a temporarily increased birth rate.

- The ageing and dejuvenation of the population will continue: in 2030, 31 % of the Flemish population will be over 60, only 19 % of the inhabitants will be younger than 18. In 2005 this was respectively 23 and 20 %. Family shrinkage will continue: the average family size and the proportion of people being part of a family with children will systematically decrease.

- The prices for coal, crude oil and natural gas will increase respectively by 32, 63 and 98 % between 2005 and 2030 (at constant prices from 2005). For instance this means that the price of Brent oil in this period will increase from 54 to 89 dollars a barrel (expressed in constant dollars from 2005).

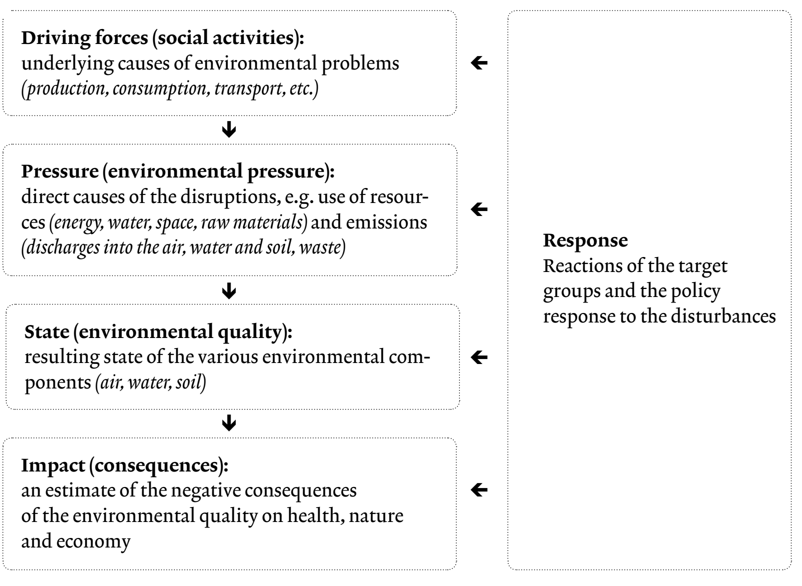
- The annual growth of the gross domestic product (GDP) is 2 % on average in the period between 2010 and 2030. This is slightly lower than the long-term average since the early 1980's. The importance of the service industry in the Flemish economy will continue to rise in relation to agrarian and industrial activities. The production of goods will only constitute 27 % of the total production of goods and services by 2030.

- The growth in employment and the level of employment will level off by 2030. In Belgium the domestic employment – expressed as a number of people – should be 13.5 % above the 2005 level in 2020 and approximately 15 % in 2030.

Introduction

Socio-economic developments must also be taken into account if a picture is to be formed of future developments as regards the environment. Indeed social and economic developments such as the increase in population or changing production and consumption patterns significantly determine tomorrow's environmental quality. This is illustrated by the DPSI-R chain: this is a frequently used international framework in environmental reporting that analyses an environmental problem on the basis of cause and effect (FIGURE 2.1). This framework forms the backbone of the MIRA reports and the Environment Outlook 2030. In this context socio-economic developments may be entirely situated in the *driving forces* (D), the first link of the DPSI-R chain.

FIG. 2.1 *The DPSI-R chain*



The main social driving forces are considered in this chapter: demography, energy prices and basic economic parameters.

The approach to the environment and nature issue is a challenge in the longer term. For that reason a set of socio-economic data drawn up from a long-term perspective is used in this future outlook. The emphasis is on analysing and projecting trends and not on the cyclic process of socio-economic variables. The projections of the socio-economic variables are based on the medium and long-term projections[1] that the Federal Planning Bureau (FPB) drew up in mid-2008 and form a coherent whole.

Choosing a single socio-economic base scenario does not detract from the fact that the future path of these socio-economic variables is sometimes very uncertain.

The (unexpected) worldwide financial crisis that broke out in the autumn of 2008 – with clear consequences on the economic activity and energy prices – illustrates the fragility of economic projections. Whether this crisis will also have long-term consequences in addition to the unavoidable short and medium-term effects remains an open question. The end of this chapter considers this question in more detail.

2.1 Demography

Population growth is not the only element that has an impact on the environment, a number of qualitative characteristics such as the age and socio-economic status of the future population and the change in the number of households and composition according to family type also has such an impact.

Births, deaths, immigration and emigration

The basic demographic data are based on 2007-2060 population forecasts (FPB/ADSEI, May 2008). It relates to the most recent official population forecasts for Belgium, drawn up by district, age and sex. The starting point for these forecasts is the observations on January 1st 2007.

Between 2005 and 2030 the average annual population increase in the Flemish Region will be 0.46 %. The Flemish population will have increased by approximately 12 % in 2030 compared to 2005 (Table 2.1). The sharpest rise is in the period between 2005 and 2015, with an annual population increase from 35 000 to 40 000. This is primarily due to a higher birth rate and a higher net external migration balance. As a result of an increase in the number of mortalities (ageing population) and a fall in the balance of external migrations, the annual population growth will decrease to 12 000 people in 2030. Then there will be more deaths in Flanders than births (negative natural balance): the population increase by the end of the projection period is thereby entirely attributable to positive internal (from other regions) and external (from other countries) migration. Flanders hereby maintains a positive natural balance much longer than the average in the EU[2]: in the EU there will, on average, already be more deaths than births from 2015.

TAB. 2.1 *Population development (Flanders, 2005-2030)*

(x 1 000 people/year)	2005	2010	2015	2020	2025	2030
Natural balance	7.0	8.6	5.6	4.0	1.5	-2.3
Births	63.9	68.3	68.2	68.5	67.2	65.3
Deaths	56.9	59.7	62.6	64.5	65.7	67.6
Balance of internal migrations	5.1	7.2	8.1	7.2	7.4	7.5
Balance of external migrations	21.7	23.8	21.7	16.1	9.6	7.2
Population growth	33.9	39.6	35.5	27.3	18.5	12.4

Source: FPB/ADSEI (2008)

With an annual growth of 0.46 % between 2005 and 2030 the Flemish population growth increases by approximately 0.2 percentage points more than the EU average. However this figure is lower compared to Wallonia and Brussels. The total annual Belgian population growth is 0.55 % (or almost 15 % in total) over the period between 2005 and 2030. The lower population growth in Flanders compared to the rest of the country reflects a population that is ageing more quickly and a lower birth rate. The proportion of the Flemish population in the total Belgian population would thereby fall from 57.9 % in 2005 to 56.6 % in 2030.

Ageing and dejuvenation

The expected increase in the Flemish population is consequently spread very unequally over the age groups (TABLE 2.2). The number of people over sixty will increase by 52 % between 2005 and 2030, whereas the number of people in the 0-17 age group will increase by only 7 %. The number of people in the 18-59 age group will even fall by almost 2 %. As a result, the population share of the 18-59 age group will fall to only 50 % by 2030. Almost one third of the Flemish population will then be over sixty. These figures clearly illustrate that the Flemish population will be characterised over the coming two decades by relatively sharp ageing: the number of seniors in the population will noticeably increase. Ageing in Flanders will run approximately parallel to the EU average until 2030. In addition the phenomenon of dejuvenation is clearly visible in Flanders (falling proportion of young people in the population), although not quite as sharply as in the rest of the EU.

TAB. 2.2 *Breakdown of the population by age (Flanders, 2005-2030)*

Age group	2005 (share in %)	2030 (share in %)	Growth rate 2005-2030 (%)
0-17	20.0	19.0	7.2
18-59	57.3	50.1	-1.7
60+	22.8	30.8	51.9
Total	100.0	100.0	12.3

Source: FPB/ADSEI (2008)

Primarily as a result of the expected ageing and dejuvenation, the composition of the Flemish population by socio-economic status will clearly be different by 2030 than it is today. TABLE 2.3 illustrates that the proportion of inactive members of the population, which primarily includes the senior citizens, will increase significantly. Workers and students increase in absolute numbers but their share in the total Flemish population will fall.

TAB. 2.3 *Socio-economic status of the population (Flanders, 2005-2030)*

	2005 (share in %)	2030 (share in %)	2005-2030 (absolute change)
Students	21.6	19.9	+45 000
Working	43.7	43.1	+283 000
Inactive	34.7	37.0	+413 000
Total	100.0	100.0	+741 000

Source: FPB

Composition of households

Between 2005 and 2030 the proportion of people making up a part of the family type ‘couple with children’ will significantly drop in Flanders, in the first place making way for single people and couples without children (TABLE 2.4). The figures show an evolution to smaller families.

TAB. 2.4 *Division of the population according to family type (Flanders, 2005-2030)*

(share in %)	2005	2030
Single without children	11	15
Single with child(ren)	8	8
Couples without children	24	27
Couples with child(ren)	50	42
Other*	7	8
Total	100	100

* Includes people living in a collective family (e.g. retirement home, an institution, a prison) and families comprising more than one nuclear family.
Source: FPB based on Desmet *et al.* (2007) and FPB/ADSEI (2008)

The fact that the average number of people per household is falling is nothing new. This evolution has already been apparent for many decades. Family shrinkage is the result of years of interaction between a series of socio-cultural, demographic and economic factors such as the increase in age at which children leave the parental home. People also more frequently live alone (amongst others as result of the social phenomenon of individualisation) and divorce more quickly (amongst others dependent on the extent of financial independence). Senior citizens want to live independently as long as possible.

2.2 Energy prices

Energy prices are relatively central prices dealt with by families, companies and governments. They consequently also play a significant role when financial decisions have to be taken. The choices, based on energy price considerations, are moreover typically non-neutral to the environment. Energy prices may significantly influence the speed by which energy innovations are spread and accepted. They are also often a decisive factor in replacing one type of energy with another.

In 2008 the FPB formulated the hypotheses in the report 'Economische vooruitzichten 2008-2013' (Economic forecasts 2008-2013), which relate to the energy prices at constant prices. Those energy prices have been used in the Environment Outlook 2030. In this way FPB forecast a fall (by approximately 2 %) of the annual average price of Brent oil (at constant prices) in 2009, followed by an increase (by 0.9 % on average a year) during the following years. In 2012 the Brent price will thereby surpass the 2008 annual average.

For the period after 2013 the energy prices were extrapolated on the basis of the changes in the PRIMES baseline scenario of the European Commission (EC) (European Commission, 2008). The PRIMES model is a partial balance model of the energy system in Europe, which includes the energy supply and demand. The PRIMES baseline scenario was used, amongst others, for the formulation of the European Climate and Energy Package 2020. It assumes an increase in energy prices (at constant prices) of approximately 0.5 % per annum between 2015 and 2030. The result of the connection of the 2008-2013 economic forecasts for Belgium to the PRIMES baseline for Europe is shown in TABLE 2.5.

TAB. 2.5 *Energy price hypotheses (at constant prices)*

	2005	2010	2015	2020	2025	2030
Coal (index 2005=100)	100.0	121.2	126.5	130.0	130.9	131.8
Crude oil (index 2005=100)	100.0	141.7	150.4	158.7	161.8	163.1
Natural gas (index 2005=100)	100.0	173.6	180.4	191.2	196.2	197.8
Brent (per barrel at constant euro from 2005)	43.7	61.9	65.7	69.4	70.7	71.3
Brent (per barrel at constant USD of 2005)[3]	54.4	77.1	81.8	86.3	88.0	88.7

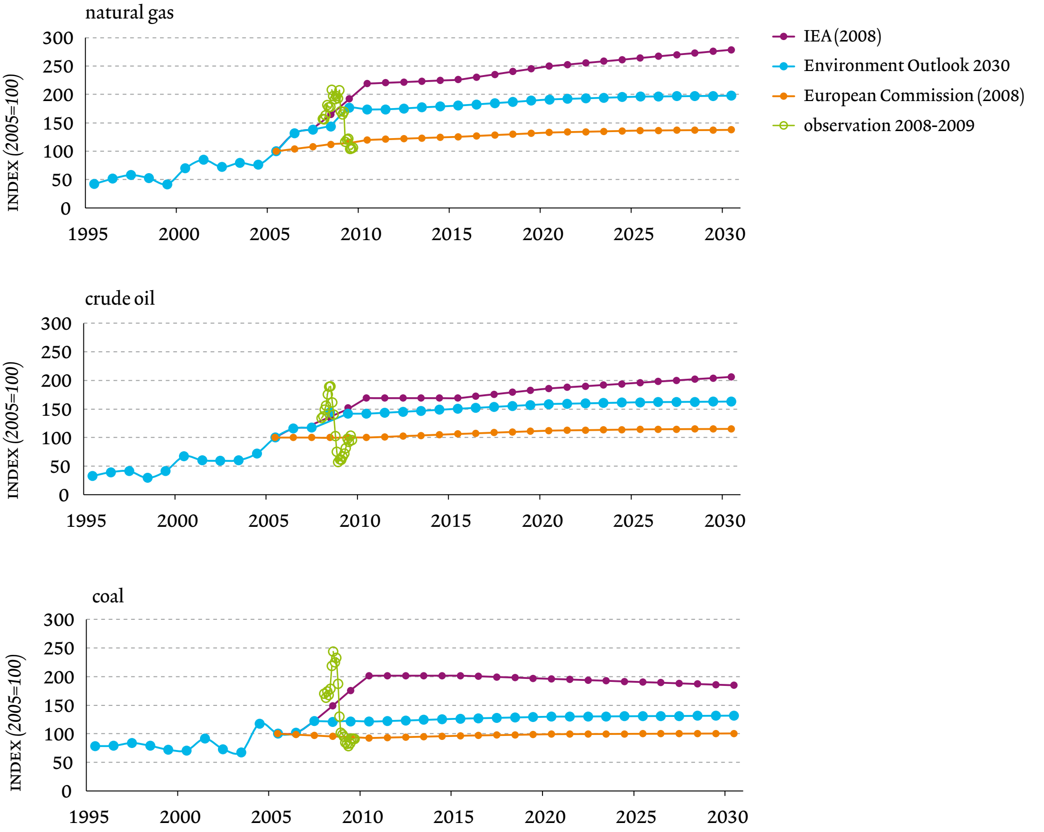
Source: FPB

FIGURE 2.2 compares the assumptions above for energy prices with the price evolution that formed the basis for the PRIMES baseline scenario itself (European Commission, 2008) and for the World Energy Outlook 2008 (IEA, 2008). The most recent observations have been added to the figure in green (January 2008 to September 2009). The very great differences between what the various institutions assume on the one hand and the extreme variability in the observations of the last year and a half on the other are immediately striking here. This indicates that there is more uncertainty now than ever before concerning how energy prices will change in the future. The International Energy Agency (IEA) reached the same conclusion in the World Energy Outlook 2008 in November 2008: *'Rarely has the outlook for oil prices been more uncertain than now ...'*

The smooth evolution of the energy prices in the figure does not at all entail that the energy markets are expected to stabilise. It simply attempts to outline a picture of the anticipated long-term trends for energy prices. The price hypotheses for the three types of energy considered in the Environment Outlook 2030 appear to be midway between the assumptions of the European Commission and the IEA.

The spectacular fall in the energy prices since the autumn of 2008 as a result of the financial crisis (and the drop in energy demand connected to it) has not been factored into the basic hypotheses of the Environment Outlook 2030. The question remains whether such price decreases on the international energy markets are entirely a thing of the past. Based on the forward rates available financial experts do not expect any further price decreases. A return of energy prices to the low levels of the nineties does not seem probable. The time and level by which the energy prices will rise again, will depend (on the demand side) on the duration of the financial crisis and the strength of the recovery (see § 2.4) and (on the supply side) on the investments to expand production capacity. Although an increase in energy prices is expected in general in the coming years, a quick return to the record levels of mid-2008 is not very probable. These current expectations are entirely in line with the price levels maintained in the Environment Outlook 2030.

FIG. 2.2 *Hypotheses for the price* evolution of natural gas, coal and crude oil*



* expressed as an index with 2005=100, and calculated at constant prices
Source: FPB, European Commission (2008), IEA (2008), Datastream

Concerning international energy prices and prices for end consumers

The fluctuations in the prices on the international energy markets can only be found in a mitigated extent in the price paid by the consumer. In addition to the costs of the energy raw materials, less changeable parameters (e.g. production costs – wages, fixed costs, depreciations, transport and distribution margins and taxes and levies) also influence the price paid by the consumer. Fluctuations in the international energy prices consequently result in less than proportionate changes in the price for the consumer. For instance an increase in the price of crude oil by 10 % only resulted in an increase of diesel and petrol prices at the pump by 3 to 4 %. Ultimately these prices are those that influence the consumer behaviour and are relevant for a study on environmental pressure.

2.3 Economic development

Naturally economic growth is also a crucial parameter to establish future environmental pressure. Structural characteristics of economic activities, such as the extent by which the importance of the service industry increases in our economy in relation to agrarian and industrial activities and the geographical spread of employment are equally important. This geographical spread was one of the main parameters for the spatial modelling in the Environment Outlook 2030 (see Chapter 10 Land use).

Starting point

The medium and long-term projections for Belgium that the FPB published in mid-2008 constitute the starting point for the basic economic data in the Environment Outlook 2030. Over the 1995-2007 period there has hardly been any difference between Flanders and the whole of Belgium in the growth of value added and employment. The estimates do not take any account of the financial-economic crisis (see § 2.4).

The Hermes and Maltese models were used for the medium and long-term projections. The Hermes model is an econometric macro-sectoral estimation tool for making medium-term projections. The most recent version of the model defines sixteen business sectors and fifteen consumption categories. The Maltese model is intended to make projections for the long-term evolution of expenses for social protection, situated within receipts and disbursements of the government. This is based on an interrelated demographic and macro-economic scenario.

The sources used for the basic economic data are:

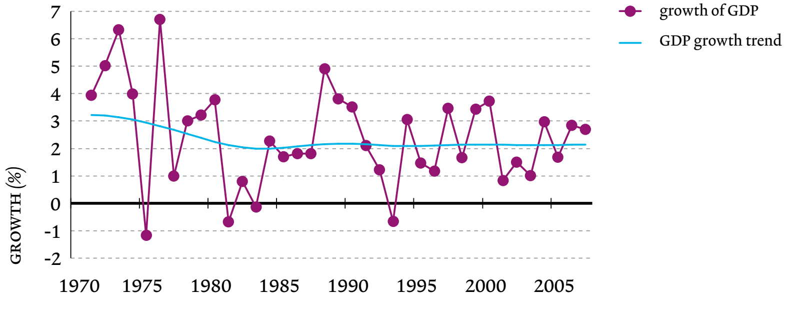
- observations from the detailed National accounts for 2006 of the Institute for the National Accounts (INR) from 2007;
- the Regional accounts for 2006 of the INR from 2008;
- the first estimate of the annual accounts for 2007 by the INR from 2008;
- The Economic forecasts 2008-2013 for the Belgian economy from the FPB from 2008, with an extension of the medium-term projection to 2020;
- The long-term projection to 2050, realised in 2008 by the FPB in the context of the activities of the Study group for ageing of the Supreme Council of Finance.

Economic growth

Although GDP growth shows large fluctuations from year to year, the trend in GDP growth over the last 25 years has shown a relatively stable development. This growth has been slightly above 2 % since the early eighties (FIGURE 2.3).

For the period between 2010 and 2030 the Environment Outlook 2030 assumed an average annual growth of Belgian GDP of 2.0 %: this is slightly lower than the trend growth over the last 25 years. In line with demographic projections and more specifically with the expected development of the population at working age, the economic growth will lose some of its strength during the course of the projection period. Where GDP growth during the period 2010-2020 is still over 2 %, this figure falls to 1.9 % in the five years following that and to 1.8 % in the period between 2025 and 2030 (TABLE 2.6). The long-term GDP growth (from 2020 on) is based on hypotheses for the annual growth of the employment productivity per capita (1.75 %) and the level of structural unemployment to be reached in 2030 (8 %).

FIG. 2.3 *Growth of GDP (at constant prices) (Belgium, 1970-2007)*



Source: FPB

TAB. 2.6 *Average annual GDP growth rate (at constant prices) (Belgium, 2000-2030)*

(%)	2000-2010	2010-2020	2020-2030
Gross Domestic Product	1.9	2.0	1.9
Productivity per capita	1.0	1.3	1.75
Employment (number of capita)	0.9	0.7	0.1
Population at working age (15-64 years of age)	0.6	0.3	-0.1

Source: FPB, PLANET-projection[4]

The PRIMES baseline scenario of the EC also assumes a growth in the Belgian GDP of 2 % in the period between 2010 and 2020. but estimates the growth in the subsequent decade at only 1.6 % per annum (European Commission. 2008). The difference between the assumptions for the Environment Outlook 2030 and the PRIMES baseline for Belgium during the last decade can primarily be explained by a different population dynamic. The PRIMES baseline did not take any account of the most recent population forecasts of May 2008 with an increased birth rate and migration balances. which were already integrated in the Environment Outlook 2030.

Importance of goods and services in the economy

The structure of economic activity is also important in addition to the level of economic growth. Indeed, all business sectors do not have the same impact on the environment. In line with the last decades it is expected that towards 2030 the importance of services will increase further in our economy in relation to agrarian and industrial activities. With the exception of 'non-tradable services' and 'trade & hotel and catering' all the service sectors will see a significant increase in their share of the total added value by 2030. A drop is expected in the share of environmental intensive business sectors like the manufacturing industry, agriculture and the energy sector, whereas the share of the 'transport & communication' sector will increase (TABLE 2.7).

TAB. 2.7 *Share of the business sectors in the gross added value (at constant prices) (Belgium, 1995-2030)*

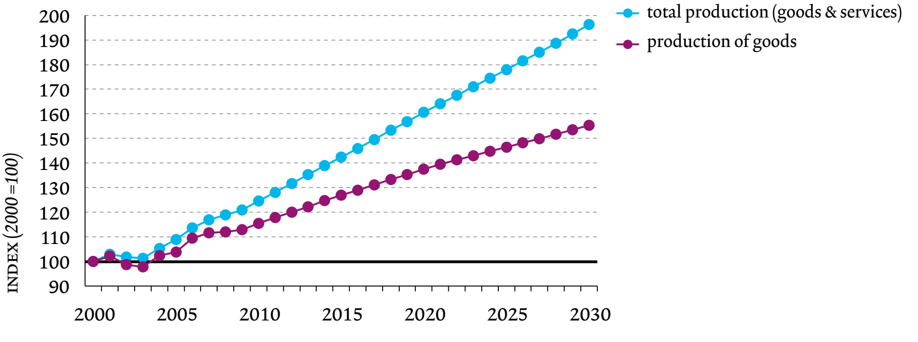
(%)	1995	2005	2030
Agriculture	1.4	1.2	1.0
Energy	3.2	2.9	2.5
Manufacturing industry	17.9	17.6	15.2
Construction	5.1	5.0	6.1
Trade & hotel and catering	15.5	13.5	10.9
Transport & communication	7.9	8.1	9.1
Financial services	5.1	6.4	7.6
Healthcare & social services	6.6	6.6	7.4
Other market services	22.7	25.4	28.0
Non-tradable services	14.5	13.3	12.4
Total	100.0	100.0	100.0

Source: FPB, PLANET-projection

The fact that the service sectors will take on a great deal of the economic growth results amongst others in the production of goods falling behind total production growth (FIGURE 2.4). Production is expected only to constitute 27 % of the production of goods and services by 2030 compared to 33 % in 2005. This anticipated drop is the continuation of a historic trend: in the early eighties the share of the production of goods was still over 40 %.

The production of goods is primarily situated in the manufacturing industry. During the period between 2000 and 2030 the share of the manufacturing industry and agriculture sector will drop in the production of goods (TABLE 2.8).

FIG. 2.4 *Evolution of production (at constant prices) (Belgium, 2000-2030)*



Source: FPB, PLANET-projection

TAB. 2.8 *Share of business sectors in the production of goods (Belgium, 2000 and 2030)*

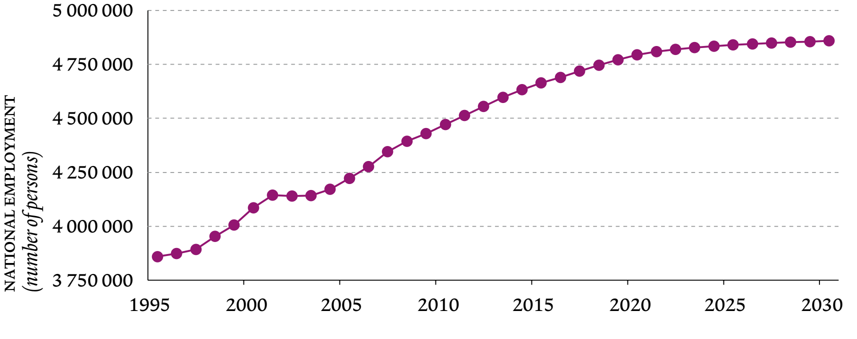
(%)	2000	2030
Agriculture	4.0	3.1
Energy	8.0	10.3
Manufacturing industry	83.4	79.9
Construction	0.6	0.8
Trade & hotel and catering	2.9	4.2
Transport & communication	0.4	0.6
Financial services	0.0	0.0
Healthcare & social services	0.0	0.0
Other market services	0.7	1.0
Non-tradable services	0.0	0.0
Total	100.0	100.0

Source: FPB, PLANET-projection

Employment

National employment – expressed in the number of people at work – will increase in Belgium on average by 0.6 % in the period between 2005 and 2030 (FIGURE 2.5). Between 2010 and 2020 the growth in employment will be 0.7 % per annum, and will fall in the decade following to 0.1 %. The main reason for the drop is the decreased dynamic of the employment available. The annual population growth of the working age population (15-64 years of age), which is still 0.6 % between 2000 and 2010, will drop to 0.3 % in the period between 2010 and 2020. After 2020 there will even be an average decrease of 0.1 % per annum. This growth profile brings the national employment in 2020 to 13.5 % and in 2030 to approximately 15 % above the 2005 level. The level of employment – expressed in percent of the working age population – increases from 62.2 % in 2005 to 66.3 % in 2020 and 67.7 % in 2030.

FIG. 2.5 *Evolution of national employment (Belgium, 1995-2030)*



Source: FPB, PLANET-projection

The coming decades predominately confirm the historic shifts in the division of employment according to business sector (TABLE 2.9). Tertiarisation is primarily expressed in terms of an increasing share of employment in the 'healthcare & social services' and 'other market services' sectors and in a further drop in the share of the manufacturing industry and agriculture.

TAB. 2.9 *Share of business sectors in employment (Belgium, 1995-2030)*

(%)	1995	2005	2030
Agriculture	2.8	2.0	1.1
Energy	0.9	0.7	0.4
Manufacturing industry	17.5	14.2	8.7
Construction	6.1	5.7	5.8
Trade & hotel and catering	18.4	17.8	17.0
Transport & communication	7.1	6.9	6.8
Financial services	3.8	3.3	2.9
Healthcare & social services	9.2	11.0	14.3
Other market services	14.9	19.0	25.5
Non-tradable services	19.3	19.4	17.5
Total	100.0	100.0	100.0

Source: FPB, PLANET-projection

In the past employment evolved differently between districts. Divergent evolutions are also expected for the projection period. The share of the five (historically) largest Belgian districts dropped from 47.4 % in 1970 to 40.0 % in 2005 and will decrease further to 39.2 % by 2030. This loss benefits both the medium and small districts. The middle group saw their share increase from 30.2 % in 1970 to 36.0 % in 2005 and will see a further increase to 36.4 % by 2030, whereas the share of the small districts increased from 22.4 % in 1970 to 24.0 % in 2005 and will increase to 24.4 % by 2030. The historic trend of a larger spread of employment (classified by workplace) over the districts will consequently continue in the projection period, albeit at a slower rate than in the past. TABLE 2.10 shows the historic and expected evolution of the share of the Flemish districts and the Brussels district in the total Belgian employment according to workplace.

TAB. 2.10 *Regional division of national employment according to workplace (Flanders and Brussels, 1970-2030)*

Share of the Flemish districts and Brussels in Belgian employment (%)	**1970**	**2005**	**2030**
Large districts			
▪ Brussels	19.10	15.61	15.69
▪ Antwerp	10.87	10.19	9.78
▪ Ghent	5.35	5.61	5.69
Medium sized districts			
▪ Halle-Vilvoorde	3.99	5.64	6.02
▪ Hasselt	3.35	4.06	4.00
▪ Leuven	3.11	3.86	3.84
▪ Kortrijk	2.87	3.03	3.00
▪ Turnhout	2.86	3.95	4.15
▪ Mechelen	2.57	2.99	3.07
▪ Bruges	2.55	2.81	2.57
Small districts			
▪ Aalst	1.86	1.86	1.82
▪ Sint-Niklaas	1.72	1.98	2.00
▪ Roeselare	1.39	1.54	1.53
▪ Dendermonde	1.35	1.34	1.35
▪ Oostende	1.22	1.15	1.05
▪ Tongeren	1.09	1.28	1.28
▪ Maaseik	1.04	1.81	1.90
▪ Oudenaarde	1.01	0.97	1.10
▪ Ypres	0.83	0.95	0.94
▪ Tielt	0.70	0.93	1.10
▪ Eeklo	0.54	0.59	0.59
▪ Veurne	0.44	0.55	0.52
▪ Diksmuide	0.32	0.39	0.39

The historically largest districts are defined here as districts which held a share of Belgian employment per workplace of more than 5 % in 1970. Medium districts have a share between 2 and 5 %, small districts have less than 2 %.
Source: FPB, PLANET-projection

2.4 Impact of the economic crisis

The financial and economic crisis that started in 2008, resulted in an extremely sharp and fast decrease in economic activity worldwide. In 2009 the global GDP is estimated to have fallen by over 1 %, a drop unprecedented over the last 50 years. The worldwide nature of this recession and its scope raises questions regarding the possible medium and long-term effects of this crisis.

The macro-economic scenario for the Environment Outlook 2030 was formulated in the summer of 2008 and consequently does not take any account of this worldwide recession in economic activity. According to the most recent official short-term forecasts of the INR (September 2009) the GDP of the Belgian economy falls by -3.1 % in 2009, followed by a slight positive growth (+0.4 %) in 2010. The annual growth during the 2000 and 2010 period would come to 1.2 % with this growth profile, compared to 1.9 % as taken for the same period in the socio-economic outlook for the Environment Outlook 2030.

In addition to the estimate of the short-term effect of the financial-economic crisis on the economic activity, there is currently a discussion concerning the impact in the longer term, more specifically on the potential GDP. Three scenarios are conceivable here (FIGURE 2.6):

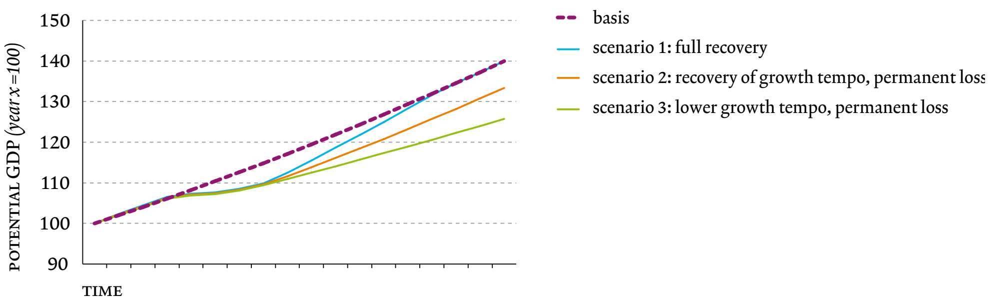
- Scenario 1: there is a temporary drop in the level of the potential output, but the potential GDP returns over time to the path defined before the crisis. This return justifies the term 'full recovery'. Accumulated over the entire period (i.e. the area below the curve) there is of course a significant negative impact from the crisis.
- Scenario 2: in due course there is a return to the potential growth tempo from before the crisis but a permanent loss is apparent in the potential level of output.
- Scenario 3: the growth tempo of the potential GDP does not return to the tempo from before the crisis but remains permanently lower. The distance between both curves consequently becomes increasingly greater.

Historic precedents for such financial-economic crises are exceptionally scarce, especially considering the global nature of the last shock, or are so far in the past which makes them significantly less useful as a point of reference. This means that there is still great uncertainty as regards the most likely scenario. In addition to the choice of scenario there is naturally also the problem of estimating the exact duration and extent of the impact.

According to the newest medium-term forecasts of the FPB in May 2009 for the period between 2009 and 2014, the growth of the potential Belgian GDP would gradually increase from 2011, but would still not have returned to the growth rhythm from before the crisis by 2014 (FIGURE 2.7). This means that at least in the medium term the gap between the potential output level before and after the crisis will increase. By 2014 the gap between both would have increased to approximately 7 % of GDP.

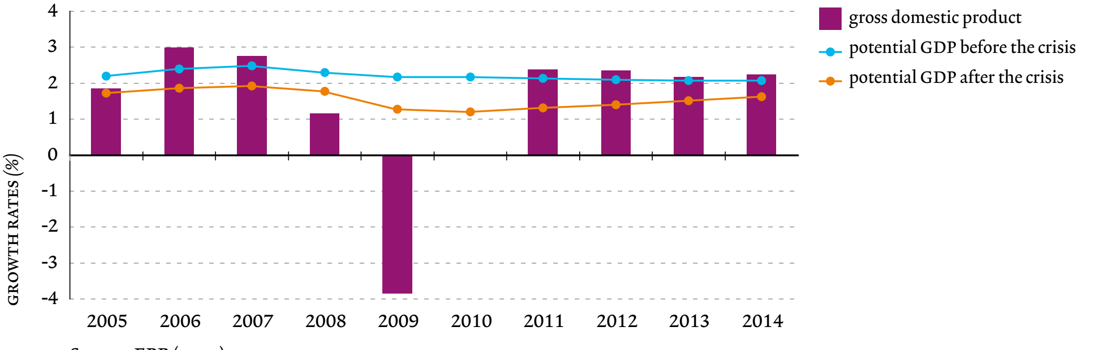
Due to the current uncertainty, the most recent future outlooks made by the FPB in mid-2009 for the Study Commission for ageing, calculate three long-term macro-economic scenarios. The long-term economic growth is slightly lower in the reference scenario than in the 2008 report, used for the Environment Outlook 2030. The difference in growth over the period between 2015 and 2030 is so minimal however that this scenario fits best with scenario 2 in FIGURE 2.6.

FIG. 2.6 *Three possible scenarios for the impact of the economic crisis on the potential GDP*



Source: FPB and MIRA on the basis of the EC (2009)

FIG. 2.7 *Estimate of the potential GDP before and after the economic crisis (Belgium, 2005-2014)*



Source: FPB (2009)

ENDNOTES

1 The medium-term is defined as a five-year horizon, long-term is limited here by the time horizon of the Environment Outlook and the Nature Outlook 2030.

2 This and further references to the EU are based on the 'EUROPOP2008 convergence scenario', the population forecasts published by Eurostat in August 2008, see Eurostat (2008) and Giannakouris (2008).

3 As this relates to price hypotheses at constant prices, the mutual exchange rate ratio EURO/USD does not matter. This remains constant at the 2005 level (1 EURO = 1.244 USD).

4 Projection generated by the MAC-module of the PLANET-model. For a full description of this projection. see Hertveldt *et al.* (2009). The PLANET-model itself is described in Desmet *et al.* (2008).

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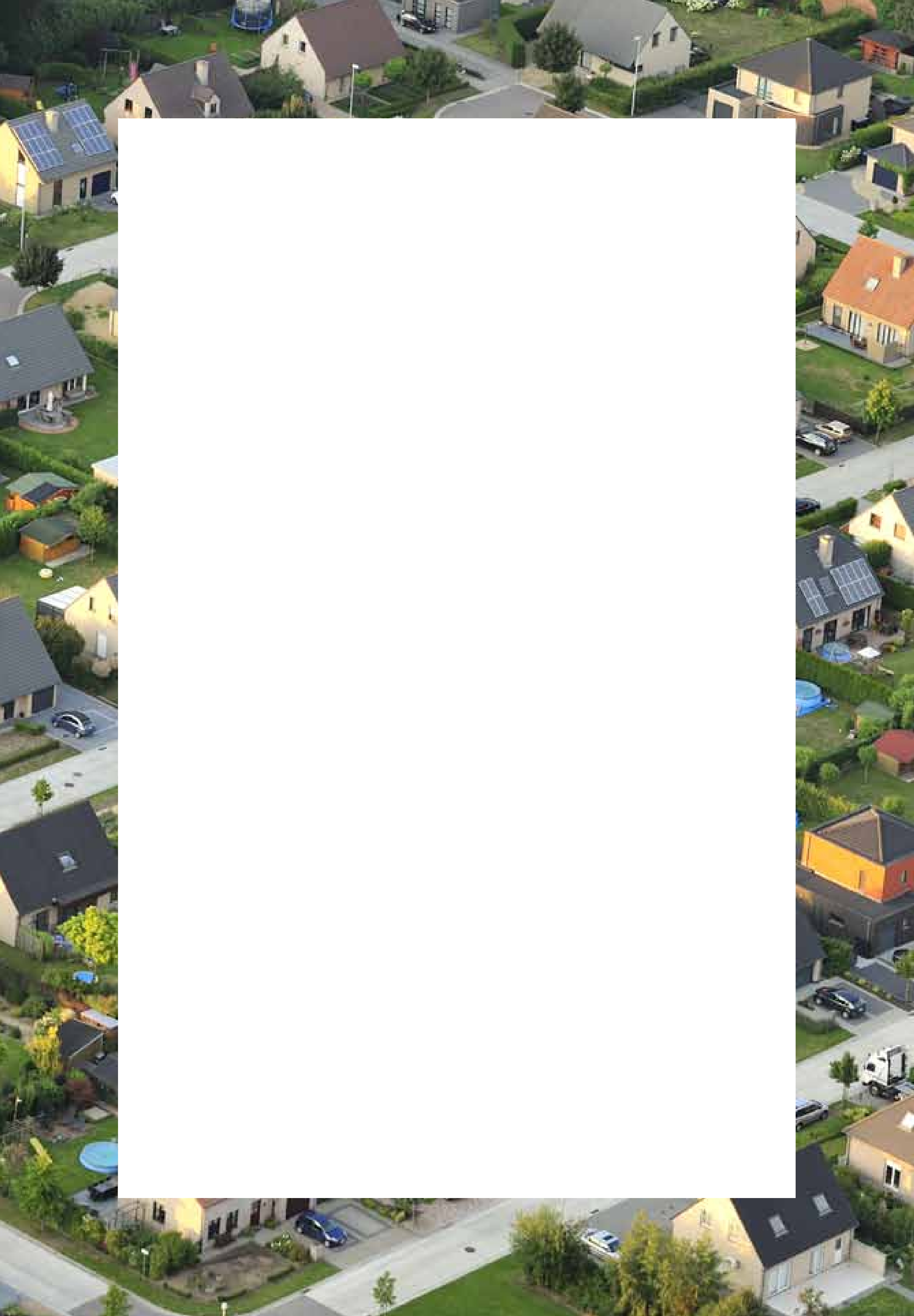

3 Households and trade & services

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OUTLINES

- The energetic quality of the houses in Flanders is low. Especially when it comes to space heating, the use of energy can be greatly reduced and the emissions limited. However, the continuation of the current policy in the reference scenario (REF) is insufficient to reduce energy consumption structurally.

- Achieving the European targets for 2020 for energy and climate in the Europe scenario (EUR) should not be a problem. Measures such as the insulation of roofs and windows, the replacement of old heating installations with more efficient models and stricter energy performance standards can decrease energy consumption sharply by 2020.

- The visionary scenario (VISI) aims to reduce greenhouse gas emissions by half by 2030, so as to stabilise climate change. Both the household sector and the trade & services sector can achieve this target. However, for this to happen, a fundamental change in the current method of living and working is necessary.

- Technological breakthroughs are needed to allow renewable energy to fulfil a major share of the energy requirement. In the VISI scenario the concept of 'living districts' promotes the use of solar heat, environmental heat and external heat supply.

- An essential condition to reduce energy consumption and emissions, in the shorter and longer term, is that adjustments are already made today. Processes such as technological innovation require many years. Furthermore, since buildings are used for a long time, many measures have a long-term effect.

Introduction

The use of space, water and energy, emissions, water pollution and production of waste in the household and trade & services sectors are all important causes of environmental pressure. The Environment Outlook 2030 investigates how the energy consumption and air emissions from the household and trade & services sectors develop between 2006 and 2030 under various policy scenarios. The Study Centre for Technology, Energy and Environment (Studiecentrum Technologie, Energie en Milieu - STEM) of the University of Antwerp has calculated a number of policy scenarios for the use of energy and the corresponding energetic emissions using the SAVER-LEAP energy accounting model. The non-energetic emissions were not included in this model however. The MIRA team has estimated these emissions on the basis of the best available information.

Part 1 of this chapter describes the SAVER-LEAP model and the starting points of the various scenarios for the use of energy and energetic emissions. Part 2 considers the evolution of the total use of energy and the shares of the various energy functions (space heating, lighting, etc.). This part also considers in greater detail how the energy mix develops: what is the share of fossil fuels and other energy carriers and how do households and the trade & services sector fulfil their own energy needs by means of renewable energy? Parts 3 and 4 describe the greenhouse gas emissions and the emissions of acidifying substances, ozone precursors and particulate matter. The figures show both the direct energetic and non-energetic emissions from households and the trade & services sector. Energetic emissions are the result of the burning of fossil fuels and/or biomass, almost exclusively for space heating and the production of domestic hot water. Non-energetic emissions include, for instance, emissions from septic tanks and emissions from fuelling stations. The main assumptions on the anticipated evolution of non-energetic emissions are also explained in this part. The MIRA team attributes indirect energetic emissions, such as emissions as a result of the production of electricity at gas, coal or oil plants to the energy sector. Part 5 briefly describes these emissions for households and the trade & services sector. Finally the conclusions for policy are considered in part 6.

3.1 Principles of the Environment Outlook

The SAVER-LEAP model

The SAVER-LEAP energy accounting model calculated the energy use and energetic emissions of households and the trade & services sector for the various policy scenarios. For the calculation of emissions, the model database contains a large number of predefined emission factors, per energy carrier and per application[1]. The model also takes a great number of detailed technical and behavioural measures into account for the calculations. Technical measures in the model include, for instance, better insulation or more economical heating installations. Behavioural measures relate to changes in behaviour. These changes are divided into investment or purchasing behaviour on the one hand (for instance consciously deciding in favour of an energy-neutral home or low energy household appliances) and energy use behaviour on the other hand (for instance lowering the thermostat one degree, low energy cooking, etc.).

When applying these measures, the philosophy of the Trias Energetica was explicitly taken into account. This is a strategy developed by the Technical University Delft to achieve the most sustainable energy supply possible in three stages:

1 Maximally reducing the energy demand, amongst others through optimal insulation and ventilation of the building, through the use of energy efficient appliances and low energy lighting, by avoiding the standby power use of electrical appliances, by switching off the light in unused rooms and lowering the thermostat one degree.
2 Optimal use of renewable energy sources, amongst others through the use of passive renewable energy such as solar heat or environmental heat, daylight and natural ventilation, by producing one's own energy on the basis of renewable energy sources (e.g. by means of solar boilers, photovoltaic panels (PV) and/or small-scale wind turbines) and by using compact energy storage, either locally, or by using systems connected to the grid or a 'living district'.
3 Using fossil energy sources as efficiently as possible for any remaining energy use, amongst others through technologies such as gas-powered heat pumps or micro-CHP.

The 'Scenarios and measures' section describes the extent to which the various scenarios apply these measures.

In the analysis of the scenarios, the following autonomous developments were taken into account:

- For all scenarios and for all years 1 714 degree-days is the standard, taking into account climate change and the clearly falling trend of the number of degree-days since 2003. The heating requirements in a year are expressed on the basis of the number of degree-days.
- The evolution of the gross floor areas forms the basis for estimating the evolution of the volume which needs to be heated. The gross floor area of trade & services increases between 2006 and 2030 by 25.5 % and for households by 24.3 %. For trade & services the evolution of the floor areas is based on the economic growth per subsector, translated in employment terms. For households this is linked to the demographic development and the composition of the households. They essentially define the number of homes required. MIRA assumes a low shift to smaller families, in which the number of families in Flanders evolves from approximately 2.5 million in 2006 to approximately 3.2 million by 2030. This is an increase by 27.7 %.

Scenarios and measures

The SAVER-LEAP model has calculated three scenarios for households and trade & services separately: the reference scenario (REF), the Europe scenario (EUR) and the visionary scenario (VISI). The reference year for the analysis of the scenarios is always 2006. The end year is 2030.

- The REF scenario departs from the current environmental policy, with the legislation and regulations already in force on April 1st 2008. Current voluntary agreements are also included in this.
- The EUR scenario applies the measures that make it possible to achieve the European mid-term objectives. For instance the objectives in the context of the European Climate and Energy package fall under this (which, amongst others, prescribes that renewable energy accounts for 20 % of the total energy use by 2020). Chapter 1 Policy scenarios explains this in more detail.
- The VISI scenario is the most ambitious scenario: it is formulated around the long-term target for climate change, as used in the Environment Outlook 2030. This target requires a reduction of greenhouse gas emissions of 60 to 80 % by 2050 compared to 1990 and by 50 % by 2030.

A variation of the REF scenario has also been calculated for households: the REF-MIN scenario. This scenario better follows previous, comparable studies as regards household energy consumption. Strictly speaking some of the assumptions of the REF scenario are based on matters that were not yet part of the official energy and climate policy in Flanders on April 1st 2008 (amongst others the 2020 Energy Renovation Programme and the European ban on filament light bulbs). In the REF-MIN scenario these assumptions are weakened. The REF scenario for households may consequently be considered an 'optimistic' implementation of the current policy, the REF-MIN scenario as a more 'pessimistic' approach.

For the analysis of energy use and energetic emissions, the various policy scenarios are based on different starting points concerning the expected demolition and new construction of buildings, energy saving measures and their penetration, the evolution of the energy mix and the self-generation of green power and heat. Each scenario includes different measures for 'new' buildings (new construction and structural alterations/renovation) and for 'existing' buildings. In this way the regulations concerning energy performance and indoor climate (EPIC) may be taken into account.

The REF scenario

In the REF scenario relatively few buildings are demolished each year. All buildings of 2006 that are still in use in 2030 have well insulated roofs and windows after a thorough renovation. Air-tightness and ventilation improve slightly. There is no increased need for mechanical cooling (e.g. air conditioning). For new construction, the current energy performance and indoor climate standards (EPIC standards) apply. All heating installations will have a very high efficiency by 2030 and will operate on natural gas in the first place. Cooking is almost exclusively on gas. By 2030 there is only efficient lighting (energy-efficient light bulbs or tube lamps). All electrical appliances comply with the current standards (energy label). People do not noticeably change their behaviour. The own production of green power with solar panels on roofs increases sharply compared to 2006, but less sharply than in the other scenarios. As a result the share in the total electricity consumption remains rather limited.

The REF-MIN scenario

The REF-MIN scenario for households retains the majority of the principles from the REF scenario but assumes that instead of 100 % only 10 % of the houses of 2006 that are not demolished by 2030 have been thoroughly renovated. A thorough renovation means better roof insulation and the installation of high performance glazing, more efficient heating and lighting. For buildings that are not thoroughly renovated the condition remains approximately equivalent to that of 2006. The mix of energy carriers is also adjusted in this scenario. The replacement of domestic fuel oil by natural gas is less pronounced. The shares of electricity (for heating) and biomass remain approximately at the same level as in 2006. LPG (propane and/or butane) and coal have not yet disappeared completely by 2030. Finally this scenario assumes that a small but significant proportion of the renovated homes will be equipped with air conditioning by 2030.

The EUR scenario

The EUR scenario assumes an accelerated demolition of old houses. The EPIC standards for new buildings become more rigorous. There is more attention for natural cooling – especially as regards trade & services. As regards heating and domestic hot water the proportion of solar heat (solar boilers) and environmental heat (heat pump boilers) increases, at the expense of fossil fuels. There is a slow start to cogeneration of heat and power (CHP) at a local level. The lighting is not only efficient by 2030 but – primarily in trade & services – an attempt will also be made to make optimal use of daylight. The population adapts its behaviour to a certain extent: for instance people will start to cook more energy efficiently, will use less hot water and limit the stand-by use of appliances. The generation of own green power increases more greatly than in the REF scenario, still primarily by means of solar panels and to a very limited extent with small wind turbines on roofs.

The VISI scenario

The starting principle in the VISI scenario is that intensive measures are required with a view to a sustainable future. The targets include a reduction of greenhouse gas emissions by 60 to 80 % by 2050, with a halving of those emissions by 2030 when compared to 1990, and the realisation of a low carbon economy. The target for energy use is to transform the built-up environment by 2050 into 'living districts', by which a certain area is provided per inhabitant for green spaces, housing, leisure, shopping, working ... 'Energy neutrality' is the aspiration for the living districts. Energy neutral means that as much energy is produced on an annual basis as is consumed.

Accelerated demolition and reconstruction of the building stock is required in the VISI scenario. On the one hand this requires great efforts from the building sector, but on the other hand this also creates opportunities for innovation and increased employment. The 'extremely low energy building' becomes the standard both for new construction and intensive renovation, with a large emphasis on thermal insulation and air-tightness and with as much recuperation of waste heat as possible (discharged ventilation air, hot wastewater). Adjoining and compact building together with sun-oriented building (sun land allotment) ensures the least possible loss of heat and as much solar benefit as possible. The optimal use of daylight and natural cooling go without saying here. The heating installations and the production of domestic hot water are based on renewable energy insofar as possible: solar heat, environmental heat and biomass. Local CHP, in particular bio-CHP, takes an important place in living districts. For washing machines and dishwashers the living districts increasingly use a shared local 'hot water network'. There is great technological progress as regards energy storage and intelligent appliances that are even slightly more energy efficient than the most energy efficient appliances today. The living districts are increasingly responsible for self-production of green power and green heat, through an intensive use of collective solar panels, solar boilers, local wind turbines and bio-CHP.

3.2 Energy use

Total energy use

Figures 3.1 and 3.2 illustrate the evolution of the total energy use respectively by households and trade & services.

The measures of the REF-MIN scenario for households are insufficient to reduce energy use. The REF scenario allows the energy use to fall by 15.5 % in 2030 when compared to 2006. At the end of the period the use of energy increases slightly because the implementation of technical and behavioural measures no longer compensates for the volume effect (the increasing number of families) in the long term.

The energy use falls in the EUR scenario by 43.4 % and in the VISI scenario by 62.1 %. For trade & services the REF scenario just fails to ensure a decrease in the use of energy by 2030 when compared to 2006. In the EUR scenario the energy consumption decreases by more than one fifth, in the VISI scenario the energy consumption even reduces by more than a third.

The innumerable possibilities offered by energy savings, especially in households, is primarily due to the low energetic quality of existing houses in Flanders. An improvement of, for instance, the level of insulation of roofs and windows and sealing cracks could consequently already have a large impact.)

FIG. 3.1 *Energy use by households in the REF-MIN, REF, EUR and VISI scenarios (Flanders, 2006-2030)*

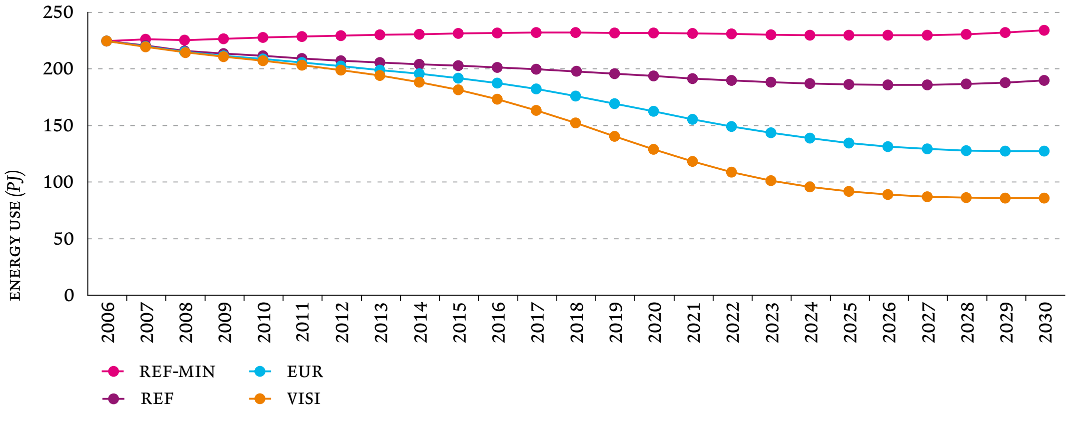
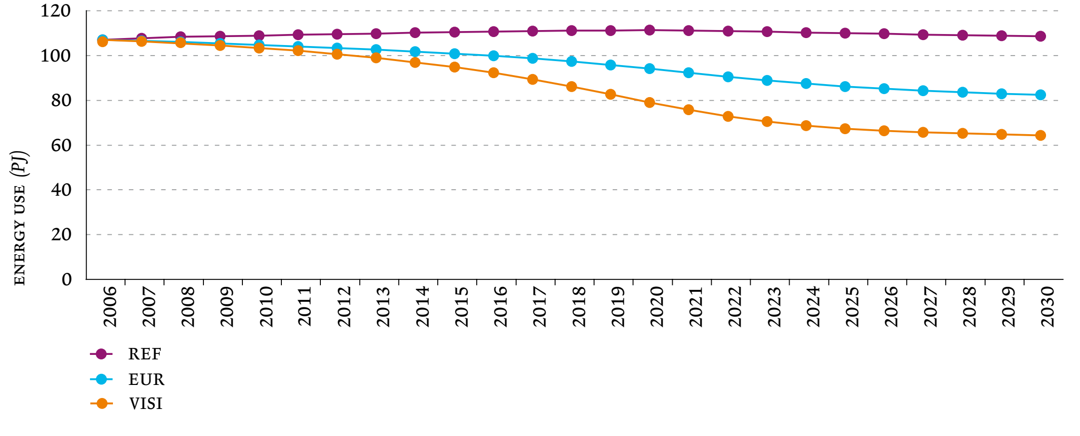


FIG. 3.2 *Energy use by trade & services in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



Shares of energy functions

FIGURES 3.3 and 3.4 illustrate how much energy is used in the households and trade & services sectors in 2006 and in 2030 for the various purposes (so-called energy functions). Space heating and cooling, auxiliary functions (electricity for pumps and ventilators, pilot lights), humidifying and lighting are building-related energy functions. For devices and domestic appliances there is a distinction between the production of domestic hot water (e.g. for bath and shower), cooking, large electronic appliances (office equipment for trade & services, multimedia equipment including PCs and printers in households), refrigeration or freezing of food and drink, and other appliances.

FIG. 3.3 *Share of energy functions in households in the REF-MIN, REF, EUR and VISI scenarios (Flanders, 2006 and 2030)*

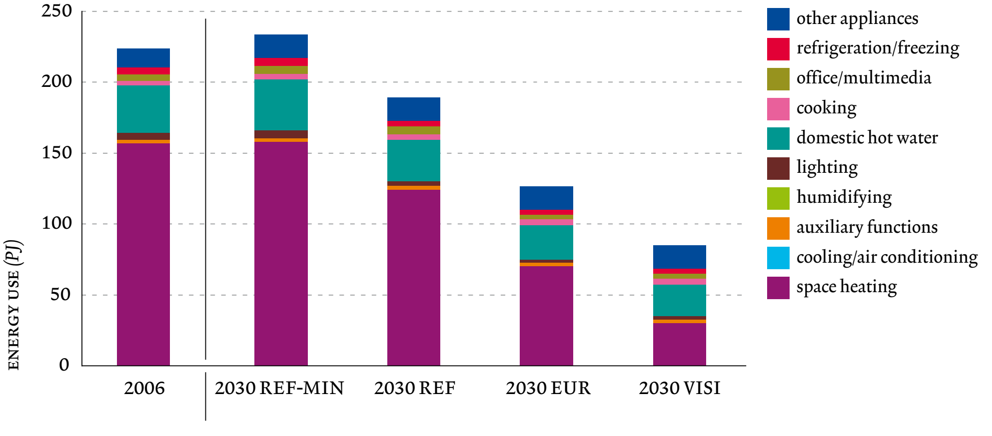
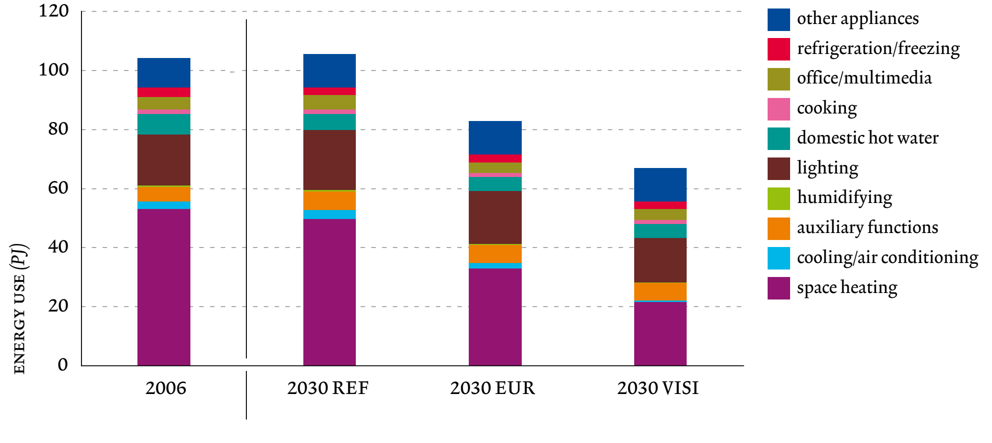


FIG. 3.4 *Share of energy functions in trade & services in the REF, EUR and VISI scenarios (Flanders, 2006 and 2030)*



In 2006 space heating takes the lion's share of the energy, both in the households (70 % of the energy demand) and in trade & services (50 %). The production of domestic hot water is mainly important in household energy consumption (15 % of the total, compared to 7 % in trade & services). A significant proportion of the energy consumption in trade & services is on lighting (17 %), for households this is only 2 %.

Both in the EUR scenario and the VISI scenario the share of space heating falls sharply for both sectors. This is not surprising: the largest savings are after all in the field of space heating. Consequently, although the energy consumption for the production of domestic hot water drops, its relative importance increases. In the VISI scenario the demand for heat for domestic hot water for households is even approximately the same as the demand for space heating[2]. The shifts are less pronounced for other energy functions. Although there are large to very large decreases in electricity consumption for lighting and almost all appliances, their share in the total use of energy increases, precisely because the drop for space heating is so great. The use of electricity for auxiliary functions increases despite the use of more energy efficient pumps and ventilators. This is primarily the result of the increase in mechanical ventilation. A major unknown is 'other appliances': these are appliances other than those used for refrigeration/freezing, multimedia and office equipment. Appliances that have hardly any or no market share today may define the electricity consumption to a great extent in the future. This chapter lets this use develop along with the number of houses or buildings, so that the relative importance of this category increases in the future.

It is striking that the energy consumption for space heating, for the production of domestic hot water and for lighting increases in the REF-MIN scenario, whereas there is a sharp decrease for all these functions in the REF scenario. This is logical: the REF scenario starts from the assumption that all roofs are insulated, that single or double glazing is replaced by high performance glazing, that condensing boilers replace all old and inefficient heating installations and that filament bulbs have to make way for low energy bulbs. The REF-MIN scenario on the other hand assumes that these measures remain relatively limited.

The energy mix

In addition to the use of energy, the energy mix – which is the share of the various energy carriers – also plays an important role in the evolution of energetic emissions of households and trade & services.

FIGURES 3.5 and 3.6 illustrate the energy mix in 2006 and 2030 respectively for households and trade & services. The share of fossil fuels – natural gas, domestic fuel oil ('light fuel oil' or 'heating oil') and other fossil fuels (coal, LPG and 'heavy' fuel oil) – are shown at the bottom of the bars. Biomass relates to the use of wood or wood pellets in fireplaces, boilers and heaters. Electricity is divided into 'own generation', 'external CHP' and 'external non-CHP'. 'Own generation' relates to the share of the electricity needs that the households and trade & services fulfil themselves through the generation of green power via solar panels (PV), micro wind turbines and micro-CHP via Stirling motors. For the remaining electricity, households and trade & services depend on external supplies originating from local cogeneration of heat and power ('external CHP') or from centralised electricity generation such as nuclear or coal power stations ('external non-CHP'). At the top of the bars, the figures show the extent to which heat is used as an energy carrier for heating spaces and for the production of domestic hot water. Households and trade & services are themselves responsible for a part of their heat requirements ('self-generation'), by means of solar boilers (solar heat) and heat pumps (environmental heat). The remaining heat originates from local cogeneration of heat and power ('external CHP').

FIG. 3.5 *Energy mix in households in the REF-MIN, REF, EUR and VISI scenarios (Flanders, 2006 and 2030)*

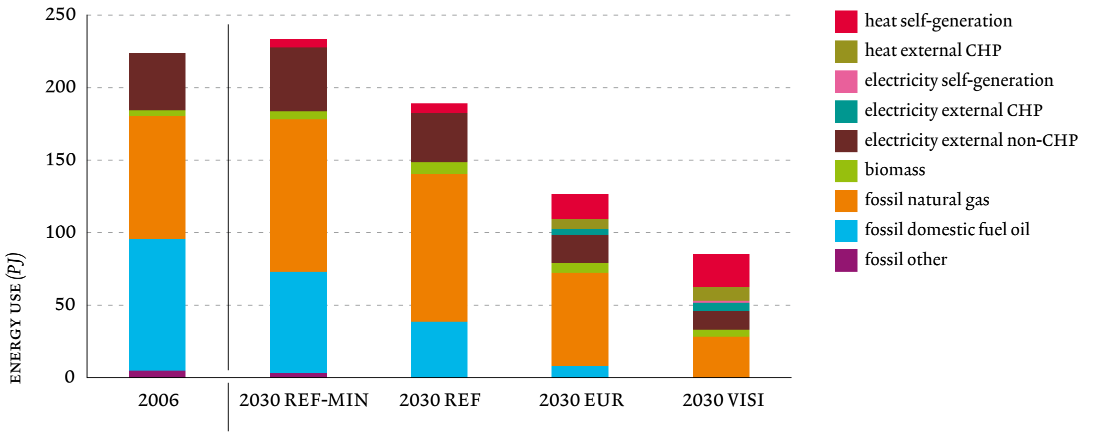
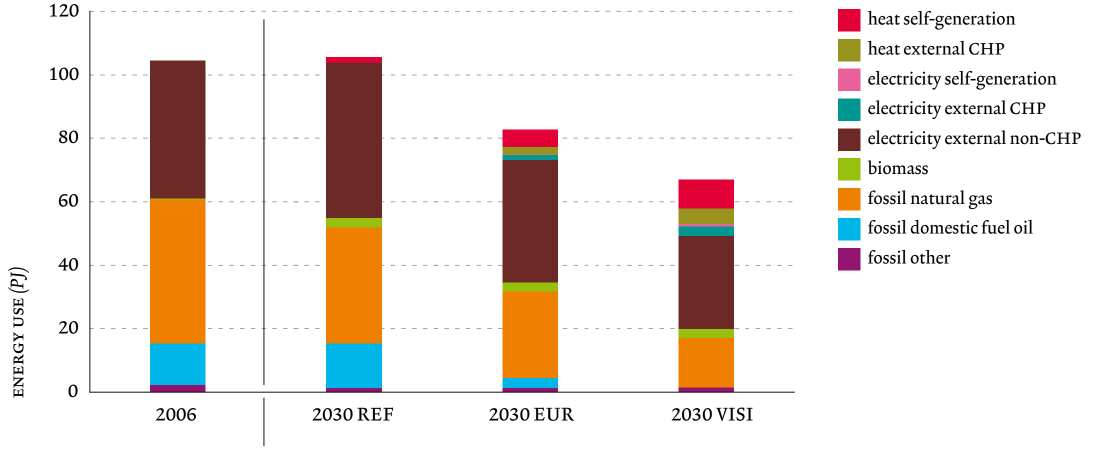


FIG. 3.6 *Energy mix in trade & services in the REF, EUR and VISI scenarios (Flanders, 2006 and 2030)*



Energy mix in 2006

The energy mix differs for households and trade & services. Both for households and for trade & services the use of fossil fuels supplies a very large proportion of the energy requirements in 2006. The shares of domestic fuel oil and natural gas are approximately the same in the households (40.6 % and 37.8 % of the total energy consumption). Natural gas is the dominant fuel for trade & services with a 44 % share: this sector uses domestic fuel oil to a much lesser extent than households. Domestic fuel oil is only 12.7 % of the total energy consumption in trade & services. The households still use a small, but not negligible amount of coal. Heavy, sulphur-rich fuel oil only occurs in trade & services. Both trade & services and households still make little use of LPG. The proportion of electricity is noticeably larger in trade & services (almost half) than in households (about one fifth). This is because the lighting and a large number of appliances amongst others in offices, shops, schools and hospitals run all day long (and are sometimes also left on all night). In addition there is more need for cooling of spaces and mechanical ventilation (air conditioning) than in households. Biomass (primarily wood or wood pellets) has a small share in households and is mainly used in stoves or open fireplaces. With trade & services the use of biomass is extremely limited. The contribution of CHP, self-generated green power, solar and environmental heat is negligible in 2006 for both sectors.

Evolution of the energy mix

There are major shifts in the energy mix particularly in the EUR scenario and the VISI scenario both for households and trade & services.

The use of fossil fuels remains about the same in the REF-MIN scenario for households but experiences a drop in all other scenarios in 2030 compared to 2006. In the VISI scenario the use of fossil fuels only amounts to a third in 2030 compared to 2006 in the household sector. It then exclusively comprises natural gas. With trade & services the share of fossil fuels in the end use decreases to slightly more than a third (in the EUR scenario) or slightly less than a quarter (in the VISI scenario). Coal and petroleum products such as oil and LPG have almost disappeared in the EUR scenario and have disappeared completely in the VISI scenario.

The use of biomass (wood or wood pellets) increases in all scenarios, both for households and trade & services. The REF scenario always experiences the greatest increase in absolute terms. The share of biomass in the total energy use remains limited however.

The consumption of electricity in households increases relatively sharply in the REF-MIN scenario. This scenario assumes that electric heating does not disappear entirely, that there is an increase in air conditioning, that inefficient household appliances are replaced more slowly (or are used as a second appliance, such as a refrigerator or freezer in the cellar or garage), and that low energy light bulbs do not completely replace filament bulbs.

The electricity consumption also increases sharply for trade & services in the REF scenario. In the other scenarios the use of electricity decreases. This type of energy does continue to be important as regards percentage in the EUR and VISI scenarios for trade & services. The share in the total use of energy even increases slightly: even low energy buildings need electricity, amongst others for low energy pumps, ventilators, lighting and appliances. In that sense there can be said to be a very limited 'electrification'.

Renewable energy

A part of the demand for electricity is realised both in households and in trade & services by green power from local cogeneration (CHP at a local estate level) and solar panels (PV), and to a lesser extent micro wind turbines and micro-CHP. For trade & services green power – especially in the VISI scenario – originates primarily from local CHP on the basis of biomass. Despite their increasing importance all these techniques even in the VISI scenario only provide 12 % of the electricity requirements for trade & services. Technological breakthroughs are required (amongst others in the field of energy storage and distribution) to ensure that the trade & services sector becomes much more self-sufficient in the period between 2030 and 2050. The halving of the electricity consumption in the household sector in the VISI scenario, combined with the sharp increase in the generation of (self or local) green power, ensure that households in 2030 will cover more than a third of their own electricity requirements. The target of 100 % energy neutrality in built-up areas by 2050 is thereby within reach, although technological innovations should ensure that this accelerates even further. Due to the relatively large amount of suitably positioned roof (and wall) area in Flanders there is a sharp increase in photovoltaic panels (PV). In the VISI scenario this is further enhanced by the systematic sun-oriented construction in living districts. However, as with trade & services, green power predominately originates from local CHP.

The big success stories in the VISI scenario are solar heat, environmental heat and external heat supply (local CHP). This is thanks to a large extent to the concept of 'living districts', in which (small-scale) heat distribution networks and solar allotments almost go without saying. For households solar heat and environmental heat together provide a quarter of the energy requirements and local CHP another 11 %. For trade & services solar heat and environmental heat together realise a share of 14 % and local CHP 7.5 %.

3.3 Greenhouse gas emissions

Figures 3.7 and 3.8 illustrate the evolution of greenhouse gas emissions (the sum of the emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and hydrofluorocarbon (HFCS) into the air) for households and trade & services.

FIG. 3.7 *Greenhouse gas emissions by households in the REF-MIN, REF, EUR and VISI scenarios (Flanders, 2006-2030)*

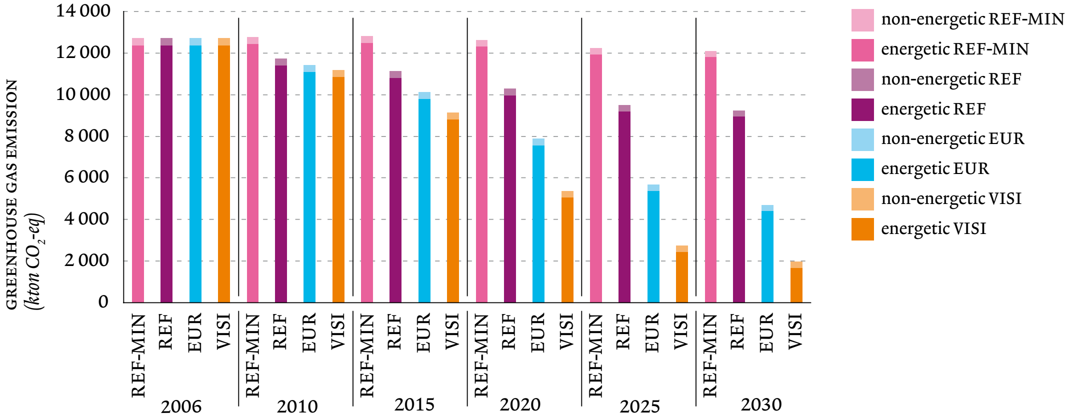
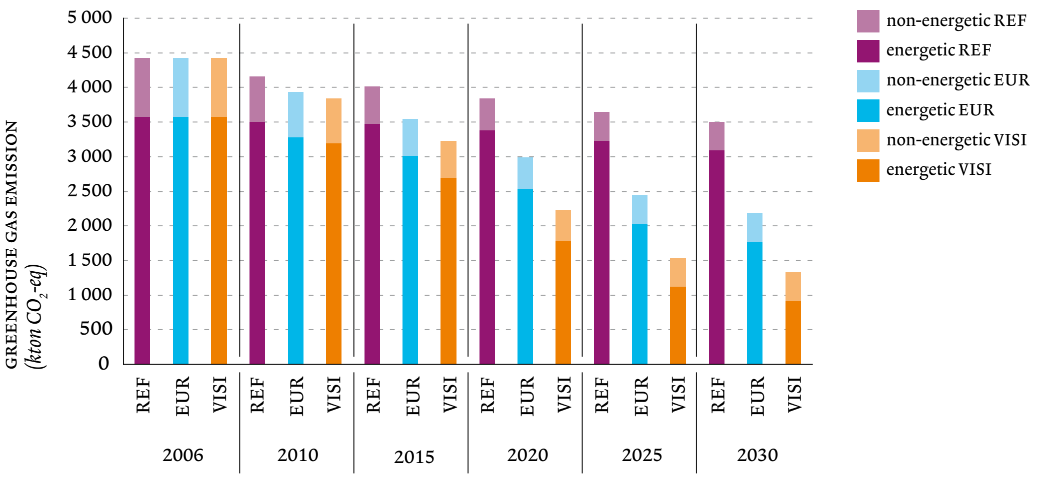


FIG. 3.8 *Greenhouse gas emissions by trade & services in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



Both for households and trade & services the evolution of the energetic emissions of greenhouse gases is almost exclusively the result of the evolution of the CO_2 emissions; the shares of CH_4 and N_2O are negligible. The decreasing energy consumption and the changing energy mix (the gradual reduction or even disappearance of coal, domestic fuel oil and heavy fuel oil to the benefit of natural gas and/or biomass) result in striking drops of the emissions in both sectors in the EUR scenario and the VISI scenario. For households there is a drop of 64 % and 86 % respectively in the EUR and VISI scenarios. For trade & services the drop in 2030 compared to 2006 is less sharp: 50 % in the EUR scenario, 74 % in the VISI scenario. The implementation of technical and behavioural measures for households in the REF-MIN scenario is just enough to decrease the greenhouse gas emissions (-5 %). In the REF scenario the greenhouse gas emissions for households fall much more sharply, by 27.8 %. For trade & services there is a decrease by 13.4 % in the REF scenario.

In the context of the European Climate and Energy Package, Belgium was given a reduction target of 15 % in 2020 compared to 2005 for the sectors that do not fall under the European emissions trading system (ETS) (households and the majority of trade & services, agriculture and transport). This target has not yet been divided according to regions or individual sectors. This report provisionally takes -15 % as the indicative target for 2020 as a target for the household and trade & services sectors. This comes down to 10 531 ktonnes CO_2-eq for households and 3 038 ktonnes CO_2-eq for trade & services. This indicative target is reached in the REF scenario for households[3], and in the EUR scenario for trade & services. Thanks to the very far-reaching measures in the VISI scenario both sectors are also able to reach the targets required to stabilise climate change: a reduction of greenhouse gas emissions by 60 % to 80 % in 2050 compared to 1990, or a 50 % decrease in 2030 compared to 1990.

The non-energetic emissions of greenhouse gases for households primarily comprise CH_4 and N_2O originating from household wastewater and septic tanks. All scenarios assume a decrease of non-energetic emissions in the period between 2006 and 2030: this is the result of the assumption that the zoning plans for wastewater purification are executed completely. These plans stipulate that 97 % of the inhabitants of Flanders will be connected to sewage stations (SSS) by 2027. Other households purify their wastewater themselves with an individual treatment plant for wastewater (ITP).

The main non-energetic emissions of greenhouse gases in trade & services are CH_4 emissions due to composting and dumping waste, and N_2O emissions from medical applications. All scenarios assume that the CH_4 emissions from landfill sites decrease sharply by 2030. This is due to the restriction of the amount of waste dumped and the removal of biodegradable waste from the dumps (amongst others due to intensive selective collection). Due to a lack of information on the expected evolution of N_2O emissions from medical applications these were kept constant at the 2006 level for all scenarios.

3.4 Emissions of acidifying substances, ozone precursors and particulate matter

Emissions of acidifying substances

FIGURES 3.9 and 3.10 illustrate the evolution of acidifying emissions (the sum of the emission of sulphur oxide (SO_x), nitrogen oxides (NO_x) and ammonia (NH_3) into the air) from households and trade & services.

FIG. 3.9 *Acidifying emissions by households in the REF-MIN, REF, EUR and VISI scenarios (Flanders, 2006-2030)*

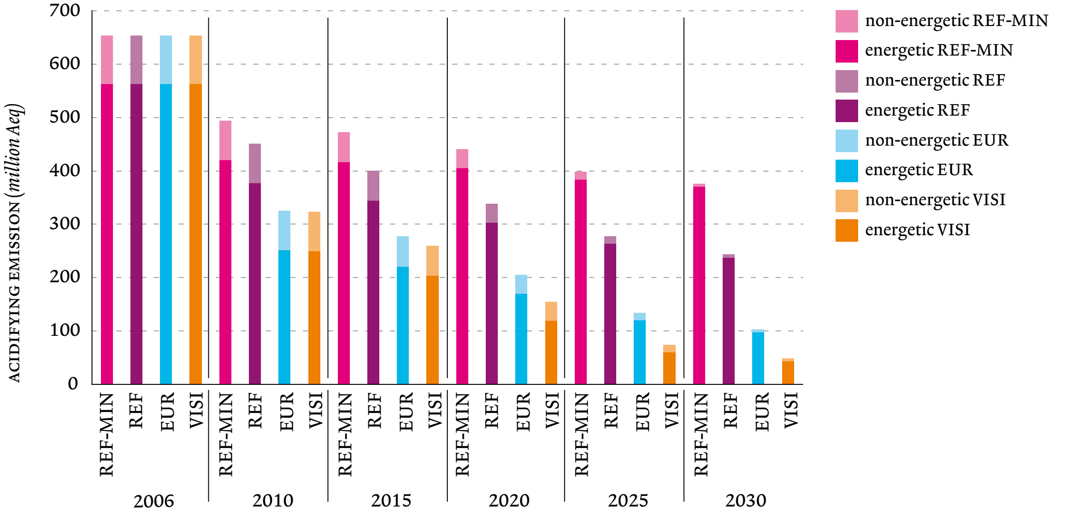
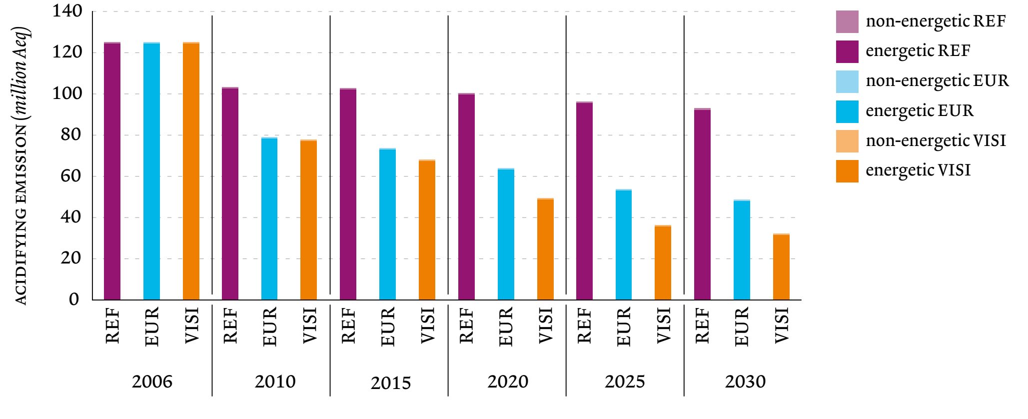


FIG. 3.10 *Acidifying emissions by trade & services in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



Both in households and trade & services the energetic emissions of acidifying substances comprise almost exclusively NO_x and SO_x. In both sectors there is a (very) sharp decrease of the emissions in all scenarios (up to -92 % in the VISI scenario for households and -75 % for trade & services). The sharp drops between 2006 and 2010 are the result of the decrease of the sulphur content of domestic fuel oil to 1 000 ppm (in the REF-MIN and the REF scenarios) or to 10 ppm (in the EUR and VISI scenarios). The decreases to 2030 may further be explained by the decreased energy consumption but also, and primarily, because highly polluting fuels like domestic fuel oil, heavy fuel oil and coal will have been (completely) replaced by 2030 by natural gas or renewable energy sources. This is true both for the EUR scenario and the VISI scenario. The differences between REF-MIN and REF for households are primarily due to the longer retention of older installations, in addition to increased energy consumption. This is because the type of fuel not only affects nitrogen oxide emissions but the incineration process itself also plays an important role. The replacement of old boilers and heaters by newer and more efficient models has a major impact on NO_x emissions.

The non-energetic emissions of acidifying substances from households are NH_3 emissions from septic tanks. All scenarios assume that these emissions fall sharply in the period between 2006 and 2030 because the number of septic tanks will decrease sharply with the full execution of the zoning plans for wastewater purification by 2027.

For trade & services the non-energetic emissions of acidifying substances are almost negligible (0.7 million Aeq); these are emissions of NO_x and SO_x from individual companies. Due to a lack of information concerning the expected evolution of these emissions these have been kept constant at the 2006 level for all scenarios.

Emissions of ozone precursors

FIGURES 3.11 and 3.12 illustrate the evolution of the emissions of ozone precursors (the sum of the emissions of nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO) and methane (CH_4) into the air) for households and trade & services.

For trade & services, the evolution of the energetic emissions of ozone precursors depends predominately on the emissions of NO_x and NMVOC. The CO and CH_4 share is relatively small. For households the evolution primarily depends on the emissions of NO_x, NMVOC and CO; here the CH_4 share is also very small. There is a slight increase in the emissions of ozone precursors in the REF-MIN scenario for households by 0.7 %. In the REF scenario the emissions increase by 5 % for trade & services. In all other scenarios the emissions fall. The differences between the REF-MIN (+0.7 %) and the REF scenario (-15.7 %) for households are, in the same way as the acidifying emissions, primarily due to the longer retention of older installations and the increased energy consumption in the REF-MIN scenario.

FIG. 3.11 *Emissions of ozone precursors by households in the REF-MIN, REF, EUR and VISI scenarios (Flanders, 2006-2030)*

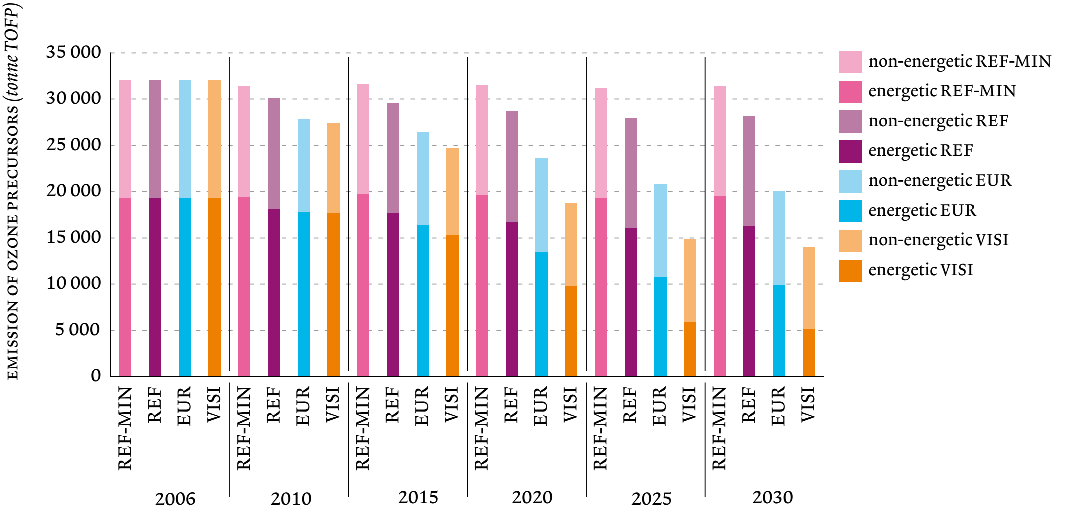
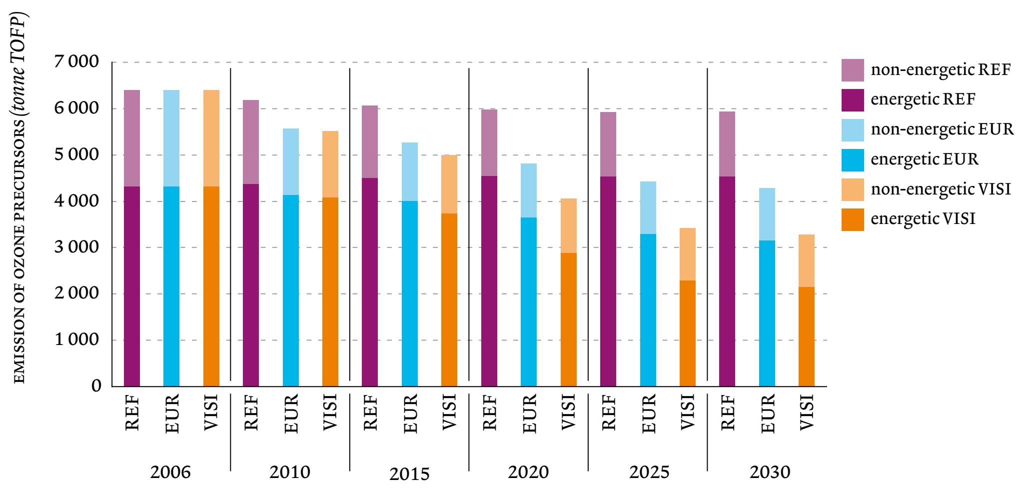


FIG. 3.12 *Emissions of ozone precursors by trade & services in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



It is noticeable that the energetic emissions of NMVOC for trade & services increase relatively sharply in *all* scenarios. This is primarily the result of the increased use of biomass (wood). There is also an increase of the NMVOC emissions for households in both the REF-MIN and the REF scenarios. This relative increase is more pronounced in the trade & services sector because households already burn a fair amount of wood in 2006 by comparison.

The non-energetic emissions of ozone precursors from households primarily consist of NMVOC emissions as a result of the use of paint and household products.

All scenarios assume that these emissions decrease thanks to the switch to paints with a low solvent content, water-based paints and natural paints.

The non-energetic emissions of ozone precursors for trade & services also primarily consist of NMVOC emissions. Fuelling stations cause more than half of these emissions. The remaining NMVOC emissions from trade & services originate from activities related to the petroleum sector and dry cleaning. All scenarios assume that the NMVOC emissions from fuelling stations will decrease in the period between 2006 and 2030. They assume that all fuelling stations will take measures from 2010 onwards to reduce the VOC emissions as a result of the storage and distribution of petrol (in execution of the European Union Directive in this regard).

Emissions of particulate matter

Figures 3.13 and 3.14 illustrate the evolution of the emissions of fine particles in households and trade & services. The figures always only show PM2.5 (the fraction of particle matter with an aerodynamic diameter below 2.5 µm). Of PM10, PM2.5 and total fine particles, these are the finest particles and the most damaging to health. The evolution of PM10 and total particles is each time almost parallel with that of PM2.5.

The energetic emissions of particulate matter (PM2.5) increase in all scenarios for trade & services. In the REF scenario the emissions increase by 110 %, in the EUR scenario by 40 % and in the VISI scenario by 10 % in 2030 compared to 2006. The emissions of particulate matter are strongly related to the composition of the energy mix. The particle emissions from natural gas are significantly lower than those from domestic fuel oil, heavy fuel oil and coal. The particle emissions from the combustion of wood (pellets), which depends, amongst others, on the combustion technology used and the quality of the wood, are however many times greater than those of natural gas and non-combustible forms of renewable energy such as wind and solar energy and environmental heat. This is even the case if account is taken of modern, efficient combustion techniques. The assumed sharp increase in the use of wood pellet boilers by 2030 compared to 2006 consequently explains the increase in the emissions of particulate matter for trade & services. In this sector the use of wood is still marginal in 2006[4]. The emissions of particulate matter are less pronounced in the EUR scenario compared to the REF scenario because a larger share of environmental heat in the EUR scenario partially compensates for the anticipated sharp rise in the proportion of wood pellet boilers in the REF scenario.

There is also an increase in particle emissions for households in the REF-MIN scenario by 8 % and in the REF scenario by 19 %. The main cause for this increase is also the increase in the combustion of wood (pellets) (in fireplaces, boilers or heaters). The emissions of particulate matter decrease in the EUR scenario and the VISI scenario for households respectively by 12 and 40 %. The development in the VISI scenario differs from that of trade & services. This is due on the one hand because families already employ a fair amount of wood combustion in 2006; on the other hand

FIG. 3.13 *Emissions of particulate matter PM2.5 by households in the REF-MIN, REF, EUR and VISI scenarios (Flanders, 2006-2030)*

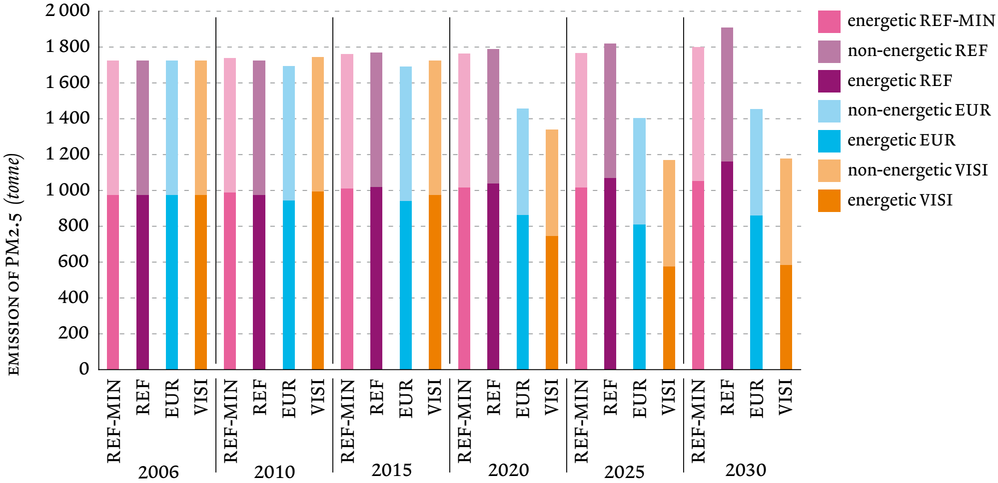
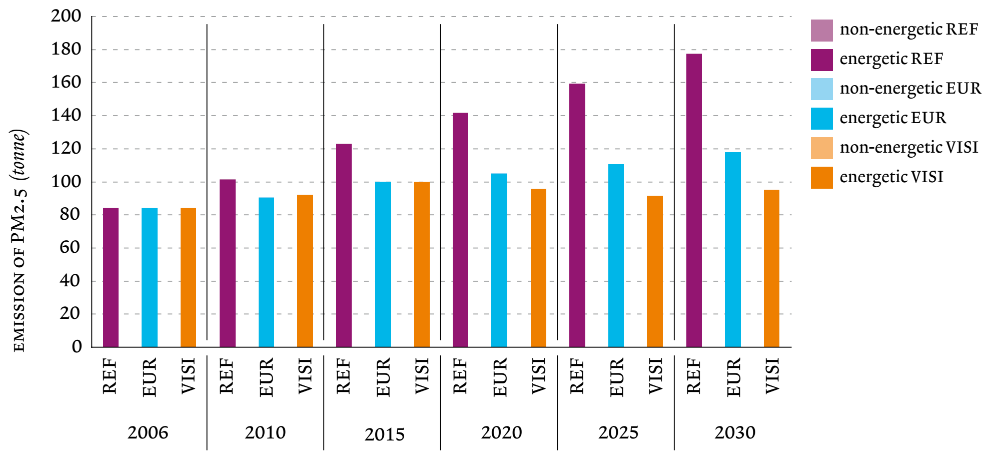


FIG. 3.14 *Emissions of particulate matter PM2.5 by trade & services in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



the combustion shifts from highly inefficient wood boilers or even open fireplaces to more efficient forms of wood combustion, such as wood pellet boilers or heaters and possibly built-in elements instead of fireplaces for the sake of cosiness. As with trade & services the VISI scenario assumes a slower increase of the wood combustion compared to the previous scenarios to the benefit of solar heat, environmental heat and heat supplied by third parties (CHP).

Households cause non-energetic emissions of particulate matter amongst others through waste incineration in open barrels and bonfires (illegal since 1981), barbecues and smoking tobacco. Little is known of the expected evolution of these emissions. All the scenarios (with the exception of the VISI scenario) keep the emissions constant for all years at the 2006 level. In the VISI scenario, which assumes 100 % compliance with the prohibition of the incineration of waste in barrels and on bonfires from 2020, the particle emissions fall.

The non-energetic emissions of particulate matter by trade & services, namely incineration emissions from crematoria, are almost negligible (0.1 tonnes). Due to the lack of information regarding the anticipated evolution of these emissions this figure was kept constant in all scenarios at the 2006 level.

3.5 Indirect emissions through energy use

The household and trade & services sectors not only cause direct energetic emissions from residential and commercial buildings as a result of their energy consumption. They are also responsible for a considerable level of indirect energetic emissions. These are emissions resulting from the production of electricity through the burning of fossil fuels and/or biomass at gas, coal or oil power stations. MIRA attributes these emissions to the energy sector but they are, in fact, also linked to the electricity consumption of households and trade & services. In this way they contribute to the general environmental pressure from these sectors.

Indirect emissions through the production of electricity in 2006 were considerable both for households and trade & services. That is the case for all pollutants (greenhouse gases, acidifying substances, ozone precursors and particulate matter). For trade & services, where electricity is responsible for a large share of the total energy use (as shown in FIGURE 3.6), these indirect emissions are even higher than the direct energetic emissions caused (primarily) as a result of the heating of buildings and the production of domestic hot water.

The development of the emissions through the production of electricity are influenced on the one hand by the net electricity requirement of households and trade & services, and on the other hand by the fuel mix (shares of the various fossil fuels) and the efficiency of the electricity production, transmission and distribution in Flanders. The greenhouse gas and particle emissions linked to the production of electricity increase sharply in the REF scenario for trade & services and in the REF-MIN scenario for households. This is because the electricity consumption rises and because both scenarios assume that the emissions of greenhouse gases and particulate matter are higher per PJ of electricity consumption in 2030 than in 2006. That is the result of the choices concerning technologies introduced in Flanders to produce electricity (see Chapter 7 Energy production). In the VISI scenario the indirect emissions of all polluting substances fall sharply, both in households and in trade & services. This fall is partially attributable to the decrease in the use of electricity but is primarily due to the breakthrough of green power (both self-generated and externally supplied green power).

3.6 Conclusions for policy

Both for households and trade & services the energy use in 2006 was far from optimal. The causes are many: often older buildings with insufficient insulation, hardly any attention to controlled ventilation, inefficient, old and poorly maintained installations for space heating and for the production of domestic hot water, energy inefficient lighting and careless use of a large number of electric appliances and equipment. A large proportion of this energy requirement is met through the use of polluting fossil fuels. The use of electricity also indirectly results in high emissions. The use of solar energy and environmental heat for space heating or cooling or for the production of domestic hot water is still in its infancy, as is the self-generation of green power through solar panels or small wind turbines and the well-thought out use of natural ventilation and daylight optimisation.

There is clearly large potential both in the trade & services sector and in the households to reduce emissions. This is possible through a maximal reduction in the energy demand, through an optimal use of renewable energy and through technologies that use fossil sources of energy as efficiently as possible. The best results for a maximum reduction of the final energy demand may be achieved in the field of space heating.

The future evolution with an unchanged policy is not rosy. The number of buildings increases, amongst others, as a result of the shift to smaller families and the growth of the service sectors. The existing building stock is renewed extremely slowly and there are still too few stimuli for intensive changes in behaviour (both energy use behaviour and investment or purchasing behaviour). The current energy performance standards are not adequate to realise a significant decrease in energy consumption by 2030. Both energy consumption and polluting emissions will consequently rise slightly or decrease insufficiently by 2030.

The good news is that a number of relatively simple measures[5] for the existing stock of houses may result in a noticeable drop in energy consumption. The insulation of all roofs and of easily accessible floors, the insulation of façades insofar as permissible in town planning, the replacement of single and ordinary double glazing with high performance glazing and the replacement of old boilers with modern boilers ensure that the European targets are feasible by 2020, and may even be exceeded. The gradual tightening of the energy performance standards for new construction and the introduction of energy performance certificates (EPC) with the related obligation to impose a minimum performance on existing residences, ensures an additional decrease.

Changes in the energy mix have a great impact on emissions. The gradual reduction of coal, domestic fuel oil and heavy fuel oil to the benefit of natural gas and/or biomass results in a decrease of the greenhouse gas emissions and acidifying emissions. However the use of wood as a biofuel causes higher emissions of ozone precursors and particulate matter in comparison with natural gas or renewable sources such as wind and solar energy. Consequently it is essential to question under what conditions wood pellets can constitute a sustainable form of energy consumption.

Technological innovations, amongst others in the field of energy storage and distribution, are required to let renewable energy (green power from solar panels and micro-wind turbines, solar and environmental heat, and electricity and heat from local bio-CHP) meet the energy requirements. In the VISI scenario the concept of 'living districts', in which (small-scale) heat distribution networks and sun land allotments almost go without saying, supports the application of solar heat, environmental heat and external heat supply. By systematically building oriented to the sun, the collective potential of solar boilers and solar panels (PV) is used optimally.

In the long term (by 2050) a drastic decrease of energy consumption and emissions is crucial. For that reason there is a need for a 'transition' (see Chapter 14 Flanders in transition?). There is not only a need for technological innovation (assisted by support for research and development), but the entire living system must also be changed structurally. These are very gradual processes. Furthermore the measures taken now will last for many years because buildings have a long life span. For that reason it is crucial that the 'adjustment' already starts now.

ENDNOTES

1 Due to a number of uncertainties regarding the technological developments of combustion techniques a number of emission factors (NO_x, CO and particulate matter from heating installations and wood pellet boilers and heaters) have probably been estimated too high, which means that these emissions may be on the high side by 2030. In the current version of SAVER-LEAP the majority of recent product standardisations for heating installations have also not yet been included.

2 The relative share of domestic hot water is less pronounced if a further far-reaching recuperation of energy from used domestic hot water is assumed.

3 The starting point is the full implementation of the Energy Renovation Programme 2020 (insulation of all roofs and windows, replacement of all old, inefficient heating installations by modern, more efficient models) and the replacement of all filament light bulbs with low energy or tube lighting.

4 The replacement of old, existing wood pellet boilers and heaters by modern boilers and heaters may naturally result in lower (particle) emissions. A significant increase in wood burning, in which not only existing wood pellet boilers and heaters but also other heating installations (such as fuel oil boilers) are replaced, will however inevitably result in more (particle) emissions.

5 Technical measures such as roof insulation or replacing glazing are 'relatively simple' both from a technical and financial standpoint – financial in the sense that the return on investment is relatively large. This means that a lot of energy may be saved with a relatively small investment and that the costs for energy consumption will consequently also fall.

LIKE TO KNOW MORE?

If you would like to know more, you can refer to the scientific report which forms the basis for this chapter:

Couder J., Verbruggen A. & Maene S. (2009) Huishoudens en handel & diensten. Scientific report, MIRA 2009, VMM, www.milieurapport.be.

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4 Industry

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OUTLINES

- Between 2006 and 2030 the industrial activity in Flanders will grow by 43 %. This will result in an increase in industrial energy consumption by 32 % both in the reference scenario (REF) based on the current energy and climate policy and in a Europe scenario (EUR) that strives for a reduction in greenhouse gas emissions of 21 % between 2005 and 2020 for all industrial installations in the EU27.

- The visionary scenario (VISI) aims at halving the Flemish greenhouse gas emissions by 2030 in relation to 1990. In this scenario the increase in industrial energy consumption is limited to 11 % between 2006 and 2030. This increase is lower than in the REF and EUR scenarios, not so much due to additional energy measures but under the influence of a weaker industrial growth with higher CO_2 prices.

- In the REF and EUR scenarios the industrial greenhouse gas emissions in Flanders increases by approximately 30 % between 2006 and 2030. In the VISI scenario, industry succeeds in allowing the greenhouse gas emissions to fluctuate around the 2006 level by 2020, amongst others under the influence of a higher CO_2 price. Thereafter there is an increase again (+12 % in 2030 compared to 2006) influenced by economic growth.

- A policy that is solely aimed at energy and climate measures is inadequate to reduce the emissions of acidifying pollutants and ozone precursors to under the level of the emission ceilings for 2020 that are to be expected at the revision of the European NEC directive. Measures specifically for emission reduction of these pollutants remain a necessity. A number of these are already set down in the current environmental policy.

- The emissions of particulate matter rise sharply after 2015. The increase is the greatest in the most damaging fraction: namely PM2.5. Even in the VISI scenario the PM2.5 emissions still increase by 23 % between 2006 and 2030 due to economic growth, the phasing out of some CHP and the fuel switch. Specific measures are required to bring this particulate matter emission under control.

Introduction

The activities of the industry sector are very diverse. This relates to the production of raw products, semi-finished products and finished products (both traditional finished products and high technological and refined equipment and appliances). The products find their way to the individual consumer but also to other industries. Petroleum refinement and the production of electricity are not included in the industry sector but are included in energy production (see Chapter 7 Energy production).

Due to the great variety of industrial activities a division into a limited number of subsectors is necessary. MIRA divides industry into six subsectors:

- chemical: basic chemical, production of paint, varnish, ink, soap, etc. the production of pharmaceutical products;
- metal: iron and steel industry, non-ferrous, metal processing industry, car manufacture, machine construction ...;
- food: food, drink and tobacco industry;
- textile: textile, leather and clothing industry;
- paper: paper industry, printing, publishing;
- other industries: metal ore and minerals, wood industry, construction, waste recuperation, ceramic industry, rubber and plastic processing industry ...

Considering the great variety of activities, industry is a major player in the environment. Despite major investments over the last decades in energy and emission reducing measures, industry still contributes significantly to the environmental burden. For instance, in this way 40 % of the gross energy consumption and over a quarter of the greenhouse gas emissions (23 %), ozone precursors (27 %) and PM2.5 (30 %) were attributable to the industry in 2006.

In this work the effects of energy and climate measures on the use of energy and on greenhouse gas emissions by industry were studied in several scenario calculations. Furthermore what these measures mean for the emission of acidifying pollutants (NO_x, SO_2), ozone precursors (NO_x, NMVOC, CO, CH_4) and particulate matter was verified.

Various specific measures to limit the emission of these latter pollutants have, insofar as possible, also been included in the scenario calculations. For emissions directly linked to the use of energy, such as the majority of incineration processes, the methodology applied does not however allow the calculation of all NEC measures[1]. For activities that have little or no relation to energy consumption, the future emissions are estimated on the basis of the effect, amongst others, of a number of NEC measures.

This chapter first explains how the three scenarios are constructed and calculated and then gives an overview of the industrial levels of activity.

The results of the three scenarios for the 2006-2030 period then follow. On the one hand this relates to the use of energy and greenhouse gas emissions and the emissions of acidifying substances, ozone precursors and particulate matter on the other. Finally the costs of the three scenarios and the conclusions for the policy are considered.

4.1 Principles of the Environment Outlook

Modelling

The industrial activities may be divided into processes that relate to incineration and other activities (e.g.: sulphuric acid production, degreasing, coating and printing activities ...). In this future outlook the incineration-related processes are calculated with the climate version of the Environmental Costing Model (Climate ECM). The emphasis in this technological-economic bottom-up model is on fulfilling the demand for production amounts at minimal cost. The scenarios do not consist of predefined measures; the model itself chooses the most cost effective package of measures. Costs that the model charges for this are the costs of primary energy, investment costs and operational costs for all installations, potential reduction techniques and any taxes and subsidies.

The measures from which the Climate ECM chooses mainly aim at a more efficient use of energy and a reduction of greenhouse gas emissions. For instance this relates to:

- fuel conversion of heavy fuel oil to natural gas or bio fuels;
- use of CHP-motors and -turbines[2];
- improved heat recuperation at diverse installations;
- direct burners in pre and post processing baths instead of steam or hot water heating in the metal coating activities;
- new burner technology in the glass industry;
- replacement of electrical ovens by gas ovens in the metal processing industry;
- increased pulverised coal injection in blast furnaces;
- transfer from mercury cell to membrane process in chlorine production.

The Climate ECM does not include all possible measures however that specifically aim at the reduction of the emissions of air pollutants such as NO_x, SO_2, NMVOC and particulate matter. The changes in the emissions of these substances calculated with the Climate ECM is consequently primarily a secondary result of the measures introduced in relation to energy and greenhouse gases. For instance emissions of SO_2, NO_x and particulate matter reduce when the switch is made from heavy fuel oil to natural gas.

Another important result of the use of the Climate ECM is that only emissions in relation to incineration processes are calculated. Emissions not related to incineration are not included in the model results. A few examples include the process emissions of NMVOC in various coating and printing processes, the NMVOC-evaporation emissions from industrial use of paint, SO_2 emissions from clay in brick production and in sulphuric acid production in the chemical industry ... In addition, the future emissions from these processes are estimated on the basis of existing sources of information. Specific emission reduction measures for air pollutants (e.g. to fulfil the NEC ceilings) have been included in the calculations for these processes.

The model results from the Climate ECM and the supplemental estimates were then combined and give an overview of the total emissions by the industrial sector.

Three scenarios

Differences

The European emissions trading system (ETS) for industrial activities is the central steering element in the energy and climate policy. The three scenarios calculated for the industrial sector with the Climate ECM are consequently related to three pricing evolutions for CO_2/greenhouse gases within this ETS system (Table 4.1). Those prices are derived from international studies and attuned to the levels of ambition of the three MIRA scenarios:

- The *reference scenario* (REF) starts from the current environmental policy with legislation and regulations (e.g. also including current agreements) that was already in force on April 1st, 2008. The price for emission rights is only applicable to CO_2 emissions from incineration processes.
- For the *Europe scenario* (EUR) the price for emission rights is derived from the cost of measures required to reduce greenhouse gas emissions from industrial installations in Europe between 2005 and 2020 by 21.3 %[3]. This price is applicable to all greenhouse gas emissions.
- The *visionary scenario* (VISI) is built around the long-term target for climate change of this Environment Outlook 2030. This target requires a reduction of greenhouse gas emissions by 60 to 80 % by 2050 and a halving of those emissions in 2030 compared to 1990.

TAB. 4.1 *Price of emission rights for the REF, EUR and VISI scenarios (Europe, 2010-2030)*

(Euro/tonne CO_2-eq)	**2010**	**2015**	**2020**	**2025**	**2030**
REF	20.0	21.0	22.0	23.0	24.0
EUR	20.0	23.7	30.0	32.0	34.1
VISI	20.0	23.7	77.6	77.6	77.6

In 2008-2009 the market price fluctuated between 8 and 31 euro/tonne CO_2.

Key parameters and evolution of the level of activity

The scenario calculations with the Climate ECM were realised simultaneously for the industry and energy production sectors (Chapter 7 Energy production). A number of joint assumptions were made for both sectors. A number of key parameters are of specific interest for the industrial sector:

- Energy prices: the fuel prices are supplied by the Federal Planning Bureau (FPB) and attuned to the PRIMES-baseline[4] scenario of the European Commission (European Commission, 2008). The prices take account of the developments on the international markets until early 2008. Distribution costs in Belgium have also been included.
- Economic growth for REF and EUR scenarios: the FPB drew up a timeline for the 2005-2030 period (FIGURE 4.1) for the production of goods (production index, added value). In addition a zero growth is maintained between 2010 and 2030 for the iron and steel production. The iron and steel production in Flanders comprises two companies, of which only Arcelor Mittal Gent produces steel from iron ore. The assumption in this future outlook is based on the current technical production capacity of this company.
- Economic growth and price elasticity for the VISI scenario (FIGURE 4.1): the economic growth forecasts of the VISI scenario differ from those of the REF and EUR scenarios. In the VISI scenario the price elasticity is calculated for all final demand for steel, chlorine, ammonia ... This elasticity entails that the final demand for products falls if the production costs rise. The cost may rise due to an increase in investment costs, operational costs, energy costs and the CO_2 prices. As the costs for the subsectors differ, the effect of price elasticity is also different per subsector.

4.2 Energy use

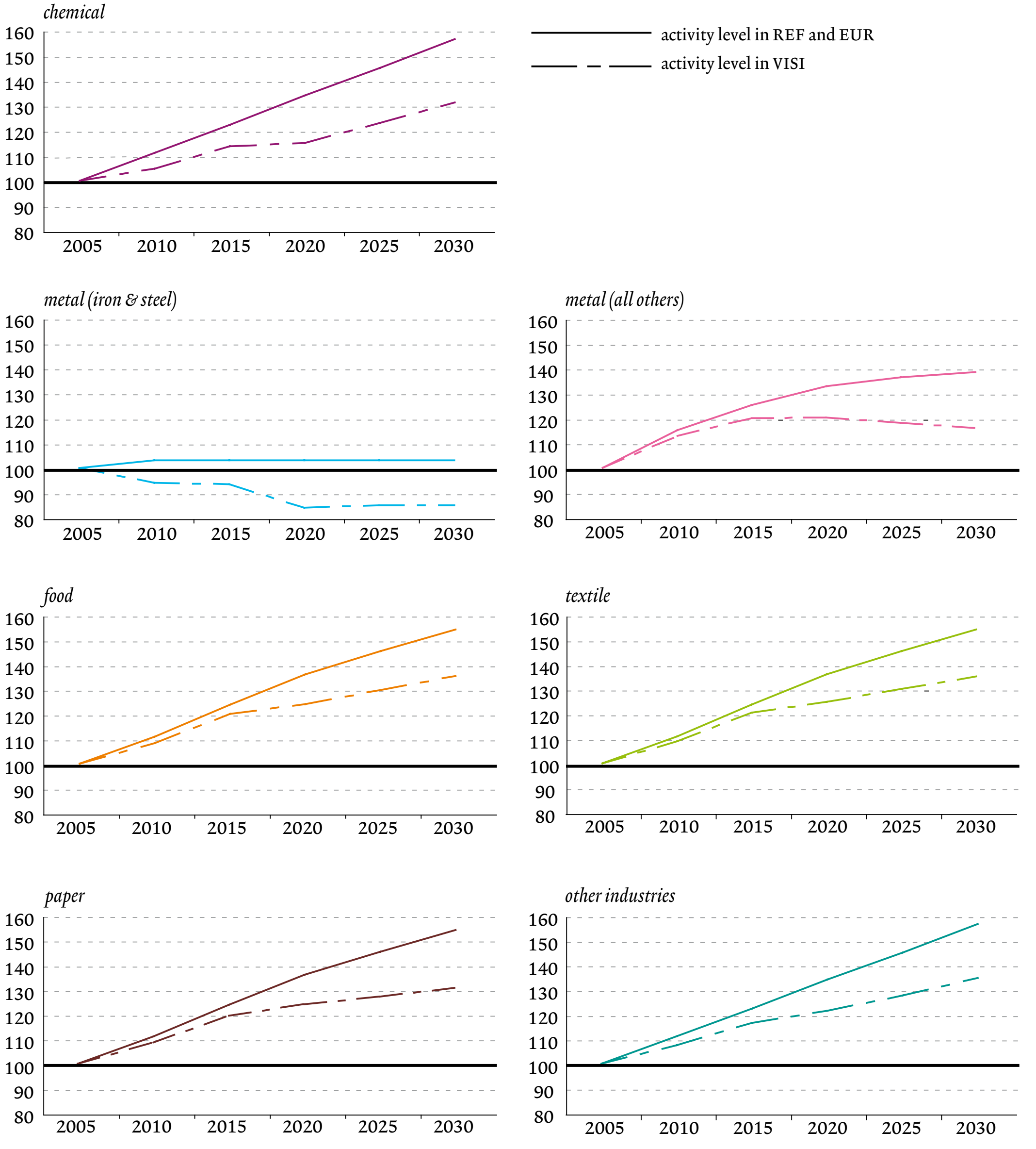
A distinction must be made in industrial energy use between:

- the energetic use of energy: use of energy carriers like coal, fuel oil, natural gas, electricity for applications like processing heat and power;
- the non-energetic energy use: use of energy carriers as raw materials, e.g.: the use of natural gas for the production of ammonia or the use of naphtha, from which, after cracking, derived raw materials like ethylene, propylene, benzene and butene are produced.

The energetic use of energy has a 60.5 % share, the non-energetic use represents 39.5 % (in 2006). The discussion below concentrates primarily on the energetic use of energy as efforts for the more rational use of energy and reduction of greenhouse gases primarily relate to this.

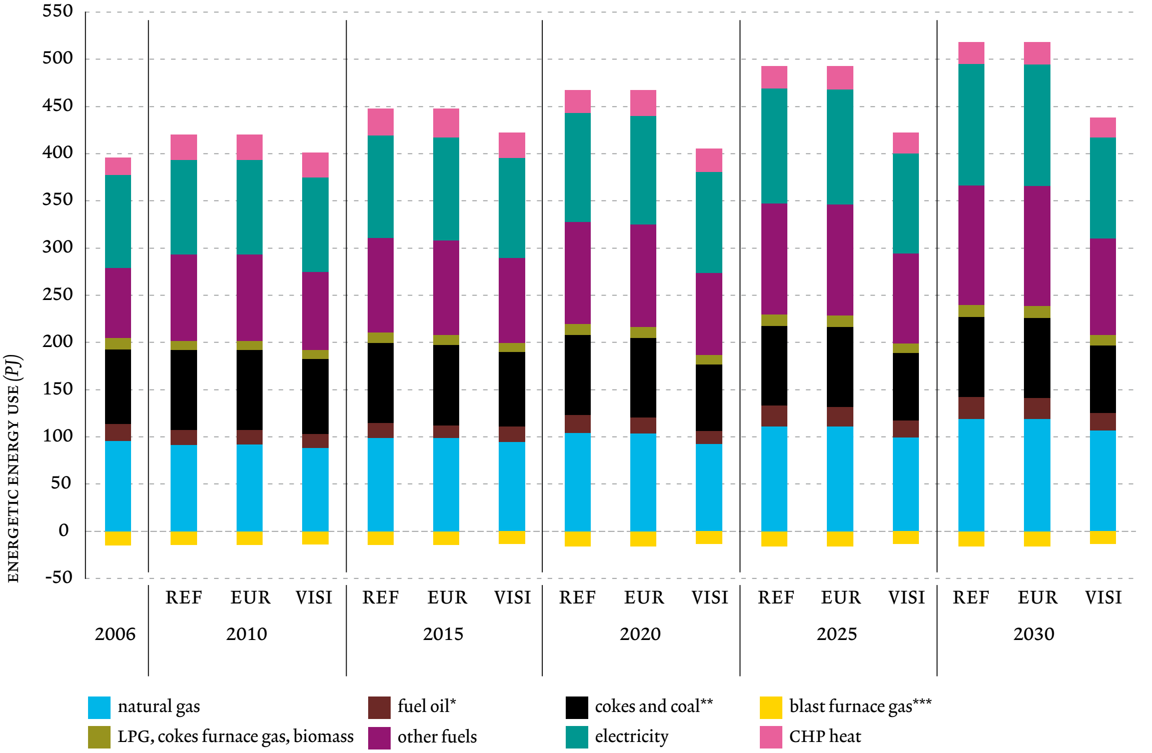
FIGURE 4.2 shows the energetic use of energy per energy carrier, FIGURE 4.3 per subsector. Both in the REF and the EUR scenarios the use of energetic energy increases between 2006 and 2030 and this despite an increase in the CO_2 price (from 20 to 24 euro/tonne in the REF scenario and from 20 to 34.1 euro/tonne in the EUR scenario, between 2006 and 2030). The increase in the REF and EUR scenarios runs extremely parallel. In the EUR scenario only a few subsectors implement additional energy-saving measures. The increase in the CO_2 price in the EUR scenario is consequently not sufficient to save more energy in a cost effective way.

FIG. 4.1 *Evolution of the economic activity level per industrial subsector for the REF, EUR and VISI scenarios (2005=100) (Flanders, 2005-2030)*



Source: Federal Planning Bureau for the REF and EUR scenarios, VITO for the VISI scenario

FIG. 4.2 *Energetic use of energy by the industry per energy carrier in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*

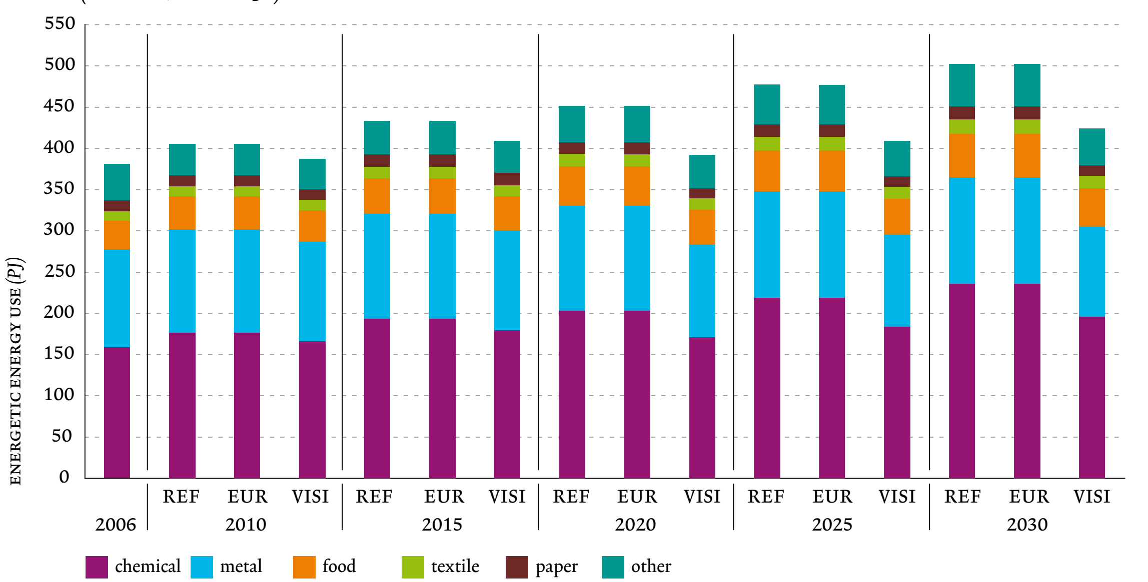


* fuel oil = light + heavy fuel oil

** cokes and coal = cokes + petroleum cokes + coal + anthracite

***The production of blast furnace gas from steel is supplied to the electricity sector and recorded as negative on the graph.

FIG. 4.3 *Energetic use of energy by the industry per subsector in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



The energetic use of energy increases less in both scenarios than the economic growth. The economic activity increases in the REF and EUR scenario by 26.8 % between 2006 and 2020 and by 42.5 % between 2006 and 2030. Whereas the energetic use of energy in the same period only increases respectively by 18.6 % and 32 %.

In the VISI scenario the use of energy is lower than in the other two scenarios (but is in 2030 still 11 % higher than in 2006). This difference is not due to the implementation of additional measures, but rather due to the lower production in the subsectors. The price elasticity of the VISI scenario drops the use of energy under the influence of production costs (amongst others the CO_2 price).

The chemical sector is responsible for 40 % of the energetic use of energy in industry. Beside chemistry, the metal sector is the second most important subsector with 29 % of the industrial energetic use of energy. In this subsector the iron and steel production is responsible for 72 % of energy use.

Chemistry increasingly uses recuperation fuels between 2006 and 2030. These are fuels that are released as a residual product in the production processes. If recuperation of these residual products is too expensive or impossible, they are used as fuel.

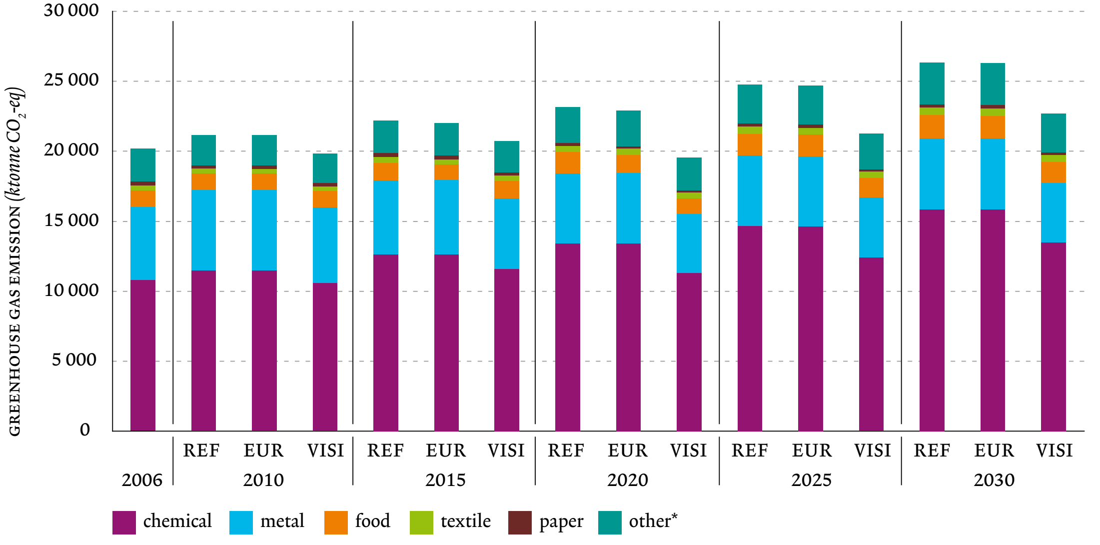
Electricity is mainly used in the chemical industry for typical production processes. Chlorine production is the main electricity consumer with approximately 22 % of the total consumption within the chemical sector. At the moment chlorine is still primarily produced using the mercury cell process. However this process will be gradually replaced in the 2010-2015 period by the more energy and environmentally friendly membrane electrolysis-process[5]. This measure saves approximately 22 % electricity for the same production quantity.

4.3 Greenhouse gas emissions

The emissions in the REF and EUR scenarios increase by approximately 30 % between 2006 and 2030 (FIGURE 4.4). In the VISI scenario the interplay of economic growth, demand elasticity and CO_2 price ensure lower emissions in 2010 than in 2006 and an increase in 2015. In 2020 the emissions are again lower than in 2006 under the influence of the high CO_2 price. Economic growth ensures that the emissions rise again after 2020. A similar development can be seen in the industrial use of energy (FIGURE 4.3). Nevertheless the use of energy remains higher than in 2006 in all years considered. The greenhouse gas emissions may however be lower than in 2006 through the use of fuels with a lower CO_2 emission factor (e.g. replacing coal or oil with natural gas or biomass).

The emissions of greenhouse gases are mainly made up of CO_2 emissions (88 % in 2006). The N_2O emissions represent 8 %, F gases 3.5 % and CH_4 emissions remain limited to less than 0.5 %. Throughout all the scenarios and years in the overview the composition of this basket hardly varies and the CO_2 emissions continue to take the lion's share, with a share fluctuating between 88 % and 90 %.

FIG. 4.4 *Greenhouse gas emissions by the industry in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



* including emissions from HFCs in all industry (not divisible per subsector)

The chemical industry produces over half the industrial CO_2 emissions (51 % in 2006). The CO_2 emissions by the chemical industry are primarily (>80 %) attributable to the energy consumption in the sector. The rest is formed in chemical processes in the production of ammonia, styrene, ethylene oxide ... CO_2 emissions increase between 2006 and 2030, both in the REF and the EUR scenarios. In the VISI scenario the greenhouse gas emissions from 2020 are 18 % lower than in the REF and EUR scenarios. This is primarily attributable to the lower production of the most energy intensive activities under the influence of the high CO_2 price.

The N_2O emissions of the chemical industry are primarily due to the production of nitric acid and caprolactam. The N_2O emissions fall between 2006 and 2010 by almost 32 % due to the use of improved catalytic agents.

The CO_2 emissions of the metal sector, which represents 29 % of the industrial CO_2 emissions in 2006, is primarily attributable to the iron and steel industry. The production increase between 2006 and 2010 ensures an increase in CO_2 emissions. Several measures such as the further implementation of direct pulverised coal injection, the replacement of coke grit by anthracite in the sintering plant, the investment in 'dry quenching' with energy recuperation of cokes ... ensure a reduction in CO_2 emissions from 2020 by approximately 13 % compared to 2010 in both the REF and EUR scenarios. As a result of the growth in the other metal sectors (non-ferrous, metal processing) the differences in emissions between 2010 and 2020 is limited for the entire subsector to 700 ktonnes. Compared to the 2006 emissions the total reduction from 2020 is limited to approximately 170 ktonnes.

The lower production in the VISI scenario also ensures lower greenhouse gas emissions in the metal sector over the entire timeline. In total the annual greenhouse gas emissions in the metal sector are almost 1 000 ktonnes (20 %) lower from 2020 than in 2006.

The measures implemented to reduce energy consumption and greenhouse gas emissions, prove inadequate to reduce the industrial emissions in Flanders to below the 2006 level. Companies in Flanders will consequently have to buy additional emission rights. This is necessary to fulfil the previously mentioned reduction targets of 21.3 % for greenhouse gases in 2020 compared to 2005 or halving those emissions in 2030 compared to 1990 at a European level. Indeed the increase in the CO_2 price in the three scenarios is insufficient for a cost effective energy reduction and lower greenhouse gas emissions by the industry within Flanders itself. The possible use of green heat and the efficient use of industrial residual heat (e.g. exchange with horticultural companies, see Chapter 5 Agriculture) are opportunities that were only estimated partially[6] in the scenario calculations.

4.4 Emissions of acidifying substances, ozone precursors and particulate matter

Emission of acidifying substances

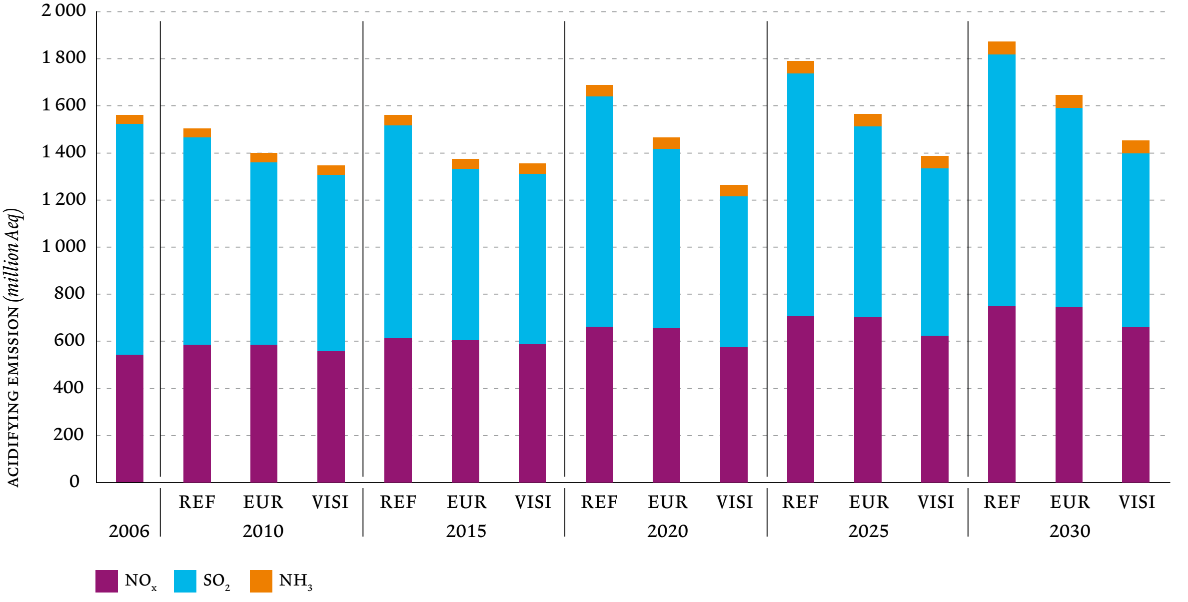
FIGURE 4.5 illustrates the total industrial emissions of the acidifying pollutants NO_x, SO_2 and NH_3. It shows that the increase in the EUR scenario is far below the increase in the REF scenario. The acidifying emissions from the industry only remain below the 2006 level in the VISI scenario.

SO_2 holds the largest share in the acidifying emissions in the 2006 reference year with almost 63 %, whereas NO_x is responsible for almost 35 %. The industrial NH_3 emissions are limited. Throughout the scenarios and the years forecast the NO_x share rises finally to reach 45 % for NO_x and 51 % for SO_2 by 2030 for the EUR and VISI scenarios.

FIGURE 4.6 and FIGURE 4.7 show the industrial NO_x and SO_2 emissions per subsector.

The chemical industry has a share of 41 % in 2006 in the industrial NO_x emissions and supplies 17 % of the SO_2 emissions. The acidifying emissions in 2030 are respectively 52 %, 36 % and 11 % higher than in 2006 for the REF, EUR and VISI scenarios. Especially the NO_x emissions rise sharply over the years, whereas the level of SO_2 emissions is significantly lower than the 2006 level for all years in the EUR and VISI scenarios. The NO_x emissions are almost entirely related to the incineration processes. The energy and climate measures have been calculated through in the scenario results just for these processes. On the other hand for the SO_2 emissions

FIG. 4.5 *Emissions of acidifying substances by the industry in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



numerous direct (NEC) measures have been applied in the calculations, especially on the important non-fuel related emissions from sulphuric acid production and related processes.

The metal subsector has a 33 % share of NO_x emissions and 31 % of SO_2 emissions in 2006. The emissions of these acidifying substances vary little across the forecast years. The NO_x and SO_2 emissions primarily come from the iron and steel industry (83 % for NO_x and 67 % for SO_2). The majority of those emissions relate to incineration processes and the evolution is consequently also entirely comparable with those of the energy use in this subsector. In 2030, the acidifying emissions are respectively 10 % and 7 % higher in the REF and EUR scenarios and 8 % lower in the VISI scenario than in the 2006 starting year.

The subsector other industries has a 16 % share of the NO_x emissions and 38 % of the SO_2 emissions in 2006. A drop can be observed for this subsector in the emissions of acidifying substances, unlike the greenhouse gas emissions. The decreasing trend is primarily visible in the EUR and VISI scenarios. This may be explained amongst others by direct reduction measures on SO_2 emissions that are not related to incineration processes. The majority of the SO_2 emissions come from the release of sulphur from clay in the production of bricks. Sharper emission limits for the ceramics industry already ensure greatly reduced SO_2 emissions from 2010.

The energy and climate measures in this Environment Outlook 2030 prove clearly inadequate also to reduce the SO_2 and especially the NO_x emissions to a level

FIG. 4.6 *NO_x emissions by the industry in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*

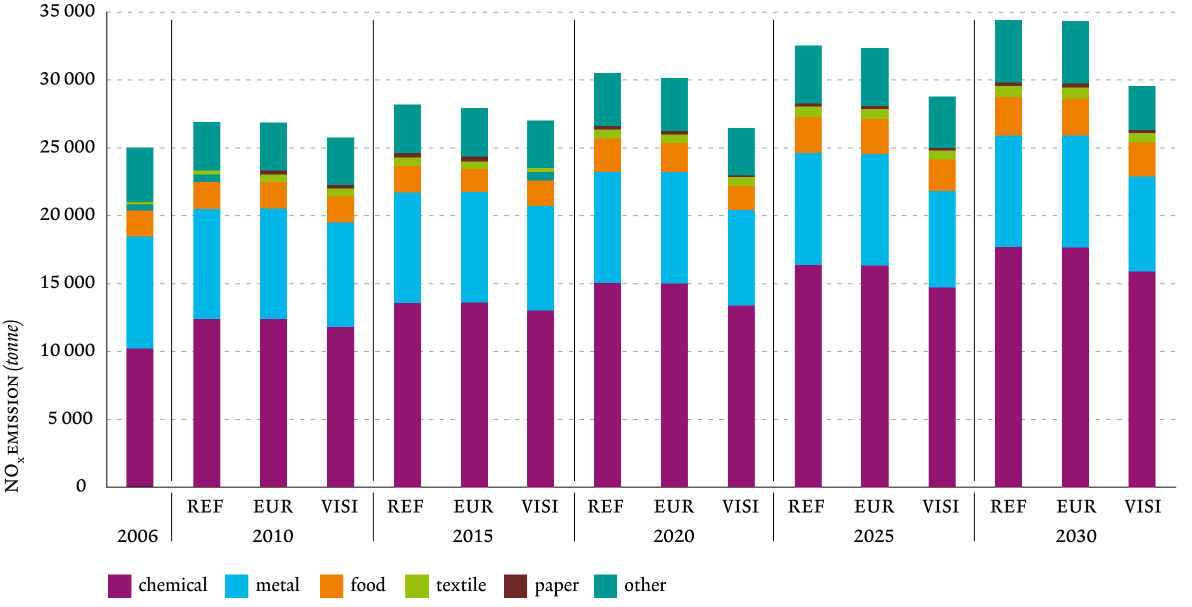
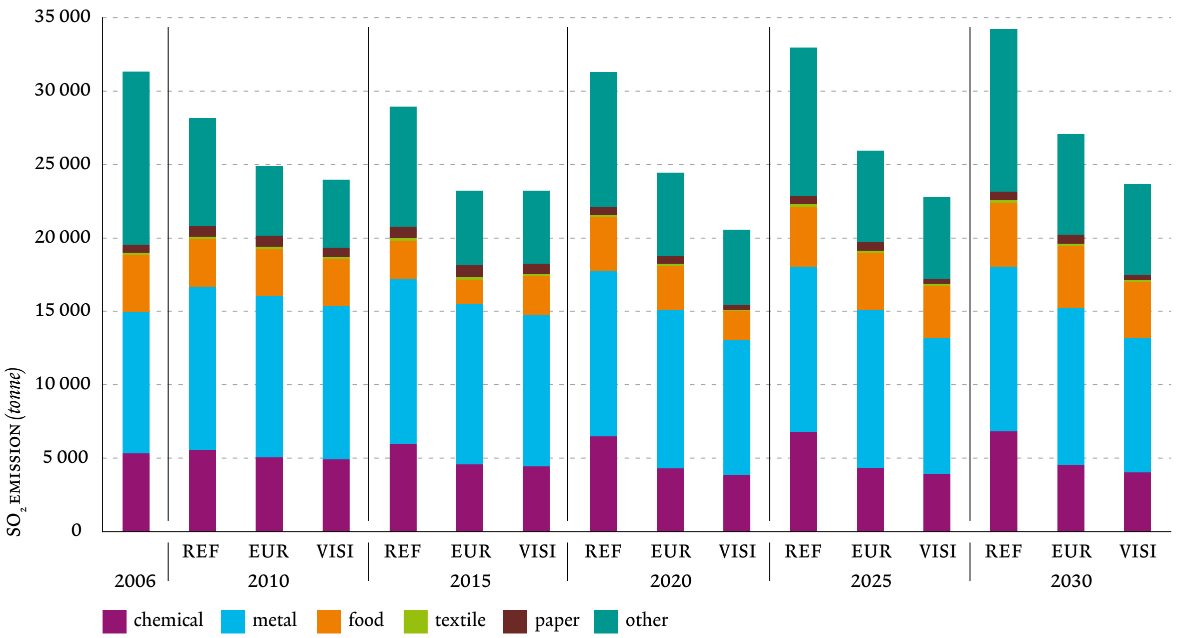


FIG. 4.7 *SO_2 emissions by the industry in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



in the vicinity of the ceilings expected for 2020 in the revision of the European NEC directive (the NEC-2020 targets[7]). The acidifying emissions only fall for activities in which the measures specifically aimed at acidifying parameters are included in the calculations. Such 'NEC measures' consequently remain a necessity in the environmental policy: in the meantime numerous measures are introduced in or planned in the environmental policy and a continued effort in this regard remains crucial.

Emission of ozone precursors

The evolution of the emission of ozone precursors (NMVOC, NO_x, CO and CH_4) (FIGURE 4.8) by industry is noticeably parallel to that of the acidifying substances. NO_x has a large share in both substance groups. Unlike the emissions of NO_x the industrial NMVOC emissions originate almost entirely from evaporation processes.

Within the emission of ozone precursors NMVOC makes the greatest contribution with a 45 % share in the 2006 reference year. NO_x is responsible for 31 %. The CO share is 24 % and originates primarily from the iron and steel industry. The emissions of CH_4 by industry are extremely limited (0.05 % in 2006). Throughout the scenarios and the years considered the NO_x contribution increases and the NMVOC share falls, finally in 2030 in the VISI scenario to result in a 45 % share for NO_x and 30 % for NMVOC. The CO contribution is then 25 %. Both in the EUR and VISI scenarios the NO_x emissions (FIGURE 4.6) remain above the 2006 level until 2030. For NMVOC (FIGURE 4.9) the emissions remain under the 2006 level until 2030 through the implementation of specific NEC measures.

The chemical subsector holds a 41 % share of the industrial NO_x emissions and 33 % of the NMVOC emissions (2006). The emissions of ozone precursors is respectively 37 %, 24 % and 3 % higher in 2030 than in 2006 in the REF, EUR and VISI scenario. For NMVOC the emission level in the EUR and VISI scenarios for all calculated years is below the level of the starting year 2006 through the introduction of diverse direct measures in numerous evaporation-related emissions.

The metal subsector has a 33 % share of the NO_x emissions and 19 % of the NMVOC emissions in 2006. The emissions of ozone precursors indicate a slightly decreasing trend: respectively 5 %, 8 % and 23 % reduction of emissions by 2030 compared to 2006 for the REF, EUR and VISI scenario. The NMVOC emissions also indicate the sharpest fall here (-45 % in VISI over the 2006-2030 period) through the introduction of diverse emission-reducing measures for activities such as cleaning, degreasing, coating and painting in the automotive assembly, metallurgical industry and machine construction.

The paper subsector has a negligible share of the NO_x emissions, but is responsible for 14 % of the industrial emissions of NMVOC in 2006. For ozone precursors, in which NMVOC always has a share of over 90 % in this subsector, the emissions fall over the entire timeline in the EUR and VISI scenarios. This is primarily due to the

FIG. 4.8 *Emissions of ozone precursors by the industry in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*

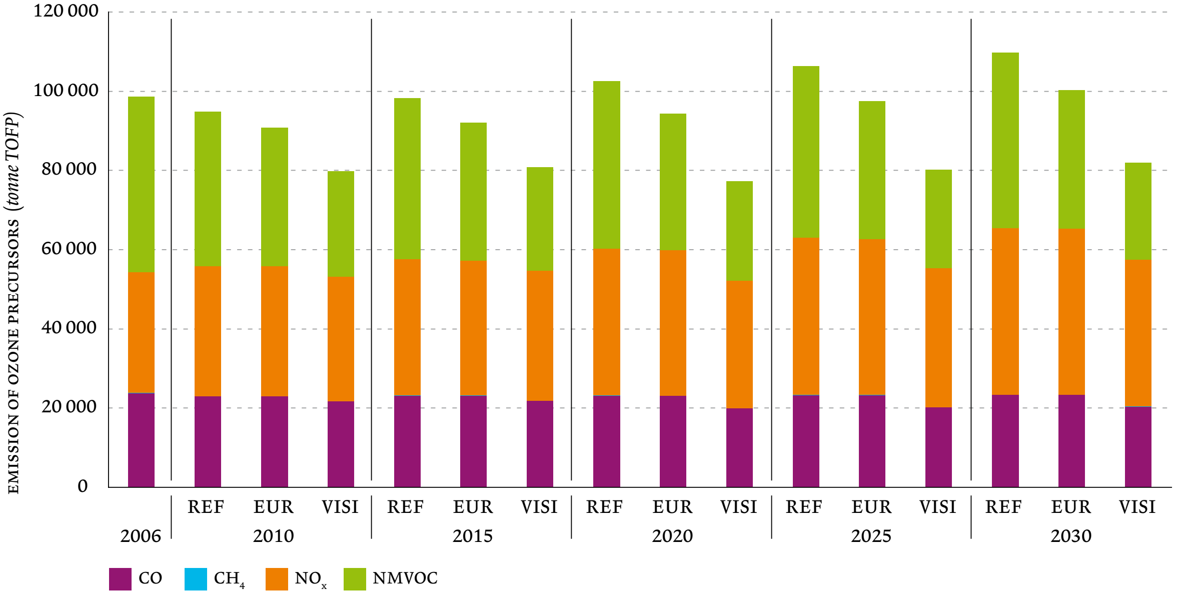
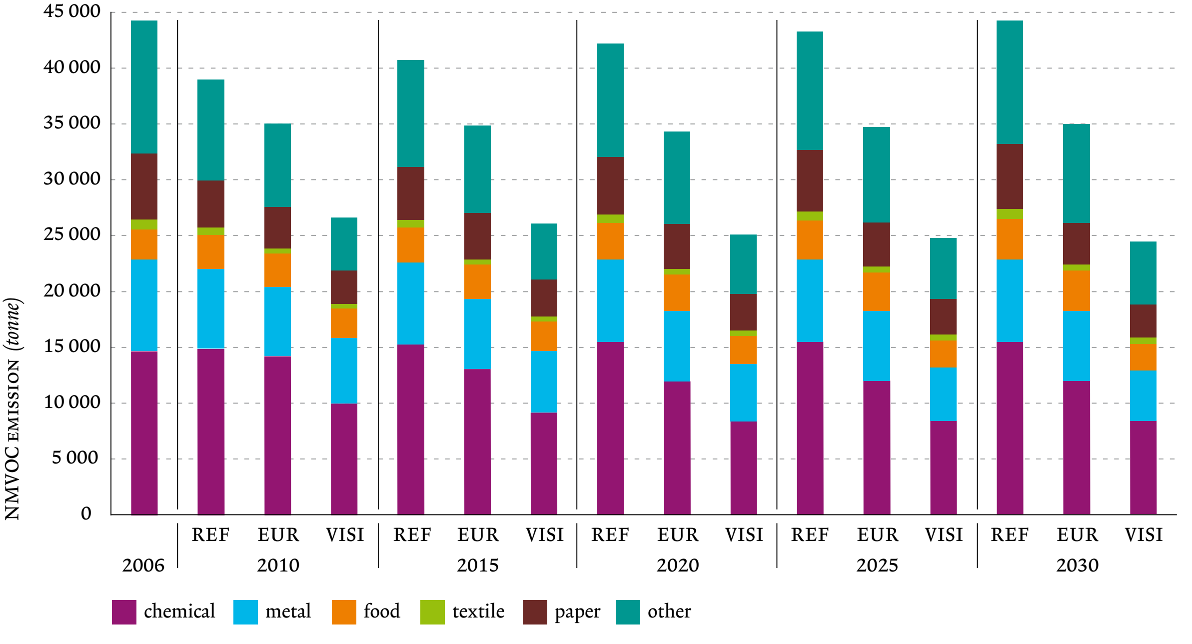


FIG. 4.9 *NMVOC emissions by the industry in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



introduction of specific emission reducing measures in the use of inks and paints in the various printing processes (flexo and helio printing, illustration deep printing, heat setting, sheet and screen printing).

The other industries subsector has a 16 % share of NO_x emissions and 27 % of NMVOC emissions for industry in 2006. Unlike the greenhouse gas emissions of this subsector, a decreasing trend may be observed in the emissions of ozone precursors, especially in the EUR and VISI scenarios. This trend may, amongst others, be explained by the NMVOC emission limitations in industrial paint use, in the ceramics industry, mineral products and glass production, the wood and furniture industry, diverse coating processes in the rubber and plastic processing industry, tank cleaning ...

As for acidifying emissions it is apparent that the energy and climate measures considered are clearly inadequate also to reduce the emissions of ozone precursors to a level close to the expected 2020 ceilings at the revision of the European NEC-directive. Measures that specifically reduce the emissions of ozone precursors consequently remain crucial to environmental policy. Many of these kinds of measures have been implemented or are planned in the meantime; perseverance is required in this.

Emission of particulate matter

The evolution of the emissions of total particles and the PM10 fractions (particles with a diameter below 10 µm) and PM2.5 (particles with a diameter below 2.5 µm) runs parallel to a large extent. The industrial emissions of PM2.5 (FIGURE 4.10) are respectively 38 %, 30 % and 23 % higher in 2030 than in 2006 in the REF, EUR and VISI scenario. Although industry comes out slightly better in the EUR and VISI scenarios, no emission reductions may be expected after 2015 on the basis of the energy and climate measures considered, on the contrary. The anticipated increase is the greatest amongst the most hazardous fraction, namely the small particulate matter (PM2.5).

The other industries subsector has the largest share of the PM2.5 emissions (in 2006) with over 56 % within industry. The evolution of the PM2.5 emissions generally runs parallel with the use of energy in the various scenarios.

FIGURE 4.10 shows that the energy and climate measures considered are entirely inadequate to limit the industrial emissions of particulate matter in the future. A policy specifically aimed at the reduction of particulate matter is consequently also essential. A number of measures are already in progress or are provided for in the current environmental policy. In the future efforts will also remain needed in order to limit the particulate matter issue.

FIG. 4.10 *Emissions of PM2.5 by the industry in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*

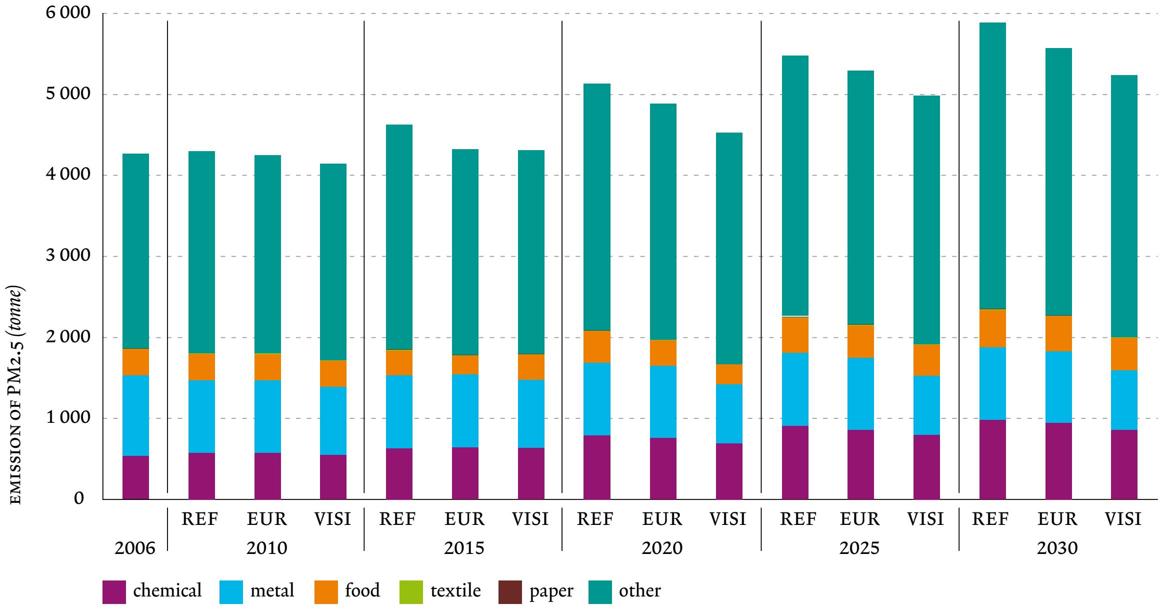
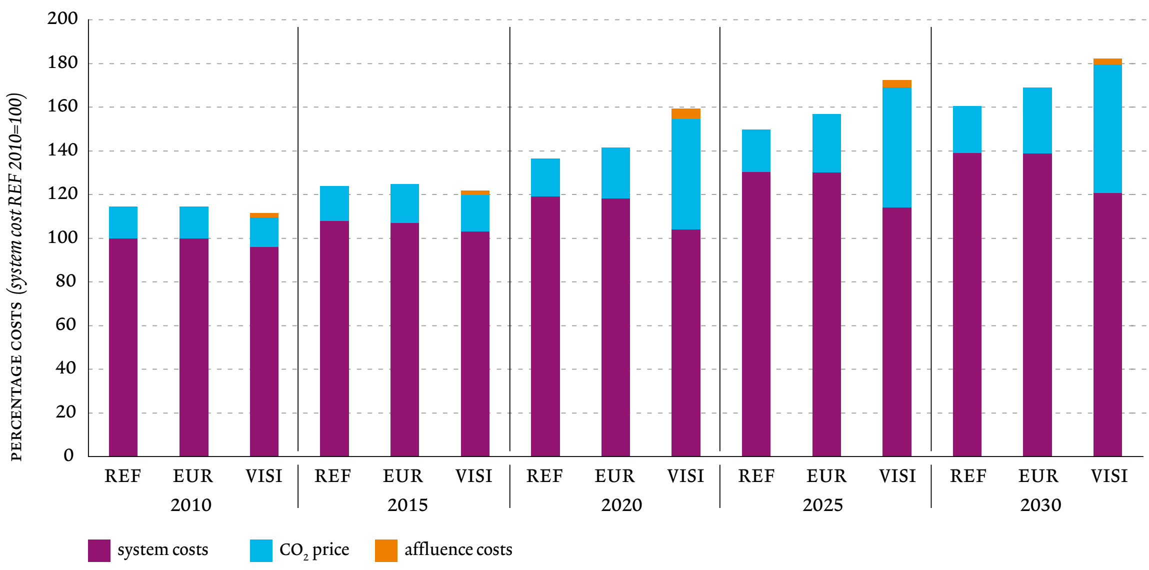


FIG. 4.11 *Relative annual costs for the industry in the REF, EUR and VISI scenarios in relation to the system cost in the REF scenario in 2010 (Flanders, 2010-2030)*



4.5 Costs of the three scenarios

Three types of costs have been taken into account for a comparison of the cost of the three scenarios (FIGURE 4.11):

- the system costs: these include the investment costs, the operational costs of the energy and climate measures and the fuel costs;
- the costs of the remaining greenhouse gas emissions due to the CO_2 price imposed;
- the loss of prosperity: this is income lost due to reduced production resulting from the price elasticity implemented in the VISI scenario.

The annual system costs of the REF and EUR scenario rise by approximately 39 % between 2010 and 2030. There are only minor differences in the annual costs between the two scenarios. From 2015 the system costs in the EUR scenario are up to 1 % lower than in the REF scenario. The main reason for this difference is the greater use of CHP for which the system costs are calculated in the electricity sector. The annual system costs are lower in the VISI scenario for all years considered than in the REF or EUR scenario. The price elasticity ensures a decreased demand and production in the industrial subsectors under the impact of the rising CO_2 price. The costs that may be attributed to the loss of affluence due to the decreased demand and production is rather limited. This is a maximum of almost 5 % in relation to the annual system costs.

The total annual costs (system costs + CO_2 costs + cost of loss of prosperity) is lower in 2010 and 2015 in the VISI scenario than in the REF or EUR scenarios. From 2020 this is higher due to a sharp increase in the CO_2 price.

4.6 Conclusions for policy

The measures that the Flemish industry takes to limit the use of energy and greenhouse gas emissions do not result in an absolute reduction of the use of energy and greenhouse gas emissions by this sector compared to 2006. The increase in the CO_2 price in the three scenarios is not to such an extent that the industry may realise more energy reductions in a cost efficient way and consequently less greenhouse gas emissions within Flanders itself. For the remaining emissions it is cheaper to buy emission rights than to realise further reductions. For industry the use of green heat and the efficient use of industrial residual heat cannot be fully estimated yet. There may be some opportunities there to limit the industrial greenhouse gas emissions within Flanders.

It is clear that the current context within which Flemish industry operates still leaves too little space to reduce energy use and greenhouse gas emissions. If Flemish industry wants or has to meet the international commitment to reduce greenhouse gas emissions sharply, fundamental, structural changes are required both in production and consumption patterns. Technological innovations are not only required for this, but also:

- redesigned planning and organisational structures (e.g. 'eco-industry parks' where one strives to close the material cycles, energetic autonomy and positive ecological effects amongst others through water and air purification ...);
- new business models (e.g. product service combinations);
- new practices and habits from the demand side;
- new and existing institutions that implement new rules and frameworks;
- ...

Traditional policy instruments, in particular pricing instruments are essential for this but insufficient. A specific transition approach is required (see Chapter 14 Flanders in transition?). This kind of transition approach can help to realise the green economy which the Flemish Coalition (2009-2014) is dedicated to.

The energy and climate measures considered are clearly inadequate also to reduce the emissions of SO_2, and especially NO_x and particulate matter, to a level in the vicinity of the ceilings expected for 2020 on the revision of the European NEC directive. The emissions only fall for activities where measures specifically aimed at NEC pollutants are implemented in the calculation. The implementation of so-called NEC measures also remains a necessity for emission flows related to incineration processes. In the current Flemish environmental policy such measures have already been introduced or are planned and will ensure a reduction of the emission of these pollutants in the coming years.

ENDNOTES

1 NEC measures: measures for the reduction of NO_x, SO_2, NMVOC and NH_3 with the aim of fulfilling the National Emission Ceilings Directive. With the revision of this directive the emission ceilings for particulate matter are also defined.
2 Energy use and emission of the CHPs are included with the energy production sector in this report.
3 The ETS-sectors (Emission Trading Scheme) in the EU27 must fulfil a ceiling of 1 880 Mtonnes CO_2-equivalents by 2020, this corresponds to a reduction by 21.3 % compared to 2005.
4 The PRIMES model is a partial balance model of the energy system in Europe, which integrates energy supply and demand.
5 The Flemish Government has decided (decree of 19.09.2008) to delay the prohibition of the use of the mercury cell process already decided in 1995 to after 2010 (see article 5.7.5.1. of Vlarem II).
6 At the time of the scenario calculations for MIRA-S (end of 2008, early 2009) there were not yet any up-to-date estimates available for Flanders for the use of green heat in industry.
7 The IIASA emission scenarios described in the NEC Scenario Analysis report n° 6 (Amann *et al.,* 2008) provide a reduction target for Belgium provided for the total emissions of NO_x, SO_2, NMVOC and PM2.5 respectively of 61 %, 63 %, 43 % and 42 % in 2020 compared to 2000. These scenarios take account of the TSAP goals (Thematic Strategy on Air Pollution) and the proposal for the Climate & Energy Package, but are not yet final.

LIKE TO KNOW MORE?

If you would like to know more, you can refer to the scientific report which forms the basis for this chapter:

Lodewijks P., Brouwers J., Van Hooste H. & Meynaerts E. (2009) Energie- en Klimaatscenario's voor de sectoren industrie en energie. Scientific report, MIRA 2009, VMM, www.milieurapport.be.

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European Commission (2008) European Energy and Transport, Trends to 2030 - Update 2007, prepared by NTUA using the PRIMES model. Directorate-General for Energy and Transport.
IIASA: http://gains.iiasa.ac.at/gains, scenario: C&E package, MRRV5.
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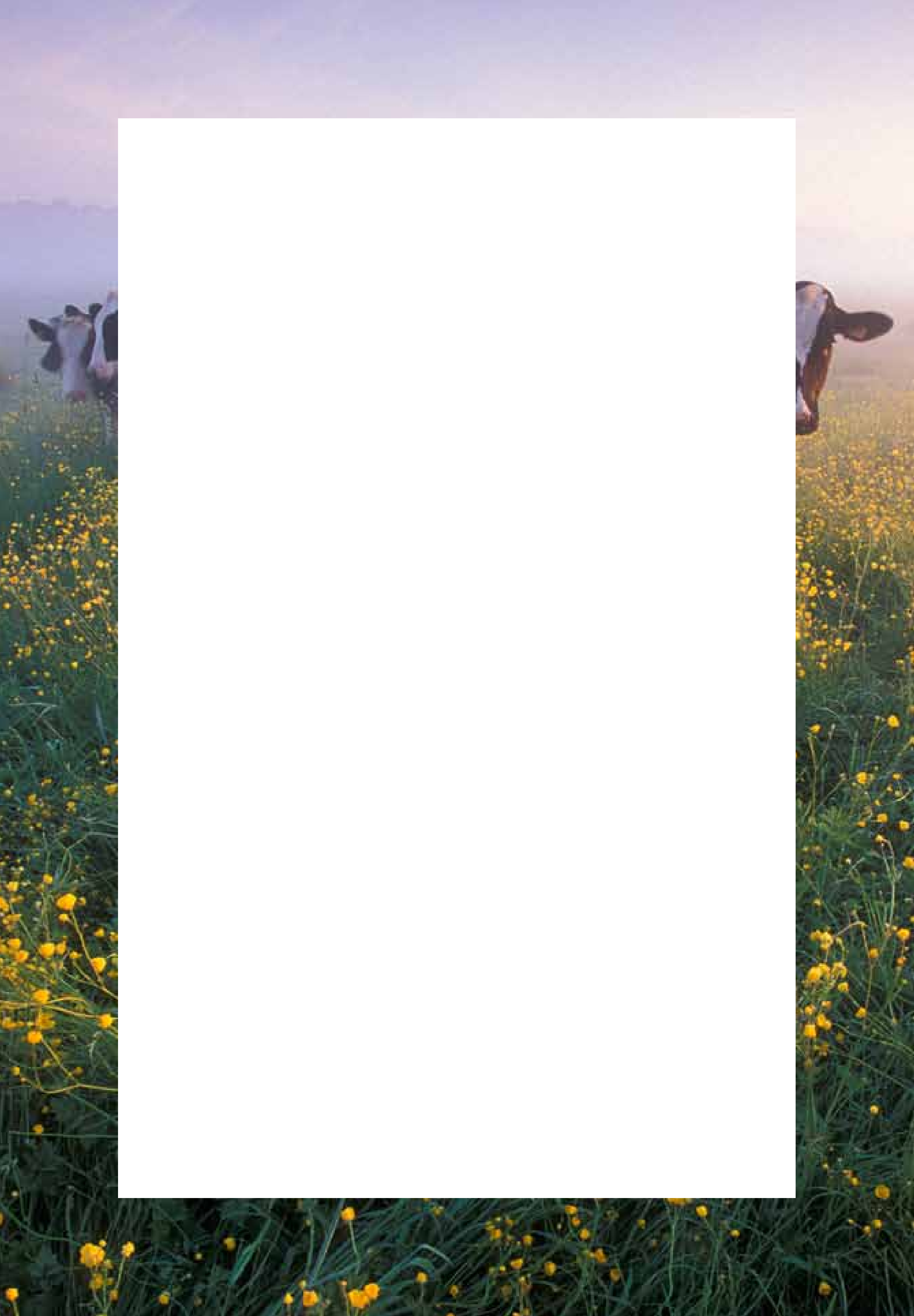

5 Agriculture

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OUTLINES

- Price developments and the assumed manure policy will result in a decrease of cattle stock by 11 % by 2030 in the reference scenario (REF) and 28 % in the Europe scenario (EUR). Landless stock-breeding of pigs and poultry may be maintained thanks to manure processing.

- Greenhouse gases, acidifying substances and particulate matter may decrease by over 15 % in the EUR scenario. This is the result of the decrease in the cattle stock and additional environmental measures in stock-breeding and greenhouse farming.

- Agriculture may only contribute to achieving the targets of the European Water Framework Directive (WFD) through a stricter manure policy as regards nitrogen (N). The revised target of 42 kg N/ha surplus is feasible in the EUR scenario.

- In both scenarios, agriculture ensures a growth in the total balance[1]. This is a consequence of the assumed increase in the sales prices of agricultural products. Together with the decrease in emissions this results in increased eco-efficiency.

- Agriculture land with environment or biodiversity targets is assumed to be established in erosion-sensitive land and along watercourses. A larger share of this type of agriculture in the EUR scenario results in decreased air and water emissions, with the exception of the emissions of particulate matter.

Introduction

This text places the future of the agriculture sector central. This future depends on the choices in the environmental policy and on autonomous developments. Although agriculture only realised 1.2 % of the gross value added in Flanders in 2007, it takes approximately half the land. Due to the production methods, agriculture makes a major contribution to air and water pollution.

This chapter first clarifies the principles of this outlook. It will then consider the possible evolution of the cattle stock and crops. This has results for animal manure production and how manure surpluses are decreased. The energy use is also studied, followed by the greenhouse gas emissions. The soil balance brings together elements from stock-breeding and arable farming and makes the connections to water quality. This chapter also discusses the emissions of acidifying substances and particulate matter and eco-efficiency. Finally a few conclusions are drawn for policy.

5.1 Principles of the Environment Outlook

Modelling

In this text agriculture is defined as arable farming, stockbreeding, horticulture, including greenhouse farming and offshore fishing. The division by sector is based on homogenous activities: dairy cattle and beef cattle with corresponding pasture and maize cultivation, pigs, poultry, twelve arable farming activities, four horticulture activities and offshore fishing.

For greenhouse farming, one of the horticultural crops, a separate study considers the issue of energy supply. The energy use results and emissions have been included in the total figures for agriculture. The future of offshore fishing has not been explored. For that reason this chapter assumes that the use of energy and emissions from them remain equal to the 2006 level.

The SELES sector model is used for the quantification of the cultivation area, cattle stock, financial total balance, soil balance and ammonia emissions. SELES is a partial balance model of the agriculture sector. Emissions to the air, greenhouse gases, particulate matter and ozone precursors were calculated on the basis of results of SELES and emission core figures from the Air Emission Inventory of the Flemish Environment Agency (VMM).

The starting year is 2006. Two environmental policy scenarios have been calculated: the REF scenario and the EUR scenario. The REF scenario is based on the measures until 1st April 2008 and considers the further effects thereof. Measures in the EUR scenario aim at the European targets agreed on energy, climate and water and on undecided targets for emissions of acidifying substances, particulate matter and ozone precursors. Chapter 1 Policy scenarios explains this approach. The sector models available did not allow the formulation of a visionary scenario, except for the greenhouse farming subsector.

Two scenarios

TABLE 5.1 illustrates the main measures and principles for the scenarios. In the 2006 starting year an agricultural area of 626 000 ha is considered, as registered in the 15-May census of the FPS Economy. This includes the farmland of professional agriculture, excluding access roads, soft verges, ditches, buildings and barns. The figures have been rounded to thousands. In Chapter 10 Land Use, agriculture also includes farmland outside the 15-May census.

TAB. 5.1 *Measures and principles of the scenarios for agriculture*

Scenario-element	Reference scenario	Europe scenario
Total agricultural area	autonomous decrease according to weakened trend 2000-2007 to 594 000 ha by 2030	more limited autonomous decrease through the expansion of agriculture with environment and biodiversity targets to 608 000 ha by 2030
Area of agriculture with environment or biodiversity targets	to 25 000 ha by 2015, stable thereafter until 2030	increasing to 162 000 ha by 2030
Technical productivity *(tonne/ha)*	increasing, except for grassland and maize	
Sales prices	decreasing for beef cattle and ornamental plant cultivation, the remainder increasing (slightly)	
Fertilizer requirement	increases equivalent to increase in productivity	increases by half the increase in productivity
Excretion	increases with productivity	increases by half the increase in productivity, for dairy cattle increases with productivity
Manure processing	processing of pig and poultry manure at 75 % of the 2006 price	processing of pig and poultry manure at 2006 prices; processing of cattle manure
Low emission barns	trend on the basis of the replacement rhythm for 2000-2006	increasing to 100 % low emission barns by 2030
Manure policy	MAP3 + derogation to green feed area	no derogation and sharpening of animal manure standard to 140 kg N/ha by 2030
Climate policy	energy saving investments in greenhouse farming	energy saving investments in greenhouse farming + renewal of entire greenhouse park
Agriculture policy	abolishing milk quota in 2015	

The area of agriculture with environment or biodiversity targets includes arable land and pastureland on which farmers take measures to minimise the environmental impact or to develop and manage specific natural values. This agriculture is a form of agriculture where green and blue services are of equal value besides production. The assumption is that this results in an average of up to 10 % loss of yield on a parcel of farmland. For the 2006 starting year the agricultural plots with existing management agreements for environment and biodiversity are included in this. The sharp increase in the EUR scenario is based on a strong increase in the second pillar of the European agricultural policy with a strong valuation of the management agreement instrument. The area suitable for the realisation of agriculture with environment or biodiversity targets is estimated on the basis of the current definition of:

- Arable farming plots in type 1, 2 and 3 erosion sensitive regions as defined in the erosion map of Flanders. This relates to 44 117 ha in 2030.
- Arable farming plots that border all navigable and non-navigable watercourses via buffer regions to the very finest category, excluding plots that also fall under erosion sensitive regions 1, 2 and 3. This relates to 107 617 ha in Europe 2030.
- Arable farming plots with agreements concerning nature management. This relates to 1 000 ha in 2030.
- Pastureland with agreements concerning nature management. This relates to 9 000 ha in 2030.

This future outlook is based on a stable evolution of sales prices. This long-term consideration is forced to ignore that the sales prices in agriculture are generally volatile by nature.

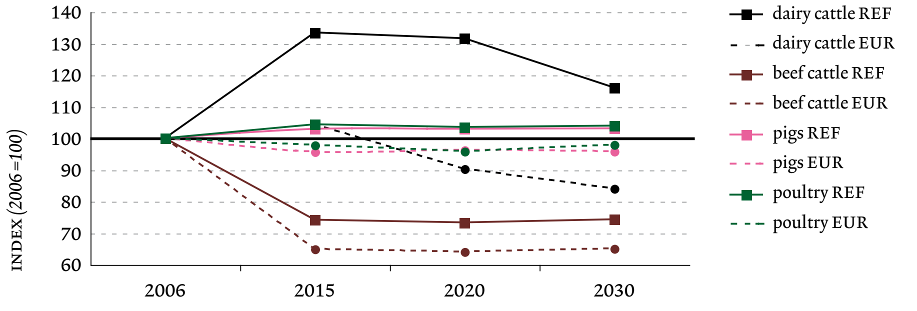
The manure policy has been sharpened greatly in the EUR scenario, with the intention of achieving the target in the WFD, specifically good water quality in all watercourses (TABLE 5.1). The ammonia policy is closely related to the manure policy. The use of low emission barns further sharpens this policy. Climate policy measures (energy savings and choice of fuel) are only used in the greenhouse farming subsector. The emissions of nitrous oxide and methane are especially dominant in stock-breeding. These emissions evolve according to the size of the stock and the manure processing. Emissions out off the agricultural soil have been kept constant to the 2006 start year.

5.2 Stock-breeding and land use

Stock-breeding

In the REF scenario the *dairy cattle stock* is higher in 2030 than in the 2006 start year (FIGURE 5.1). In the EUR scenario the dairy cattle stock is lower than in the REF scenario. Both scenarios assume the abolishment of the milk quota in 2015, which re-

FIG. 5.1 *Stock-breeding in the REF and EUR scenarios (Flanders, 2006-2030)*



sults in a strong increase in the dairy cattle stock. This policy decision thereby reverses the decrease in the dairy cattle stock, which would exist with the retention of the quota regulation by more productive cows. Despite the abolition of the milk quota the number of dairy cattle in the EUR scenario is still lower in 2030 than in 2006 due to the stricter manure policy.

In both scenarios the *beef cattle stock* falls due to a decreased profitability and due to the competing occupation of space by dairy cattle. The effect of the sharper manure policy in the EUR scenario results in the largest decrease. Cheaper manure processing facilities, including for cattle manure temper this decrease to some extent.

The size of the *pig stock* in both scenarios does not deviate greatly from the situation in 2006. A slight expansion is possible in the REF scenario as a result of the positive circumstances for manure processing. This trend corresponds to the policy line in the Manure action plan 3 (MAP3), namely an expansion on condition of manure processing. In the EUR scenario there is a decrease compared to 2006 due to a limited sales area for manure and the stricter environmental requirements for manure processing.

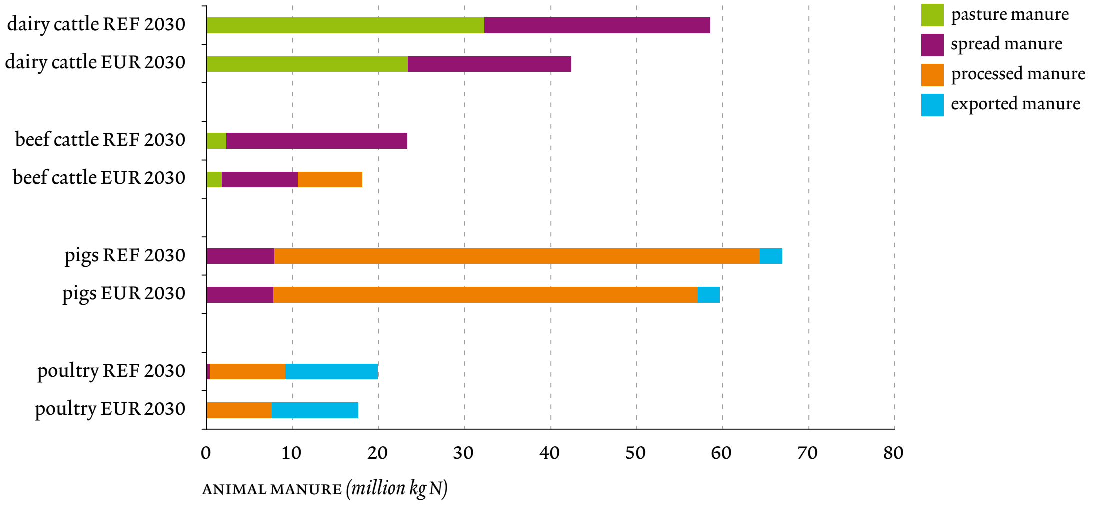
The *poultry stock* hardly deviates from the 2006 level in both scenarios. In the REF scenario a slight expansion is possible due to the positive circumstances for manure processing and the continuation of the current manure policy. In the EUR scenario there is a decrease compared to 2006 due to the more limited market for the manure.

Animal manure production and use

Animal manure production is only an environmental problem if there is a surplus of manure. The issue of the surplus of manure is considered later. This part studies how manure production, the use of manure on arable land and pastureland and manure processing may evolve. After all, these are extremely important for air emissions and the loss of nutrients to ground and surface water.

In the first place animal manure production develops along with the size of the stock-breeding. The decreasing stock-breeding in the EUR scenario results in a

FIG. 5.2 *Animal manure production and manure processing without deduction of N-losses in the REF and EUR scenarios (Flanders, 2030)*



decrease in the manure production for all types of animals in FIGURE 5.2. Secondly the manure production per animal is also lower in the EUR scenario than in the REF scenario because more efficient production techniques are used. The stricter environmental policy also increases the demand for this technology.

The total manure production in the REF scenario 2030 is 169 million kg nitrogen (N) and decreases by 1 % compared to 2006. In the EUR scenario the decrease continues more sharply to 19 %. These decreases correspond to the decreased stock but the increased productivity results in greater manure production per animal.

The scale of the 2030 manure processing is comparable in both scenarios. It is 65 million kg N in the REF scenario and 64 million kg N in the EUR scenario. In addition 13 million kg N is exported in both scenarios without processing. In 2007 the manure processing and export together totalled 19 million kg N. 47 % of the animal manure or 79 million kg N is processed and exported in the REF 2030 scenario. In EUR 2030 this is 77 million kg N, or 56 % of the animal manure produced. In both scenarios manure processing is successfully developed to a great extent by the agriculture sector. The assumption in this is that a market can also be found for the processed manure either nationally or internationally. Whether this is sufficient to achieve the basic environmental quality in the groundwater and surface water will be considered below.

Use of manure on arable land depends on the type of animal. The amount spread decreases sharply together with the cattle in the EUR scenario due to the limited market area for the manure. For dairy cattle the manure production during pasturing decreases proportionately to the manure produced in the barn, which is spread. There are fewer dairy cows. This also means that less manure is produced on the pasture and in the barn.

Use and choice of crop

The land use of agriculture decreases by 5 % in the REF scenario 2030 and by 3 % in the EUR scenario. The difference is set in such a way because the EUR scenario assumes a large increase in agriculture with environment or biodiversity targets. More land is needed to produce the equivalent amount due to an assumed 10 % loss of yield on the cultivation area.

FIGURE 5.3 gives an overview of the shares of the various crops for the year 2006 and 2030. In the REF scenario the share in the area of grain decreases due to the sharp increase of the dairy cattle with the related food area of maize and pasture/grassland. In the EUR scenario the arable farming area with environment or biodiversity target (EBT) grows sharply. This is at the expense of the grain area and to a lesser extent of potatoes and beets. These arable activities remain possible within EBT arable farming, although with a 10 % loss of yield. The share of maize area increases in the REF scenario as feed area for the growing dairy cattle and due to the decreasing agricultural area (-5 %). In the EUR scenario the area of maize decreases compared to 2006. Because the entire cattle stock decreases, this typical green feed area is freed up for other crops, including EBT.

The strong reduction of the cattle stock in the EUR scenario 2030 may result in a similar decrease of the grassland feed area. This is in contravention to the precondition directive of the European agricultural policy. A minimum of 22.3 % of the agricultural area registered for the collective request must be retained as permanent grassland. Grassland in this outlook includes both permanent grassland and temporary grassland. The standard for permanent grassland may be realised with a further decrease of cattle within the EBT area. More extensive pastureland may be used there. FIGURE 5.3 consequently indicates the EBT grassland share separately. This share is kept up to comply with the European directive.

FIG. 5.3 *Share of the crops in the agricultural area in the REF and EUR scenarios (Flanders, 2006 and 2030)*

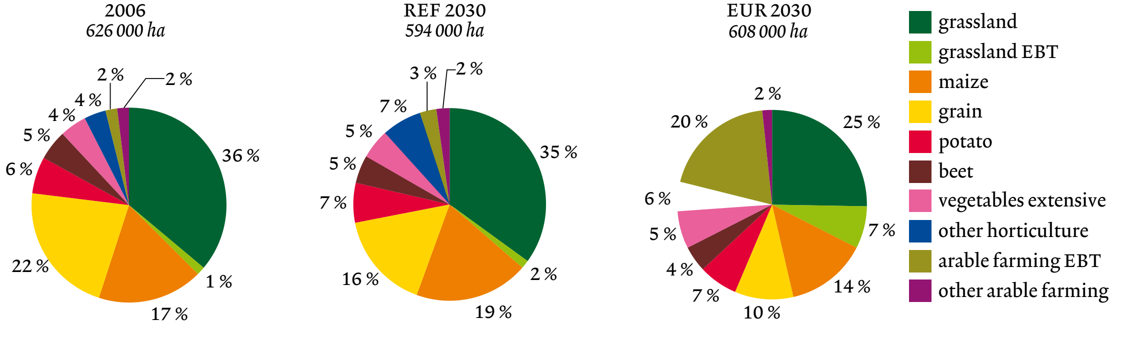
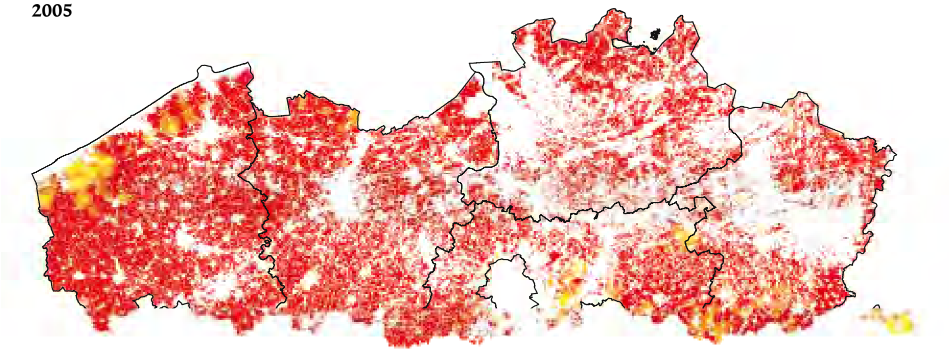
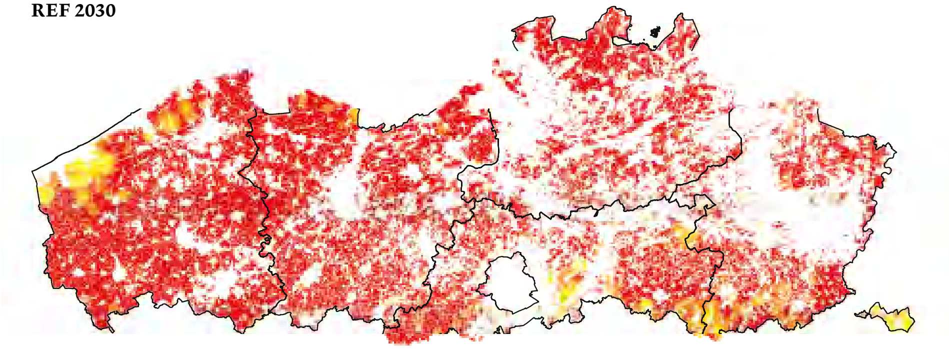


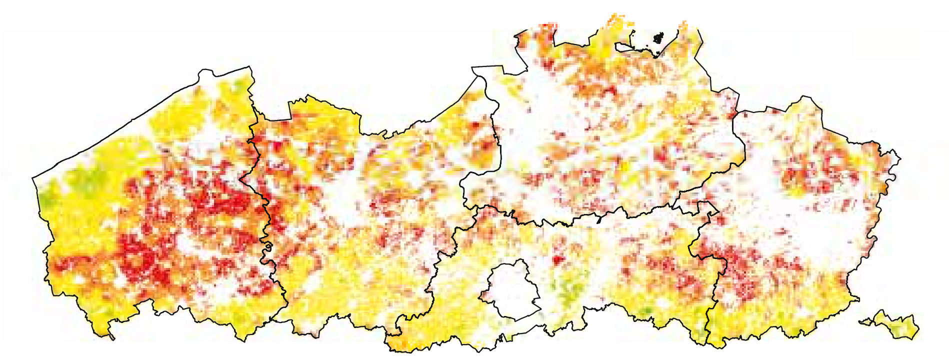
FIG. 5.4 *Interweaving of production agriculture and agriculture with environment or biodiversity targets, calculated as a share of EBT in a radius of 1 500 m around an agricultural plot of 2.25 ha (Flanders, 2005 and 2030)*

2005



REF 2030





Share of EBT

- 0 – 10 %
- 10 – 20 %
- 20 – 30 %
- 30 – 40 %
- 40 – 50 %
- 50 – 60 %
- 60 – 70 %
- 70 – 80 %
- 80 – 90 %
- 90 – 100 %

The share of horticulture, as the total of extensive vegetables and other horticulture increases in both scenarios. Other horticulture includes fruit cultivation, ornamental plant cultivation, intensive vegetable cultivation and greenhouse farming. The share in the EUR scenario is lower due to the slightly larger agricultural area. All horticultural activities are growing, except the greenhouse farming area, which remains constant. High investment costs limit the further expansion of greenhouse farming.

A dynamic-spatial land use model simulates the evolution of the use of land in Flanders (see Chapter 10 Land use). Land use indicators were derived from the model simulations. FIGURE 5.4 illustrates the extent to which agriculture with environment or biodiversity target is *interwoven* with production agriculture in Flanders, for the start year, the REF scenario and the EUR scenario in 2030. Production agriculture is a complement to EBT agriculture. The extent of this agricultural activity is described in TABLE 5.1.

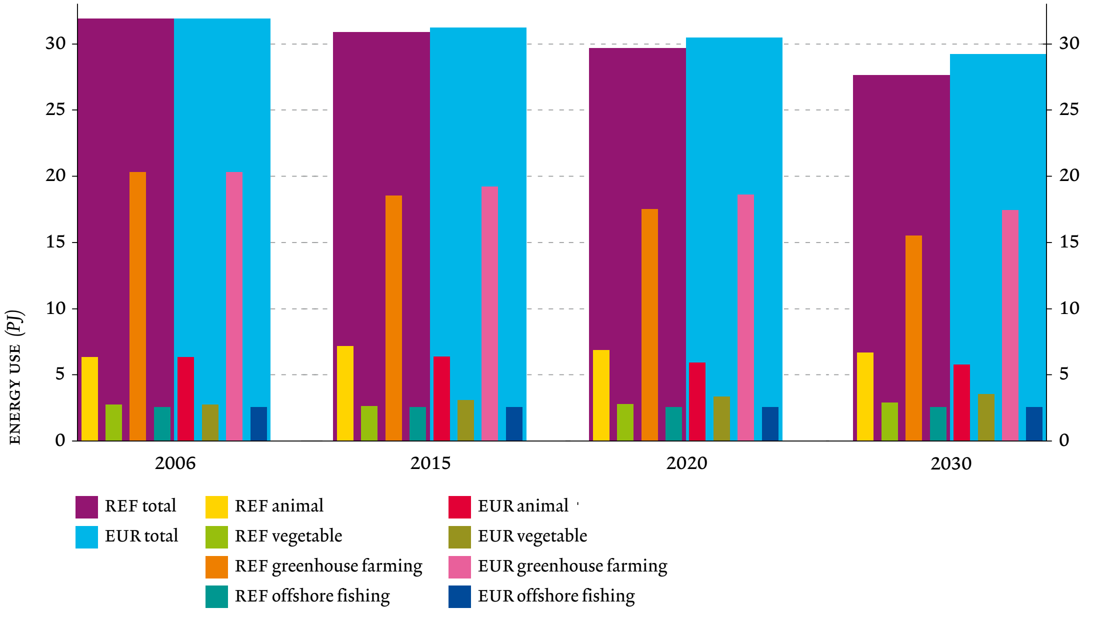
The 100 % value means 100 % agriculture with environment or biodiversity target, considered in a radius of 1 500 m around 2.25 ha unit. Where agriculture with environment or biodiversity target is established, depends on the allocation per agricultural region, of agriculture with environment or biodiversity target already present and finally the erosion sensitivity or the vicinity of watercourses in a region. From a 50 % value and higher, EBT agriculture dominates. In the pattern on the EUR scenario 2030 map erosion sensitive regions may be identified in southern Flanders. In addition the regions with a lot of digitised watercourses may also be identified, e.g. the polders in West Flanders and the Nete basin in Antwerp.

5.3 Energy use

Direct agricultural energy use decreases in both scenarios (FIGURE 5.5). In the future outlook the use of energy decreases in 2030 by 13 % in the REF scenario and 9 % in the EUR scenario. The motor for this decrease is the sharp fall in energy use in greenhouse farming. The share of greenhouse farming in energy use in the agricultural sector will consequently also drop from 64 % in 2006 to 56 % in REF 2030 and 60 % in EUR 2030. Specific measures have been taken in the scenarios for greenhouse farming (see inset text *Energy use in greenhouse farming).*

For the other subsectors no special energy measures have been taken. This means that the energy use is a reflection of the evolution of the level of activity. Nevertheless energy saving (more efficient engines), recuperation (e.g. heat exchange) and production (e.g. wind turbines, biogas, solar energy) are also possible here.

FIG. 5.5 *Energy use by agriculture in the REF and EUR scenarios (Flanders, 2006-2030)*



Energy use in greenhouse farming

The energy use decreases in all scenarios, due to the phasing out of coal and fuel oil, through energy saving cultivation techniques and through the use of cogeneration of heat and power (CHP) and industrial residual heat. However this results in the growth of more energy intensive crops, which partly counteracts some of the savings. All the figures below are applicable to the year 2030.
The shift to lower energy crops, the use of energy saving techniques and the use of CHP for 45 % of the energy needs , causes a sharp decrease in the REF scenario. The use of energy saving techniques applies to 53 % of the glass area with greenhouse renewal. The energy use is higher in the EUR scenario. This is the result of 25 % more energy intensive crops in the EUR scenario. In addition the share of CHP increases to 66 % of the energy requirement. Due to the complete renewal of the greenhouse area, energy saving techniques over the entire glass area are introduced at a rate of 17 % savings per m² compared to a standard greenhouse in 2006.
The visionary scenario (VISI scenario) uses residual heat in clustered greenhouse parks in the vicinity of heat-supplying industries. The VISI scenario aims to halve greenhouse gas emissions by 2030 (see Chapter 1 Policy scenarios) . Energy saving techniques become more efficient through the use of advanced integrated greenhouse systems with 75 % savings per m². This ensures that more energy intensive crops are cultivated because the financial return increases as a result. The total energy use is thereby higher than in other scenarios. However on the other hand the energy is used more efficiently, with fewer greenhouse gas emissions.

5.4 Greenhouse gas emissions

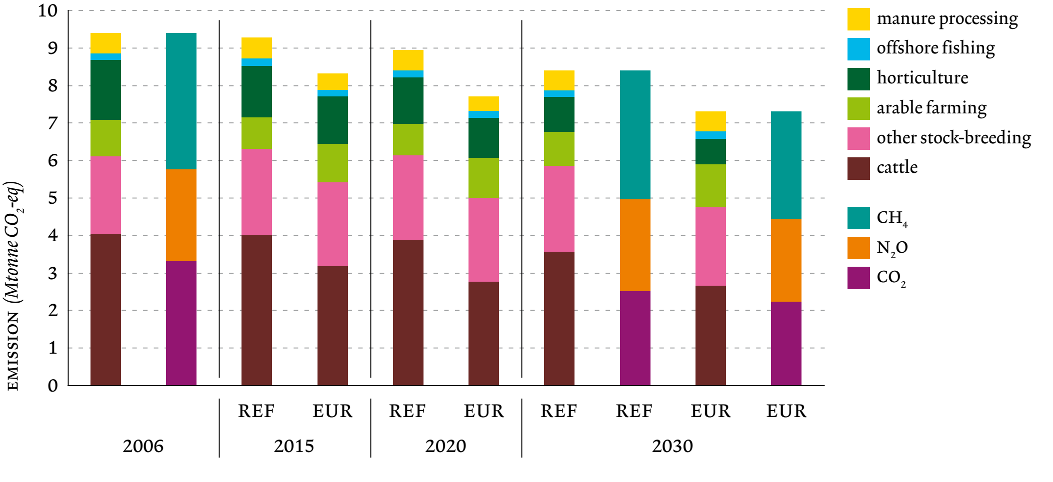
The global share of agriculture in greenhouse gas emissions was 13.5 % in 2004, not taking deforestation for agriculture into account. This is stated in the fourth *assessment report* by the Intergovernmental Panel on Climate Change (IPCC). Deforestation for agriculture and other purposes has a 17.4 % share. Aligned to the agrarian processes in Flanders this share comes to 11 %. It is characteristic for the sector that the greenhouse gas emissions resulting from the combustion of fossil fuels (energetic greenhouse gases) have a limited share. The greenhouse gases come especially from biological processes: methane (CH_4) from digestive processes and from natural fermentation of animal manure, nitrous oxide (N_2O) with the use of fertilisers and carbon dioxide (CO_2) from the decomposition of organic soil material. This chapter does not pay any further attention to the emissions caused by production processes outside Flanders but resulting in consumption in Flanders.

This section summarises the agricultural activities from FIGURE 5.3 in four groups:

- Arable farming includes the cultivation of grains, excluding feed maize, potatoes, beets and other commercial crops including EBT agriculture.
- Horticulture includes fruit cultivation, ornamental plant cultivation, vegetable cultivation and greenhouse farming.
- Cattle includes the cattle stock and the pastureland and maize feed area.
- Other stock includes the pig and poultry stock, without land.

FIGURE 5.6 outlines the possible evolution of the emissions of the greenhouse gases CO_2, N_2O and CH_4. In the REF scenario the emissions decrease by 11 % compared to 2006 to 8 403 ktonnes CO_2 equivalents. Causes include the decrease of the less

FIG. 5.6 *Greenhouse gas emissions by agriculture in the REF and EUR scenarios (Flanders, 2006-2030)*



profitable beef cattle stock and the energy saving measures in greenhouse farming. The growing dairy cattle stock and the pig stock partly counteract this decrease.

In the EUR scenario emissions drop by 22 % compared to 2006 to 7 303 ktonnes CO_2 equivalents. The decrease in greenhouse farming is twice as large due to the additional implementation of CHPs and the phasing out of coal and fuel oil. In addition to beef cattle, the dairy cattle stock also decreases. These reductions are greater than in the REF scenario due to a stricter manure policy.

As before, the manure policy also contributes to the reduction of emissions of nitrous oxide and methane. Nevertheless the cattle share in the emissions remains equivalent at approximately 65 % in both scenarios. The share of energetic greenhouse gases drops by 22 % in 2006, to 16 % in the REF and 14 % in the EUR scenario 2030. This is primarily the result of energy savings in greenhouse farming in an equivalent glass area. The share of manure processing in greenhouse gas emissions fluctuates around 6 % in all years and scenarios considered. This source of emissions is estimated the same everywhere. Better control of the manure processing procedures can reduce emissions further.

If the emissions from the production of electricity and heat are included in the calculations for agriculture, then this increases the emissions by 361 ktonnes in 2006 or 4 %, 916 ktonnes or 11 % in REF 2030 and 1 343 ktonnes or 18 % in EUR 2030. Greenhouse farming increasingly uses CHP on the one hand, for which the emissions are allotted to the energy sector and industrial residual heat on the other, for which the emissions are allotted to industry. The emissions are thereby passed to other sectors but at the same time these are both more efficient techniques that result in lower emissions across sectors.

5.5 Soil balance, emissions of acidifying substances and particulate matter

Soil balance

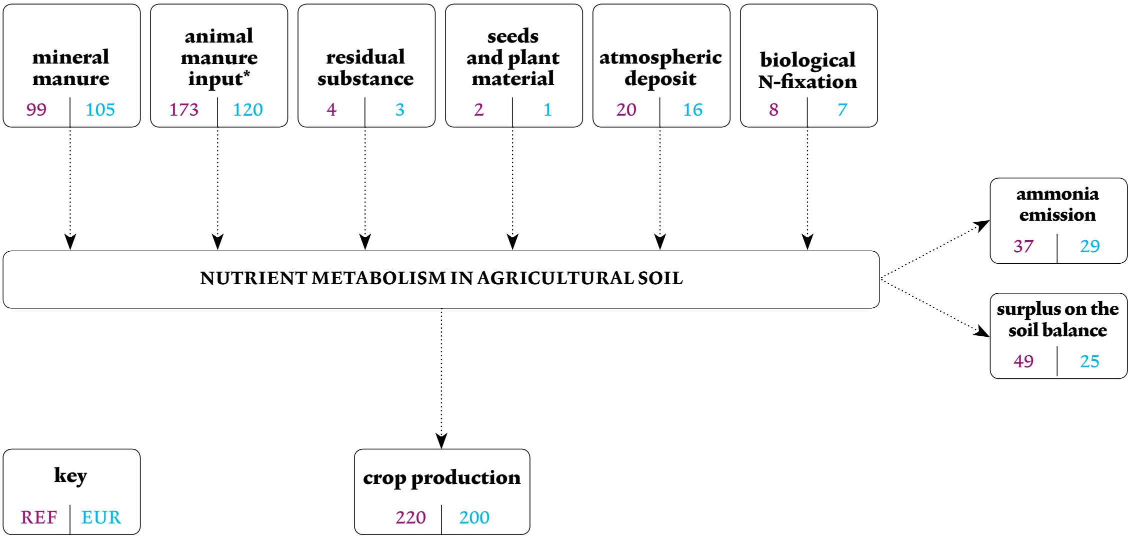
The soil nutrient balance for agriculture consists on the one side of the number of nutrients that are input into the agricultural soil (manure, atmospheric deposit, biological nitrogen fixation, sown goods). The output side is then the quantity leaving the agricultural soil: these are nutrients that are removed with the harvest crops, the ammonia emissions from the soil and the manure and the other emissions that pass to the environment via the agricultural soil. The latter flow is the surplus on the soil balance.

In the Flemish 2008-2010 Environmental Policy plan the *target* for the surplus on the soil balance is set at 70 kg N/ha. To achieve good water quality this target must be tightened. Good water quality means that the 90^{th} percentile of the nitrate measurements is below 10 mg NO_3-N/l in the surface water. This is the quality standard for good water quality in the water type stream according to the draft river basin management plan for the Scheldt and Meuse (CIW, 2008). For groundwater the standard of 11.3 mg NO_3-N/l is applicable. A new target for the surplus from the soil balance is derived here against which the results of the scenarios are tested. This is determined at 42 kg N/ha.

The surplus only goes below the target of 42 kg (FIGURE 5.7) in the EUR scenario. Compared to the REF scenario not only the animal manure input is lower but also the removal of nutrients through crop production. In addition the decrease of the area of feed crops maize and grass results in a lower nutrient removal through crop production. Less nitrogen is circulating as a result of the stricter manure policy. In order to keep agricultural production at the right level, a higher use of artificial fertilizer to 105 kg N/ha compensates for the limitation of the animal fertilizer to 140 kg N/ha in the EUR scenario. This is an increase by 6 % compared to the REF scenario 2030. However the surplus on the soil balance drops to 25 kg N/ha in the EUR scenario in 2030, halving that of the REF scenario. A marginal note here is that the increased use of artificial fertilizer may result in greater dependence on energy. The production of artificial fertilizer requires a huge amount of energy.

These results show that even the extensive manure processing in the REF scenario 2030 is not sufficient to keep the surplus on the soil balance under the target derived from the WFD in the long term. This does succeed in the EUR scenario through a stricter manure management and the greatly decreased inflow of nitrogen in agriculture. This result is only applicable for nitrogen. The indicator 'surplus on

FIG. 5.7 *Soil nutrient balance of agriculture in kg N/ha in the REF and EUR scenarios (Flanders, 2030)*



* animal manure input = animal manure production - manure export - manure processing

the soil balance' is an average here for the whole of Flanders. It consequently does not guarantee that the water quality standard will be achieved locally for surface water.

Emissions of acidifying substances

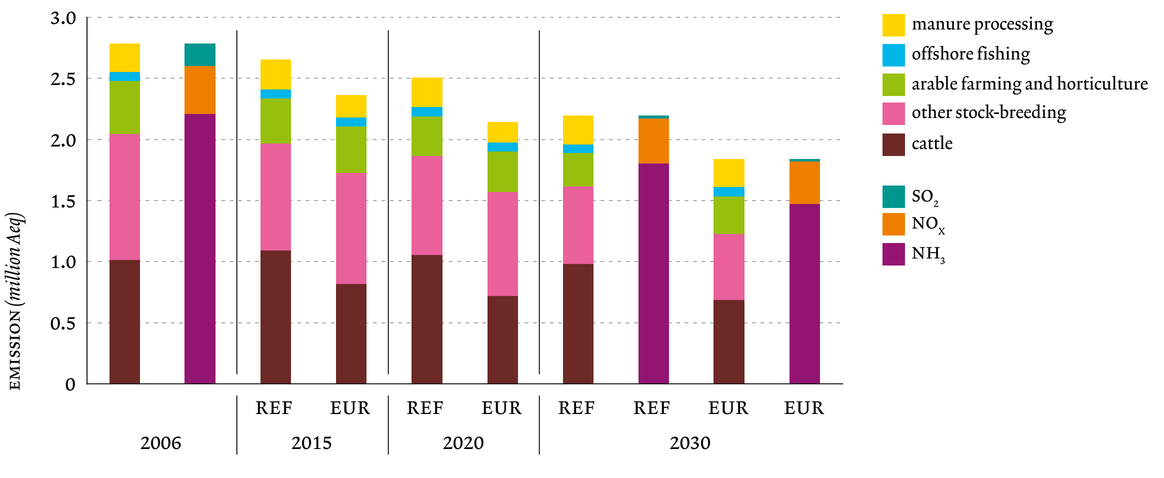
Flemish agriculture was responsible for 34 % of acidifying emissions in 2007. The emissions of acidifying substances cause cross border acidification and eutrophication (see Chapter 9 Air Quality). The contribution of agriculture mainly consists of ammonia (NH_3), which is released from fertilizers. Fertilizers are either animal based or artificial substances used in arable farming and horticulture. Nitrogen oxides (NO_X) and sulphur dioxides (SO_2) are released from the combustion of fossil fuels in all subsectors of agriculture.

In the REF *scenario* the acidifying emissions fall by 21 % between 2006 and 2030 (FIGURE 5.8). New low emission barns for pigs and poultry explain two thirds of the drop or 14 % compared to 2006. Low emission barns also result in decreased odour emissions from pig barns. Various measures in greenhouse farming, such as the phasing out of coal and heavy fuel oil, the new energy efficient greenhouses and new CHP installations play a role in this.

In the EUR *scenario* the drop by 34 % is even larger. Here the reduction in the cattle stock causes the decrease. It represents a third of the reduction or 12 % compared to 2006. Due to the slightly decreasing pig and poultry stock these emissions also decrease further by 2 %. In addition the same measures in pig-breeding and greenhouse farming realise the same decrease in emissions.

In 2030 all pigs are housed in *low emission barns* in both scenarios. Poultry makes the difference, as the annual emissions for poultry drop to 87 kg NH_3/animal in REF 2030 to 63 kg NH_3/animal in EUR 2030. The reduction in cattle in the EUR scenario further reinforces this effect.

FIG. 5.8 *Emissions of acidifying substances by agriculture in the REF and EUR scenarios (Flanders, 2006-2030)*



The ammonia emissions drop far below the emission ceiling of 44.5 ktonnes of emissions imposed as a target for Flanders in 2010 in all sectors as a result of this reduction. Agriculture has to make the largest contribution with 93 % of the share of emissions in 2007. In the 2015 REF scenario the emissions are 36.3 ktonnes and in the REF scenario 2030 30.5 ktonnes. In the EUR scenario it is even harder, to 25 ktonnes in 2030.

Emissions of particulate matter

Particles are released in agriculture through:
- the combustion of fossil fuels;
- stock-breeding (amongst others NH_3);
- non-exhaust emissions from agricultural vehicles;
- blown soil dust during tillage of agricultural land.

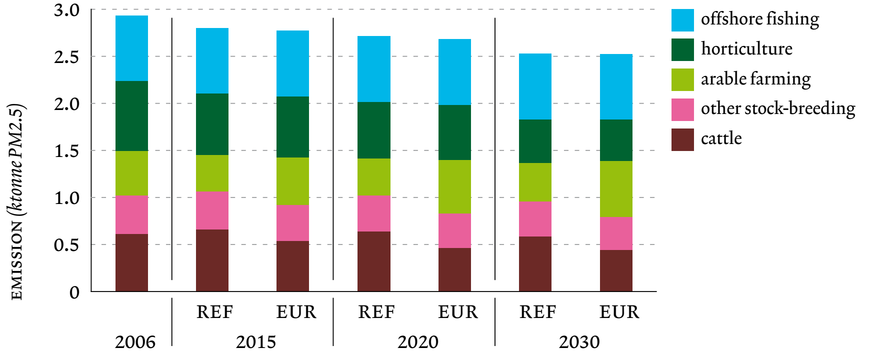
In 2006 agriculture was responsible for 36 % of the total Flemish dust emissions. For the PM10 and PM2.5 fractions this comes to 35 % and 21 % of Flemish emissions.

The evolution in the scenarios is identical for all the aforementioned fractions and for the total particulate emissions for the entire agriculture sector. Depending on the fraction, the share of the subsectors is different here however. The discussion further relates to the PM2.5 fraction. This is an important fine particle fraction, amongst others for public health.

Between 2006 and 2030 the emissions in both scenarios decrease by 14 % (FIGURE 5.9). However the cause is different in the different scenarios. In the *REF scenario* the decrease in emissions from greenhouse farming is prominent, with 9 % compared to the total PM2.5 emissions in 2006. The area development for arable farming represents a 2 % decrease in emissions due to the reduced grain area. The smaller cattle stock results in a 1 % decrease in emissions. Other stock-breeding represents a 1 % decrease in emissions due to the effect of low emission pig barns.

In the *EUR scenario* the reduced cattle stock results in a 6 % decrease in emissions. Other stock realises a 2 % drop in emissions. In greenhouse farming the measures have a slightly larger effect. There emissions decrease by 10 %. The choice of crops in arable farming causes more emissions from the tillage of agricultural land and use of fuel, which results in an increase by 4 %. The arable farming area grows, due to vacant ground for green feed production. *No-tilage* farming may be applied to limit particle emissions during soil cultivation. This entails that no ploughing is carried out, which also decreases the particle emissions in addition to limiting erosion.

FIG. 5.9 *Emissions of the particulate matter fraction PM2.5 by agriculture in the REF and EUR scenarios (Flanders, 2006-2030)*



5.6 Eco-efficiency

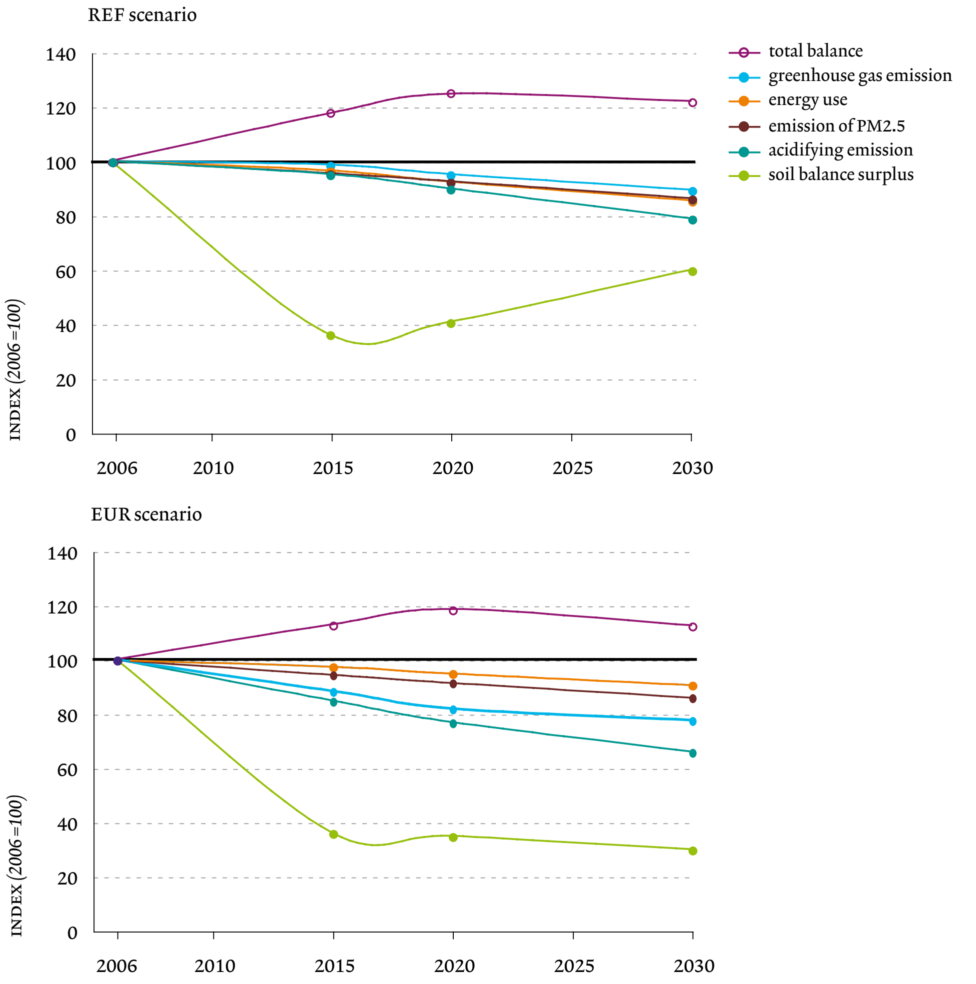
This section compares the evolution of the environmental pressure to the development of the activities, as modelled in the scenarios.

The total balance for agriculture is the activity indicator here. The total balance is calculated with actual prices. An increasing balance is consequently the effect of real price developments and volume developments. The real price developments eliminate the effect of inflation. Eco-efficiency of agriculture, as published in MIRA-T 2007, uses the gross value added in real prices as an activity indicator. The total balance differs from the gross value added on the cost side. This is because non-allocated variable costs and fixed costs are not charged in the total balance but hidden costs[2] are. On the return side the gross value added includes non-product-related subsidies. For 2006 the gross value added in constant prices is estimated at 2 156 million euro (MIRA-T 2007). The total balance in this study is estimated at 2 256 million euro for 2006.

The total balance for the Flemish agricultural sector is higher in both the REF scenario and the EUR scenario than in 2006 (FIGURE 5.10). The increases are a result of an increase of the financial balances, both in stock farming and in arable farming and horticulture. For the latter the increase in the balance is even slightly larger, which is due to the more beneficial price evolutions. However the total balance is not as high in the EUR scenario. This is the result of the dampening effect of the stricter manure policy.

In both scenarios the eco-efficiency of agriculture increases. In both cases there is a question of absolute disconnection. In the EUR scenario the disconnection is even greater as a result of the stricter manure policy.

FIG. 5.10 *Eco-efficiency of agriculture (excluding offshore fishing) in the REF and EUR scenarios (Flanders, 2006-2030)*



5.7 Conclusions for policy

There is a clear disconnection between the economic growth of the agriculture sector and the environmental pressure in both scenarios. This disconnection may be explained by the increase of the total balance and the decrease in environmental pressure. Both the current environmental policy and the stricter environmental policy ensure increasing eco-efficiency. The increasing eco-efficiency does not however guarantee that all targets will be reached. The continuation of the current environmental policy results in further reductions of emissions, which are insufficient to achieve all the long-term environmental targets.

Measures in greenhouse farming make it possible to decrease energy use. In addition it becomes possible to be less dependent on fossil fuels. As a result of the use of more energy intensive crops greenhouse farming may again increase energy use in the EUR and VISI scenarios. The air emissions do decrease in this as a result of the use of more environmentally friendly sources of energy. For the other subsectors there is also a potential for energy saving (e.g. more economical engines), energy recuperation (e.g. heat exchangers) and energy production (e.g. wind turbines, biogas, solar energy).

The greenhouse gas emissions decrease sharply in the EUR scenario. This is realised both through measures that reduce the energy use in greenhouse farming and as a result of the decrease in the cattle stock, which is in turn due to a stricter manure policy.

This is also true for the indicator 'surplus on the soil nutrient balance'. The surplus only drops below the target proposed here in the EUR scenario. This makes it possible to achieve the targets from the water policy for nitrogen. The key is the decrease in the stock-breeding. Manure processing alone is not sufficient in the EUR scenario.

The emissions of acidifying substances decrease as a result of the current policy of low emission barns. A further decrease is possible in the EUR scenario because the cattle stock is reduced and as a result of the energy policy in greenhouse farming.

This study does not indicate any difference for particulate matter emissions between the scenarios. The emissions decrease equivalently in both scenarios but there are different causes for it. The emissions due to the cultivation of agricultural land may constitute the difference. The choice of crop and the cultivation practices for the soil determine this source of emissions. Naturally this also depends largely on both the agricultural policy and the size of the stock.

Buffer measures in agricultural area with environment or biodiversity targets have an effect on the erosion formation and washing into the surface water. These effects have not been factored in but may be important.

Although the EUR scenario imposes strict environmental measures on the sector, a sustainable agricultural sector is possible in the long term. Only the simulated agricultural area with environment or biodiversity targets of 162 000 ha results in very low financial balance per hectare and is not feasible without any additional compensation. This compensation must serve as a recompense for the environment and biodiversity services the farmer provides to society.

END NOTES

1 The total balance in the SELES model is the product of the financial balance and scope of the activity. The balance is the financial yield of an activity minus the variable costs attributed, including the product related agricultural subsidies. Fixed costs such as investments and non-attributable variable costs are not deducted in the calculation of the financial balance (depreciations, maintenance, interests, labour, expansion, etc.).

2 Hidden costs are costs that are not explicitly stated in the accounting data but are assumed to calibrate the model to real observed starting situations or in the context of an outlook on assumed autonomous developments.

LIKE TO KNOW MORE?

If you would like to know more, you can refer to the scientific reports which form the basis for this chapter:

Overloop S., Gavilan J., Carels K., Van Gijseghem D., Hens M., Bossuyt M. & Helming J. (2009) Landbouw. Scientific report, MIRA 2009 & NARA 2009, VMM, INBO.R.2009.30, www.milieurapport.be, www.nara.be.

Bergen D. & Vander Vennet B. (2009) Deelsector glastuinbouw. Scientific report, MIRA 2009, VMM, www.milieurapport.be.

READERS

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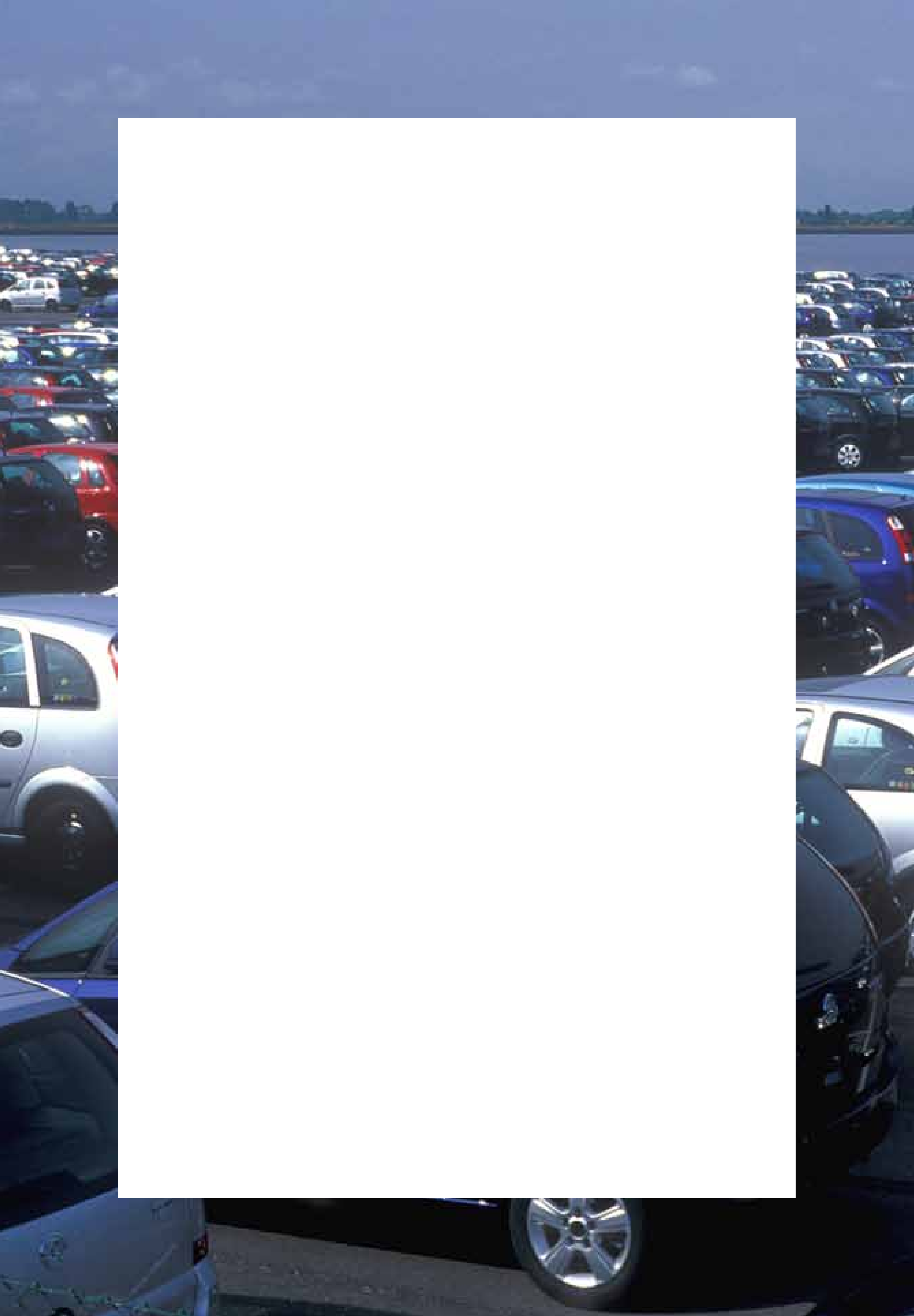

6 Transport

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OUTLINES

- If the current policy is continued (reference scenario, REF), the transport flows will increase until 2030. The road-pricing system, as provided in the Europe scenario (EUR), does decrease motorised road traffic but does not result in any major shift in rail transport and inland shipping. Due to a modal shift and increased efficiency in the visionary scenario (VISI) the motorised road traffic decreases further but is still higher than today.

- In 2030, greenhouse gas emissions from transport will be 10 % higher than today if the policy is unchanged. More stringent measures in the context of the future European Climate and Air Policy (EUR scenario), result in a 25 % decrease during the same period. The VISI scenario, the most ambitious of the three, results in a reduction by more than 35 %.

- The additional policy measures result in a lower share of fossil fuels in 2030. More intensive use of biofuels (EUR scenario) triples their share in the energy mix used for transport. The VISI scenario does not use biofuels. It assumes a more efficient use of biomass in other sectors. The persistent use of plug-in hybrids and electric vehicles doubles the share of electricity in the energy mix in this scenario in 2030 compared to the EUR scenario.

- The REF scenario does not reach the European target to use 10 % renewable energy by 2020 in transport. The EUR scenario does achieve that target, thanks to the increased use of both first and second-generation biofuels.

- The recently approved measure that further limits NO_x emissions of heavy goods vehicles, is important to reach the indicative 2020 target for NO_x. A further reduction of the sulphur content of shipping fuels ensures that the SO_2 emissions decrease sufficiently. The measures in the EUR scenario are inadequate for emissions of particulate matter (PM2.5). Additional efforts are necessary.

Introduction

Without the transport of people and goods our society and the economy would come to a complete standstill. Transport is essential, but at the same time a source of environmental problems. Indeed it contributes to climate change through greenhouse gas emissions. Transport is also harmful to health: emissions of particulate matter thereby lead to an increase in respiratory disorders. Emissions of nitrogen oxides (NO_x) and non-methane volatile organic compounds (NMVOC) result in the formation of ozone, which in turn damages both our health and the ecosystems. The acidification of the environment is a direct result of the emissions of nitrogen oxides and sulphur dioxide (SO_2). Transport finally also requires bags of energy. The stock of fossil fuels is finite. For that reason energy must be used economically and more energy efficient and environmentally friendlier modes of transport are preferred.

In this chapter two scenarios are considered that may result in a more environmentally friendly and more energy efficient transport. Both scenarios are compared with the reference scenario, in which the current policy is continued.

The first part of this chapter gives a description of the three scenarios. How these scenarios influence the transport flows is then considered and what the effects are on the amount of energy, the type of energy used and the greenhouse gas emissions. Which scenarios reach the indicative European targets for the emission of specific air pollutants are then investigated. Local effects are not taken into account here: only effects at a Flemish scale are considered. This chapter finally describes certain cost aspects of the various scenarios. The policy conclusions complete the topic. This chapter does not consider the issue of noise pollution. Chapter 13 Noise considers this in more detail.

6.1 Principles of the Environment Outlook

Modelling

The transport sector includes road transport, railway transport, inland shipping, maritime shipping[1] and air transport[2]. Different models were used for the various transport modes in the reference scenario (REF) and the Europe scenario (EUR). The models calculate the use of energy and the emissions starting from the flows of transport. For road traffic, railway traffic and inland shipping a specialised traffic model was used to calculate the transport flows, the Flanders multimodal model. The calculations for maritime shipping and air transport are more straightforward: an annual growth is assumed here. In order to reduce the emissions and use of energy, solutions are possible both at the level of transport flows and technological developments. The visionary scenario (VISI) starts from the results of the EUR scenario and provides a supplemental policy for road traffic, railway transport and inland shipping. The VISI scenario does not estimate the future development of maritime shipping and air transport itself. In order to be able to compare the results of the three scenarios, the VISI scenario uses the same data for maritime shipping and air transport as the EUR scenario.

Three scenarios

- The *REF scenario* assumes that the current environmental and transport policy is sustained. The measures are described in the framed text *Measures from the REF scenario.* More details can be found in the scientific reports of the Transport sector of the Environment Outlook 2030.
- The *EUR scenario* plans additional measures that may help to realise the European medium-term targets (2020) (see the framed text *Measures from the EUR scenario).* This relates to the targets in the framework of the European Climate and Energy package and the indicative targets for the emission of certain air pollutants. This scenario primarily uses technological measures. Measures to influence the transport flows are rather limited. The formulation of the new Flanders Mobility Plan is still fully in progress. As a result insufficient information was available on the future transport policy in the formulation of the scenarios.
- The *VISI scenario* contains the most drastic and ambitious measures to reduce greenhouse gas emissions in the longer term (see the framed text *Measures from the VISI scenario).* After all, the further limitation of greenhouse gas emissions after 2020 is an international goal. Therefore, the VISI scenario invests technologically in a more intensive use of electricity as a source of energy. Electric vehicles are more energy efficient and more market ready than vehicles using hydrogen. The VISI scenario also uses more green power than the other scenarios, so the use of electricity generates even more environmental benefits. This scenario is finally also characterised through more intensive mobility measures on top of those in the EUR scenario.

Measures from the REF scenario

- Introduction of the policy decided on April 1st 2008 concerning the standardisation of vehicles and vessels and fuels.
- Use of vehicles with smaller engines while retaining the power. Introduction of hybrid vehicles and electric vehicles to a limited extent. The number of vehicles using hydrogen remains negligible.
- Limited use of biodiesel and bio-ethanol for road traffic and biodiesel for rail.
- Installing more environmentally friendly engines in inland shipping (*retrofitting*).
- Improving energy efficiency in inland shipping and air transport.
- Infrastructure changes included in an execution programme or that will almost certainly be executed by 2020.
- Realisation of the Gewestelijk ExpresNet (Regional Express Network - GEN) around Brussels and the Diabolo connection to Brussels airport, plus a few more limited adaptations to public transport.
- Improved efficiency of the railways, i.e. an improvement of seat occupancy, load factor or train scheduling.

Measures from the EUR scenario

- Introduction of Euro VI for heavy goods vehicles, further emission and fuel standardisation for inland and maritime shipping.
- Measures that fit with the stricter legislation on CO_2 emissions of new cars: on the one hand further improvement of efficiency and more use of alternative engine fuels and vehicle technologies, on the other hand more use of biofuels, teaching eco-driving and the use of better tyres.
- Measures that reduce the fuel consumption of trucks: improved aerodynamics for heavy goods vehicles and teaching eco-driving.
- Introduction of less energy consuming air conditioning systems in private cars.
- Introduction of biofuels in inland shipping, use of higher proportions of biofuels in rail.
- Use of quayside electricity in inland and maritime shipping.
- Road-pricing for freight transport from 2012 and for passenger transport from 2017. On all roads a fixed rate is applied of 0.034 euro per vkm supplemented by a congestion charge of 0.11 euro per vkm during rush hours on all roads within the Flemish Diamond.
- Inclusion of air transport in a global emissions trading system (ETS system).

Measures from the VISI scenario

- More intensive use of plug-in hybrid cars and battery electric cars, limited use of hydrogen.
- No use of biofuels.
- By 2030, using the bike for half the commuter travel of less than 15 km that would otherwise be made by car.
- Limited modal shift from the car to public transport.
- Growth of rail and inland shipping by half through modal shift for freight transport.
- Further decrease by 8 % of freight transport by road, due to improved efficiency.

6.2 Transport flows

The transport flows continue to rise until 2030 in the REF scenario. In the EUR scenario (motorised) road traffic and air traffic decrease compared to the REF scenario. No significant increase is observed in rail transport and inland shipping. In the VISI scenario the road traffic transport flows are the lowest in 2030 compared to the other scenarios. However, they also remain higher than today in this scenario. Rail transport and inland shipping increase significantly.

To verify whether measures such as road-pricing cause a shift from one mode of transport to another, this chapter discusses the transport flows of passenger transport and freight transport separately. This difference cannot be made for air transport: consequently air transport is discussed as a whole.

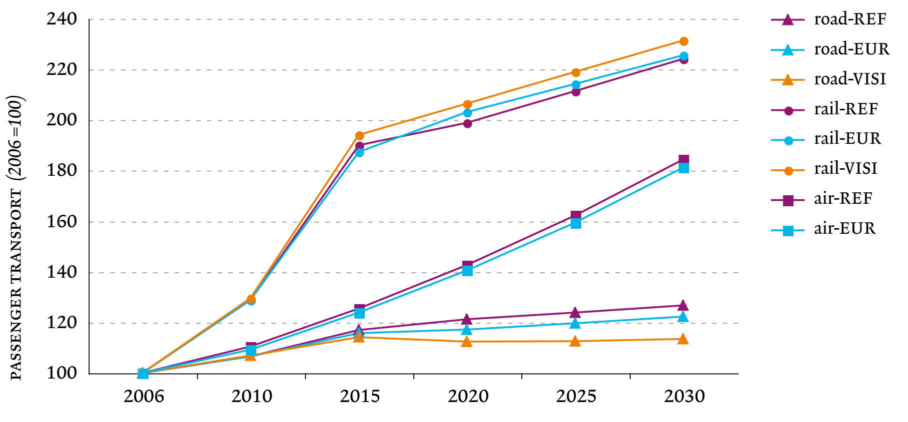
Transport flows of passenger transport

In all scenarios, the passenger transport for both (motorised) road traffic and rail traffic is higher in 2030 than in 2006 (FIGURE 6.1). If the current policy is continued the road traffic will increase by 27 % in 2030, railway transport will more than double. It is possible that the predicted growth of rail is overestimated because it is based on data during rush hours. The sharp increase until 2015 is due to the development of the GEN. This network will absorb the increasing transport needs in and around the capital.

The road-pricing system as provided in the EUR scenario, has a limited effect on road and rail traffic. Compared to the REF scenario, road-pricing allows road traffic to decrease by 3 % by 2030 (TABLE 6.1). The increase in rail transport is less than 1 %. Note: both scenarios assume the same economic and socio-demographic data. Consequently, for passenger transport, the model does not allow for people deciding not to make certain trips as a result of road-pricing. Motorists may avoid the road-pricing system by taking a shorter route or a route outside the Flemish Diamond, by car-pooling to share costs more or by using public transport.

As a result of the increased use of the bicycle and train, (motorised) road traffic decreases by 11 % in 2030 in the VISI scenario compared to the REF scenario, railway travel increases by 3 %.

FIG. 6.1 *Transport flows of passengers in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



TAB. 6.1 *Transport flows of passengers in the REF, EUR and VISI scenarios (Flanders, 2006 and 2030)*

	2006	REF 2030	EUR 2030	VISI 2030
Road (billion pkm)	67.12	85.06	82.10	76.08
Rail (billion pkm)	6.66	14.92	15.02	15.41
Air (movements)	360 275	664 322	652 277	-

Data for road traffic is representative for 2007 instead of 2006. Bicycle travel is not included in the number of passenger kilometres (pkm) by road. Air travel includes both goods and passengers but excludes military flights.

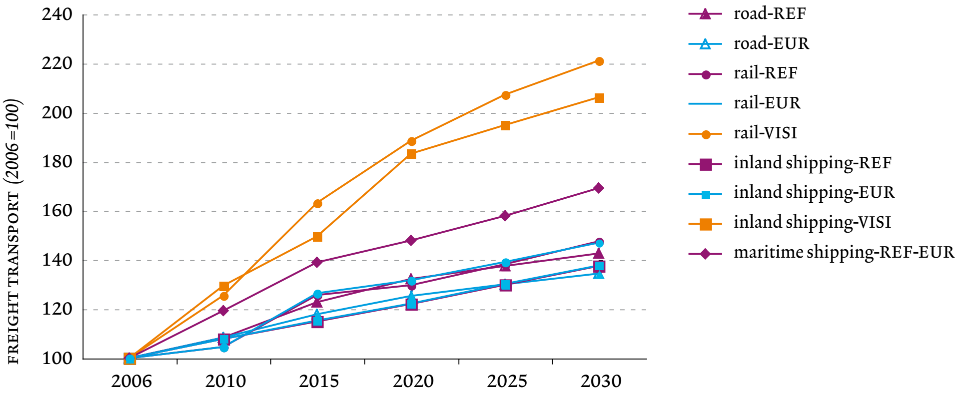
Transport flows of freight transport

In both the REF and EUR scenarios the freight transport increases for all modes until 2030 (FIGURE 6.2). In the REF scenario maritime shipping increases the most. Rail, freight transport by road and inland shipping also increase significantly. The main effect of the system of road-pricing applied here is that the road traffic decreases for freight transport without causing a major shift to railway transport and inland shipping (TABLE 6.2). This is because only 10 to 20 % of the total freight traffic is eligible to use other transport modes. In addition compared to the total costs for freight traffic (including labour costs) the added cost of road-pricing is limited. In 2030 road traffic will decrease by 6 % compared to the REF scenario. The decrease is primarily the result of better loading.

Because no detailed calculations are available for light vans, TABLE 6.2 cannot give the total number of kilometres for road transport in the VISI scenario.

For heavy goods vehicles a conclusion may be drawn: the number of kilometres driven by heavy goods vehicles is approximately one fifth lower in the VISI sce-

FIG. 6.2 *Transport flows of freight in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



TAB. 6.2 *Transport flows of freight in the REF, EUR and VISI scenarios (Flanders, 2006 and 2030)*

	2006	REF 2030	EUR 2030	VISI 2030
Road (billion vehicle km)	12.37	17.63	16.63	-
Rail (billion tonne km)	4.32	6.37	6.35	9.55
Inland shipping (billion tonne km)	6.46	8.88	8.90	13.32
Maritime shipping (reports)	1 204	2 037	2 037	-

Data for road traffic is representative for 2007 instead of 2006. Road traffic is expressed in vehicle kilometres and not in tonne kilometres due to uncertainties of load factors. Railway transport also includes shunting activity and activities by operators other than the NMBS (Belgian National Railways). Maritime shipping only includes callings from trading ships and no activities of dredging and tug boats, the annual growth is the same in the REF and EUR scenarios.

nario than in the REF scenario in 2030. Compared to 2006 the number of kilometres is still a third higher. Railway transport and inland shipping are 50 % higher in 2030 in the VISI scenario than in the REF scenario.

Transport flows for air transport

Air transport is a combination of both cargo and passenger transport (FIGURE 6.1). The air transport activity increases in the REF scenario by 84 % in 2030 compared to 2006. The inclusion of air transport in the ETS system has little impact on demand: compared to the REF scenario the demand has fallen by 2 % in 2030. To enhance the decrease, the price of a tonne of CO_2 would have to be higher than the price currently implemented of 33 euro/tonne CO_2 in 2030 (see Chapter 7 Energy production).

6.3 Energy use

Energy use in the three scenarios

The three scenarios apply measures to deal with energy more efficiently in the future. FIGURE 6.3 shows that the level of ambition is different however. In the REF scenario the energy consumption increases until 2020 because the transport flows continue to increase. The energy use stabilises in the period between 2020 and 2030. The transport flows do continue to rise but not as strongly as previously. The stabilisation of the energy use is however mainly due to higher efficiency in passenger transport through the use of smaller engines and hybrid vehicles. The improvement in efficiency in the new generations of vehicles as well as the hybridisation is considerably lower for trucks. In 2030 the energy use for the transport sector is almost one fifth higher than in 2006. The figure also shows that the share of road traffic in the total energy use remains almost constant. Road traffic still accounts for 94 % of the energy use in 2030 in the REF scenario.

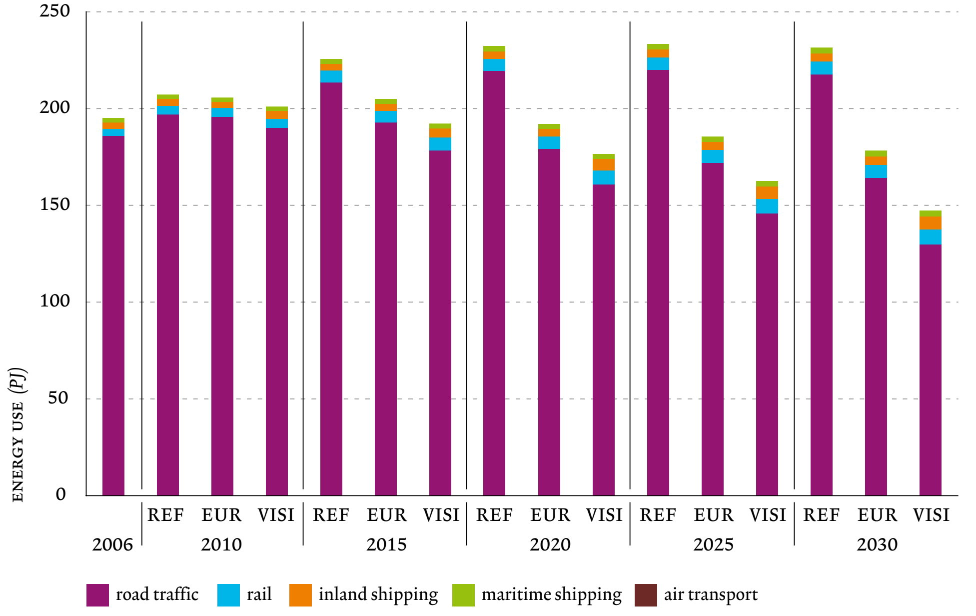
The policy assumptions in the EUR scenario reverse the increasing trend in energy use. Energy use already decreases from 2015 and continues to decrease. In 2030 the energy use by the transport sector is 9 % lower than in 2006. Compared to the REF scenario there is a reduction by 23 % in 2030. The share of road traffic falls slightly compared to the REF scenario and is 92 % in 2030.

The policy measures hardly influence the energy demand of non-road traffic. This is the result of two contrary effects. Road-pricing ensures a slight increase in rail transport and inland shipping activity. This increase counterbalances the decrease in energy requirement as a result of improved efficiency.

The fact that the energy use falls in the EUR scenario is entirely attributable to passenger transport by road. The implementation of legislation on CO_2 emissions for new cars with binding and ambitious targets plays a major role in this. The more pronounced technology shifts also have a noticeable effect. The number of hybrid vehicles thereby increases significantly by 2030: 34 % of the total fleet of cars consists of hybrid vehicles in the EUR scenario compared to 19 % in the REF scenario. Road-pricing and the execution of the measures concerning eco-driving and the use of low-energy tyres play a more limited role. For freight transport energy use increases continuously. The increase is not as large as it is in the REF scenario. On the one hand, this is the result of the introduction of Euro VI-vehicles that are more energy efficient than their predecessors and on the other hand (albeit to a lesser extent) of the more important role of hybrid technology. Better streamlining of trailers by attaching side wings and teaching eco-friendly driving also contribute to reduced energy use and a less sharp increase in energy use in the EUR scenario compared to the REF scenario.

In the VISI scenario the energy use decreases even further. In 2030 the energy use is 76 % compared to 2006. Compared to the REF scenario there is a decrease by 36 % in 2030. The VISI scenario also leaves the EUR scenario far behind. This is pri-

FIG. 6.3 *Energy use by the transport sector in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



Data for road traffic is representative for 2007 instead of 2006. For air transport only the fuel use of small planes and not for international flights. Maritime shipping and air transport are not modelled in the VISI scenario. To make a comparison possible, the energy use of those modes is assumed to be the same as for the EUR scenario. The energy use of electric bicycles is not included in the final calculations in the VISI scenario but is negligible in size compared to the total.

marily due to the introduction of plug-in hybrids from 2020 and the entire breakthrough of battery electric vehicles. In 2030 they respectively make up 80 % and 10 % of newly purchased cars. As it will take a while before the more energy efficient technologies gain the upper hand in the vehicle fleet, the largest benefit will become apparent further in the future. In addition the decreased use of energy in the VISI scenario is also the result of the assumption that the freight transport will decrease because of improved efficiency (e.g. better loading).

Energy mix in the three scenarios

The measures in the various scenarios not only influence the extent of the energy use. They also have an impact on the energy mix: there is a shift from fossil diesel to biofuels and electricity. Use of hydrogen is only limited until 2030. FIGURE 6.4 shows the share of the various energy carriers for the three scenarios for all modes together, compared with that of the base year 2006.

In 2006 diesel was by far the main fuel, followed at a distance by petrol. Electricity and biofuels were of approximately the same importance. If the current policy is continued, the share of diesel will be approximately the same in 2030. The share of petrol decreases mainly in favour of electricity and biofuels. Each is responsible for 4 %. Road traffic uses approximately the same amount of electricity as rail, use of biodiesel is marginal for rail.

The share of biofuels in the energy mix increases to more than 11 % in 2030 in the EUR scenario. This is primarily due to a higher use of biofuels by road traffic. An increase in rail transport and the introduction of biodiesel with inland shipping also makes a small contribution. The share of electricity further increases to almost 8 %. Road traffic contributes more than rail traffic in this, mostly as a result of the use of hybrids and to a lesser extent electric vehicles. Inland and maritime shipping also contribute to a limited extent through the introduction of quayside electricity, in which ships are supplied with electricity from the quay. The use of CNG *(compressed natural gas)* increases to almost 2 % by 2030 in the EUR scenario. Hydrogen use is limited to niche markets and remains marginal.

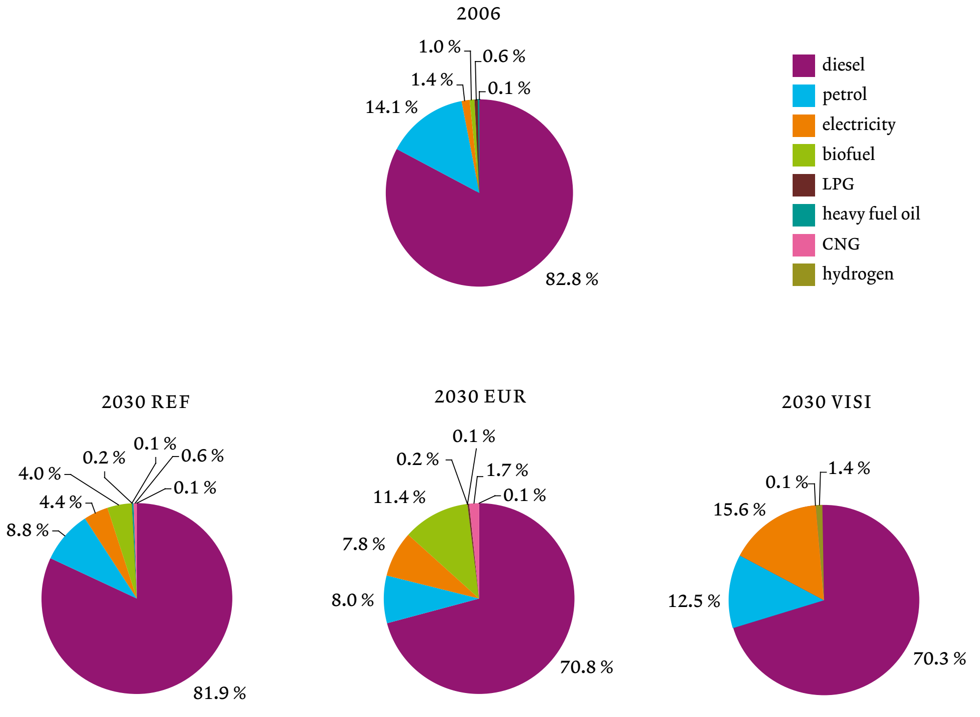
Biomass can be used more efficiently in sectors other than transport: that is one of the basic assumptions in the VISI scenario. For that reason this scenario does not use any biofuels but concentrates fully on plug-in hybrids and electric vehicles. By 2030 the share of electricity consequently doubles in the VISI scenario compared to the EUR scenario. The introduction of fuel cell vehicles, in which electricity is produced through the reaction of hydrogen and oxygen, results in a 1.4 % share for hydrogen by 2030.

Share of renewable energy in the three scenarios

One of the targets in the framework of the European Climate and Energy package is to increase the share of renewable energy in the future. The share of renewable energy must be at least 10 % by 2020 for the transport sector. Both biofuels and electricity based on renewable raw materials, so-called green electricity, contribute to this.

The continuation of the current policy results in a 4.5 % share of renewable energy in 2020. The additional policy, as presented in the EUR scenario, results in a share of 10.5 % renewable energy by 2020 for the entire transport sector. This is almost entirely due to a higher use of biofuels. The use of second-generation biofuels, which have better environmental performance, also plays a role in road traffic.

FIG. 6.4 *Contribution in percentage of the energy carriers to the energy use by the transport sector in the REF, EUR and VISI scenarios (Flanders, 2006 and 2030)*



Electricity usage increases slightly in the transport sector and consists of green electricity to a larger extent than in the REF scenario (22.3 % compared to 10.9 % by 2020, see Chapter 7 Energy production).

The VISI scenario does not use biofuels but invests strongly in electric vehicles. However by 2020 the amount of electricity used and the share of green power is too small to reach the target. Only 2 % of the energy is renewable then. After 2020 the plug-in hybrids and battery electric vehicles break through. 90 % of new vehicles sold use electricity by 2030 compared to 15 % in 2020. The proportion of green power has also risen sharply compared to 2020 (69.2 % compared to 23.1 %). This results in a share of renewable energy for transport of approximately 20 % by 2030. This means that electricity may compensate, in the longer term, for the lack of use of biofuels as renewable energy.

6.4 Greenhouse gas emissions

The European Union (EU) also puts forward targets for greenhouse gas emissions. For the transport sector these relate to greenhouse gas emissions during the transport itself or direct emissions. The emissions released during the production of the fuel, i.e. indirect emissions, are attributed to the energy sector. However to verify the effect of an increased use of electricity in the transport sector this chapter also considers indirect emissions.

Direct emissions

For the transport sector greenhouse gas emissions from air traffic are not included because air traffic will fall under the ETS system from 2012. FIGURE 6.5 consequently only shows the emissions from road traffic, rail traffic, inland and maritime shipping. The greenhouse gases concerned in transport are CO_2, CH_4, N_2O and HFCs (hydrofluorocarbons).

In the REF scenario the emissions rise until 2020. Then there is a gradual reduction until 2030. The emissions still remain 10 % above the current level. The decrease after 2020 is primarily due to the technological evolution of the passenger car fleet, which counteracts the increase in the number of kilometres driven. This development is the result of the voluntary agreement between the car manufacturers and the European Commission, which limits the CO_2 emissions of new cars, and of increased hybridisation.

The measures in the EUR scenario however already result in a reduction of emissions by 2015. These measures include:

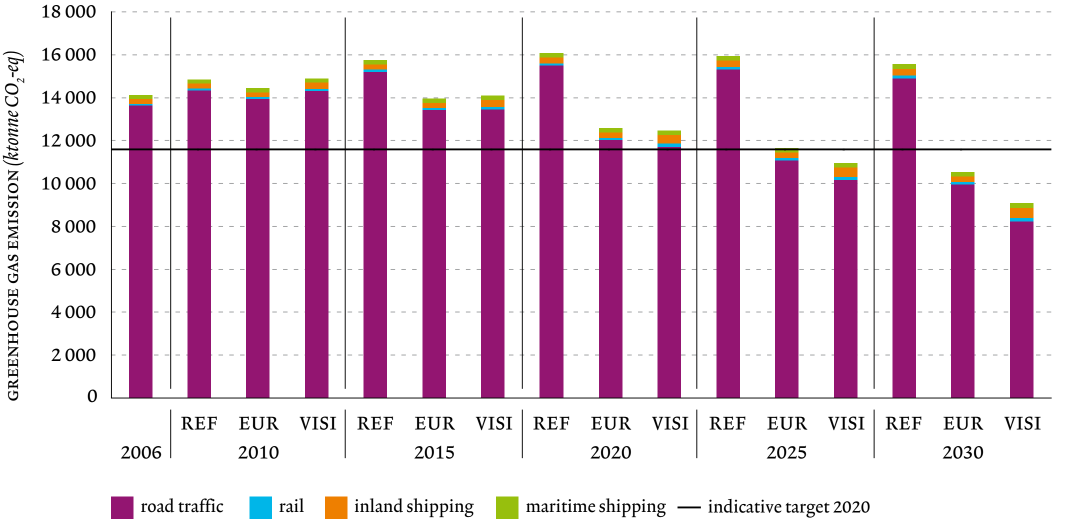
- the improvement of the energy efficiency of vehicles;
- a wider use of biofuels;
- an accelerated use of alternative technologies;
- road-pricing;
- teaching eco-driving.

As a result, greenhouse gas emissions of the transport sector decrease by almost one third compared to the REF scenario in 2030. Compared to 2006 there is a 25 % reduction in greenhouse gas emissions by 2030.

The VISI scenario does not use biofuels. Initially this results in higher greenhouse gas emissions than in the EUR scenario. From 2020 the greenhouse gas emissions decrease compared to the other scenarios. In 2030 the emissions are 14 % lower than in the EUR scenario: this is primarily due to the increase in plug-in hybrids and electric vehicles. However the further limitation of (motorised) road traffic due to a shift in mode and improved efficiency also plays a role. In 2030, the emissions are more than 35 % lower when compared to 2006.

Road traffic will also be responsible for the largest part of greenhouse gas emissions in the future. The share of other modes of transport remains limited until

FIG. 6.5 *Greenhouse gas emissions by the transport sector in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



Data for road traffic is representative for 2007 instead of 2006. Maritime shipping is not modelled in the VISI scenario. To make a comparison possible, the maritime shipping emissions are assumed to be the same as in the EUR scenario.

2030 with an unchanged policy. The policy implemented in the EUR scenario and the VISI scenario increases the share of inland and maritime shipping and railway transport. This is the result of both the increased use and the more modest technological improvements in these modes.

In the framework of the European Climate and Energy package Belgium must reduce its greenhouse gas emissions by 15 % by 2020 compared to 2005. This applies to the sectors that do not fall under the European emissions trading system (households and the majority of trade & services, agriculture and transport). The level of reduction attributed to the regions or individual sectors is not yet agreed. For that reason the 15 % reduction is provisionally used as an indicative target for the transport sector for 2020 in this chapter (11 513 ktonnes CO_2-eq). Despite the realisation of the very strict CO_2 legislation for new cars (which has in the meantime been weakened by Europe), a stronger breakthrough of alternative engine technologies for light vehicles (cars and vans) and an increased share of biofuels in the EUR scenario, that indicative target is not reached. In 2020 the greenhouse gas emissions in the EUR scenario are 12 567 ktonnes CO_2-eq or 9 % more than the indicative target. The VISI scenario also results in little change within this period.

More ambitious long-term targets are also being put forward internationally for greenhouse gas emissions. For industrialised countries this will come down to a global reduction by 60 to 80 % by 2050 compared to 1990. The transport sector achieves a 45 % reduction by 2050 compared to 1990 in the VISI scenario that puts significant emphasis on the use of alternative technologies, a shift in mode and increase in the efficiency of freight transport by road.

Emissions due to the use of electricity

Electric vehicles do not emit pollutants. Due to an increased use of these vehicles, greenhouse gas emissions in transport decrease in the EUR and VISI scenarios. However it is important to realise that greenhouse gases are released during the production process for electricity. Consequently it is useful to bear this in mind when comparing the scenarios.

If the scenarios also take these emissions into account, then the greenhouse gas emissions in the transport sector rise by approximately 12 % by 2030 in the REF and EUR scenarios and by 7 % in the VISI scenario. Although the VISI scenario uses more electric cars, this scenario also results in lower levels of indirect emissions in 2030. This is due to the future change to the composition of the power production park in Flanders combined with emission reducing measures in the power stations (see Chapter 7 Energy production).

6.5 Emissions of acidifying substances, ozone precursors and particulate matter

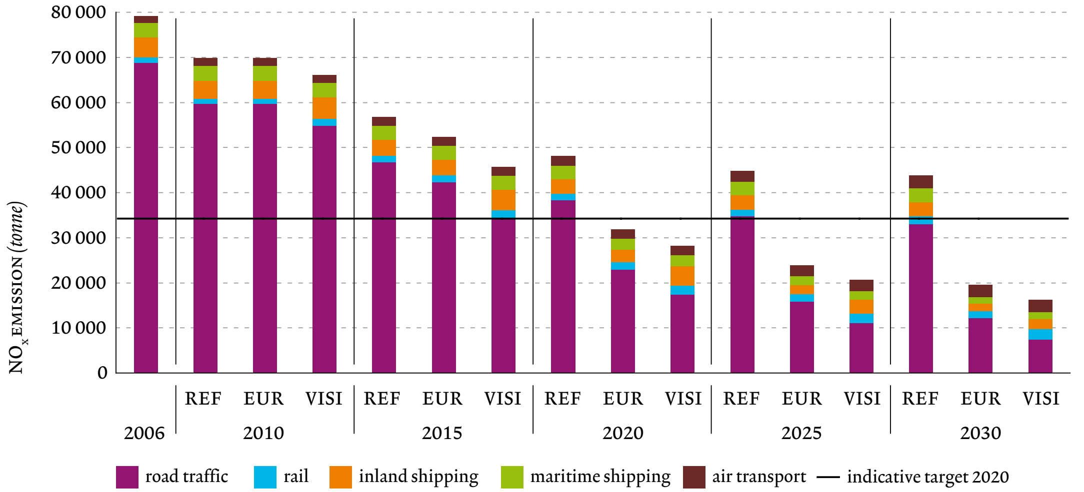
The transport sector not only plays a role in greenhouse gas emissions but this sector is also important for other pollutants. The EU formulates specific targets, so-called NEC targets for pollutants such as NO_x, SO_2, NMVOC and particulate matter. For evaluating these targets, air traffic has to be included as part of the transport sector. The 2020 targets considered here have not yet been decided for Flanders. They are a guideline and give an indication of whether the measures taken go far enough.

NO_x emissions

NO_x contributes to the formation of ozone. A limitation of NO_x emissions ensures that the harmful effects of ozone for both health and ecosystems decrease. In addition NO_x emissions also result in the acidification of the environment.

Even with an unchanged policy there is already a sharp decrease in NO_x emissions over time (FIGURE 6.6). This is the result of stricter emission standards combined with a renewal of the fleet. To achieve the indicative target for 2020 (33 817 tonnes), the EUR scenario measures are required. The introduction of Euro VI for heavy road transport in 2014, a measure that has been approved in the meantime, will particularly lead to the decrease required. The stricter emission standards for

FIG. 6.6 *NO_x emissions by the transport sector in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



Data for road traffic is representative for 2007 instead of 2006. Maritime shipping and air transport are not modelled in the VISI scenario. To make a comparison possible the emissions of those modes are assumed to be the same as in the EUR scenario.

new ships will also have an impact after 2015. In addition the decrease in the number of kilometres driven as a result of road-pricing also has an effect. In 2020 the total NO_x emissions in the EUR scenario amount to 31 892 tonnes. More intensive use of alternative technologies and a lower number of vehicle kilometres result in a further decrease in NO_x emissions in the VISI scenario. In 2030 the NO_x emissions will amount to 55 % of the emissions in 2006 with an unchanged policy, to 25 % in the EUR scenario and to 21 % in the VISI scenario.

In 2006 road traffic is responsible for the largest share of NO_x emissions within the transport sector. But in 2030 the share of the road traffic has decreased to less than two thirds in the EUR scenario and to less than half in the VISI scenario. The share of air transport increases in both scenarios as no additional policy has been established for NO_x emissions for air transport.

SO_2 emissions

The SO_2 emissions contribute to the acidification of the environment. The transport sector is making an effort to reduce emissions of SO_2. If the current policy is continued, the SO_2 emissions will fall in 2010 (FIGURE 6.7). This is because the sulphur content of the fuels used by road traffic, railways, inland and maritime shipping decreases. The SO_2 emissions will again be higher in 2030 than in 2006 due to the increased activity of these modes of transport. The share of maritime shipping will remain very high in 2030 (73 %). Inland shipping and air transport are equally important by then.

The EUR scenario starts from a decrease in the sulphur content of shipping fuels for inland shipping with a factor 100 from 2012, to a level comparable to the sulphur content in diesel for road vehicles. The sulphur content of the fuel used in maritime shipping decreases slightly in 2010, and falls by a factor 10 from 2015. FIGURE 6.7 clearly illustrates the effect of these measures on the SO_2 emissions. Compared to the REF scenario the emissions in the EUR scenario reduce by 77 % in 2015. From then the air transport emits the most SO_2: in the air transport no limits are imposed on the sulphur content of the fuel. Emissions from inland shipping on the other hand are negligible from 2015.

The indicative target for 2020 is clearly not achieved for the SO_2 emissions in the case of an unchanged policy. The SO_2 emissions still amount to over double the maximum permitted emissions. Reducing the sulphur content of shipping fuels in the EUR scenario is essential to achieve the indicative target (715 tonnes).

NMVOC emissions

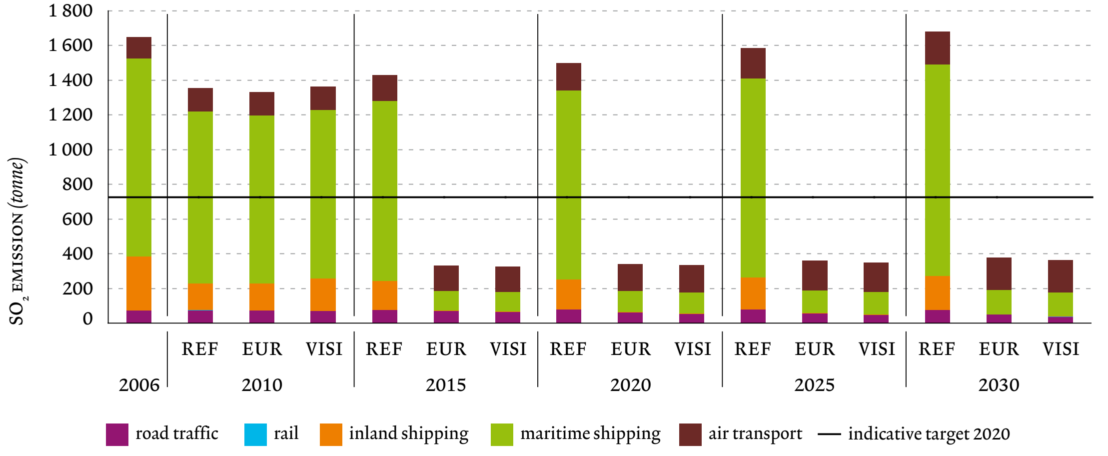
Non-methane volatile organic compounds (NMVOC) are, together with NO_x, responsible for the formation of ozone. A limitation of NMVOC emissions is an absolute necessity.

The current policy ensures that the NMVOC emissions decrease by about two-thirds during the 2006-2020 period (FIGURE 6.8). This decrease is large enough to achieve the indicative target for 2020 (4 716 tonnes) by 2015 already without taking any additional measures. Road traffic especially contributes to this through stricter emission conditions for new vehicles and the gradual introduction of new fuel and vehicle technologies. After 2020, NMVOC emissions will continue to fall slightly.

The measures in the EUR scenario ensure that the NMVOC emissions continue to fall slightly from 2020 compared to the REF scenario. The emissions by road traffic but also to a lesser extent by inland shipping especially make the difference. For road traffic the positive effect is mainly due to a decrease in the number of kilometres driven, the Euro VI-standard for trucks and the increased introduction of alternative motor fuel and vehicle technologies. The use of biodiesel and quayside electricity has a positive effect on inland shipping.

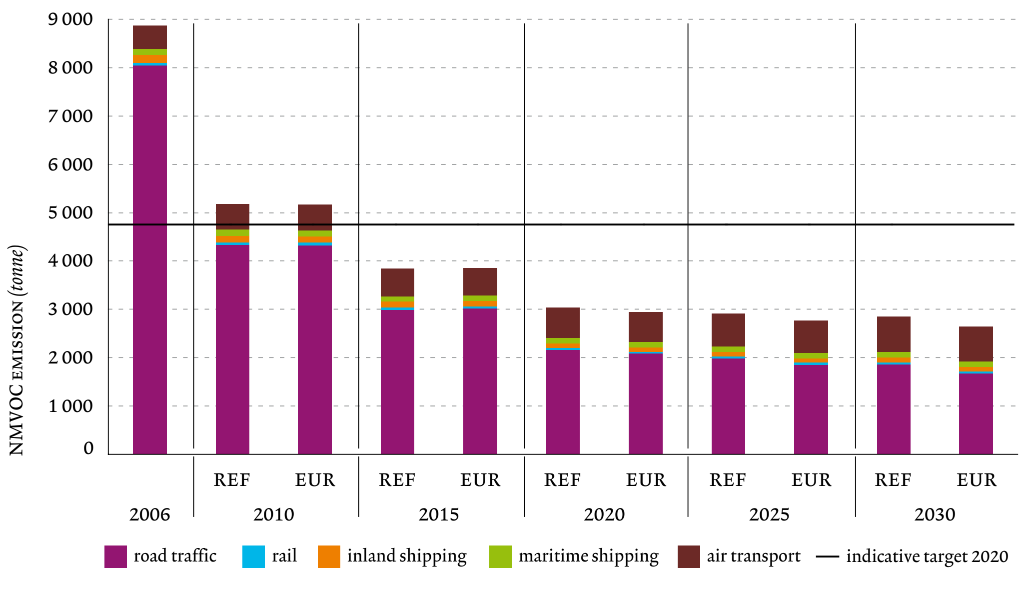
In both scenarios road traffic is responsible for the largest share but that share decreases from more than 90 % in 2006 to approximately 65 % by 2030. Air transport is the only mode of transport for which the NMVOC emissions increase in the future. In 2030 air transport will emit more than a quarter of the NMVOC emissions from transport.

FIG. 6.7 *SO_2 emissions by the transport sector in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



Data for road traffic is representative for 2007 instead of 2006. Maritime shipping and air transport are not modelled in the VISI scenario. To make a comparison possible the emissions of those modes are assumed to be the same as in the EUR scenario.

FIG. 6.8 *NMVOC emissions by the transport sector in the REF and EUR scenarios (Flanders, 2006-2030)*



Data for road traffic is representative for 2007 instead of 2006. No NMVOC emissions are available for the VISI scenario.

PM2.5 emissions

Breathing in particulate matter can result in more heart and respiratory disorders. Particulate matter is a mixture of particles in the air of diverse composition and dimensions. The smaller the particles, the more problems they cause. The discussion in this chapter is therefore aimed at PM2.5, the smallest fraction for which data is available. These are particles with an aerodynamic diameter below 2.5 µm.

The PM2.5 emissions not only include exhaust emissions (emissions from the vehicle) but also non-exhaust emissions, i.e. emissions due to the wear and tear of the road surface, braking, rails, overhead wires and wheels. Non-exhaust emissions are responsible for a great deal of the total emissions by rail transport.

Figure 6.9 illustrates that the emissions of PM2.5 decrease in every scenario. In the REF scenario the emissions stabilise however in the period between 2025 and 2030. The emissions from the road traffic decrease insufficiently to compensate for the increased emissions of other modes as a result of increased activity.

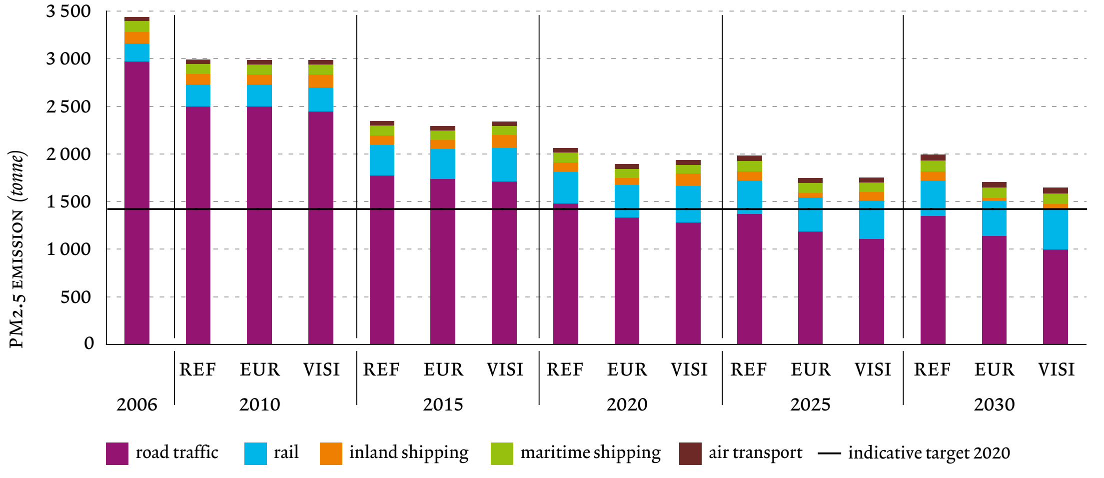
The introduction of the Euro VI-standard for heavy goods vehicles leads to lower PM2.5 emissions in 2020 in the EUR scenario compared to the REF scenario. The stricter emission standards (Stage IIIb emission standard) for inland shipping also contribute to this. The measures are insufficient however to achieve the indicative target for 2020 (1 400 tonnes). The exceedance is 35 %.

The measures in the VISI scenario do not initially appear to help, on the contrary. After all the VISI scenario does not implement any biofuels, which have a positive effect on the emissions of particulate matter. An increased use of rail transport and inland shipping also results in higher emissions. PM2.5 emissions are only slightly lower in the VISI scenario than in the EUR scenario in 2030, due to the increase in electric cars and plug-in hybrids.

None of the scenarios include measures to reduce the wear and tear to the road surface, brakes, rails, overhead wires or wheels. Due to the increased activity the non-exhaust emissions also increase in the future. In 2006 they were responsible for 24 % of the total, by 2030 this will already be 69 % in the EUR scenario.

The environmental impact of the non-exhaust particles is less well known than that of exhaust emissions. More research is required to determine the specific effect of these emissions as regards health and the environment. But they have already been included in the emission target for 2020.Therefore it is appropriate not only to take action on the exhaust emissions but also to further limit the non-exhaust fraction. This is for instance possible by using wear-resistant materials. The limitation of traffic flows also contributes to this. Halving the non-exhaust fraction by 2020 would result in achieving the indicative target in the EUR scenario.

FIG. 6.9 *PM2.5 emissions by the transport sector in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



Data for road traffic is representative for 2007 instead of 2006. Maritime shipping and air transport are not modelled in the VISI scenario. To make a comparison possible the emissions of those modes are assumed to be the same as in the EUR scenario.

6.6 Costs of some measures or packages of measures

Measures to limit energy use and emissions cost money. This section provides more information on the cost of certain measures included in the various scenarios. The entire costs are not considered here. For instance the benefits of measures that improve environmental quality are not calculated for the transport sector. Chapter 9 Air quality does discuss a few aspects of external costs. This chapter illustrates the differences in external healthcare costs due to particulate matter and photochemical air pollution between the REF and EUR scenarios for the whole of Flanders. Emissions from all sectors are taken into account in this.

The EUR scenario, road traffic

Only costs to improve fuel efficiency for road traffic in the EUR scenario compared to the REF scenario are considered. Various measures that have an impact on fuel efficiency, increase the purchase price of vehicles but simultaneously reduce fuel costs. Only direct costs are included, excluding taxes, subsidies, infrastructure and regulation costs. The quantification takes into account that petrol and diesel vehicles become more expensive in the future because of the stricter environmental requirements. For hybrid and pure electric vehicles a price reduction is assumed in the future due to an increase of scale.

The average annual additional cost (compared to the REF scenario) of the measures that improve fuel efficiency amounts to 197 million euro (in euro 2005) for the period between 2010 and 2030. Technical engine and vehicle adjustments are responsible for the largest added cost. These adjustments are responsible for 76 % of the average annual additional costs. Measures for better tyres contribute to over 15 %. The lowest additional costs are for measures that respond to driving behaviour, the introduction of improved air-conditioning systems and the aerodynamics of trucks. They respectively contribute approximately 5 %, 2 % and 2 % to the average total annual additional costs.

There is not only a cost associated with the measures taken in the EUR scenario but also a financial profit due to a lower energy use compared to the REF scenario. This is due to the use of more efficient technologies, energy-saving driving behaviour and a decrease in the number of kilometres driven as a result of the road-pricing system implemented here . The average annual additional benefit is 407 million euro.

Only taking these direct costs and benefits into account regarding energy efficiency results in an average annual benefit of 210 million euro for the EUR scenario compared to the REF scenario.

The EUR scenario, non-road traffic

The cost of measures may differ widely. For non-road traffic modes the cost effectiveness of a number of measures taken in the EUR scenario is calculated. For instance the cost for the reduction of 1 tonne of CO_2 is determined. Three different measures were examined for CO_2: the ETS system in air transport and the use of biofuels in railway transport and inland shipping. On average the three measures cost approximately 40 euro per tonne for the period between 2010 and 2030.

The current policy in the REF scenario sets stricter conditions on inland shipping than on maritime shipping as regards the sulphur content of the fuel used. The EUR scenario anticipates a further reduction of the sulphur content for both modes. During the period between 2010 and 2030 it is ten times cheaper to reduce one tonne of SO_2 in maritime shipping than in inland shipping. This is logical as inland shipping already has to make bigger efforts in the REF scenario than maritime shipping. The total reduction in emissions is also larger. This means that maritime shipping is more suitable to achieve additional SO_2 reductions than inland shipping.

A similar conclusion is applicable to NO_x. The implementation of the emission standards in the EUR scenario results in an equivalent total reduction of emissions for maritime as well as for inland shipping in the 2010 to 2030 period. Cost effectiveness is also in this case approximately ten times better for maritime shipping.

The VISI scenario

The VISI scenario calculates the effect of the shift to more environmentally friendly technologies, compared to the EUR scenario, on the cost for users. The added cost for the technology and the difference in energy costs have to be taken into account. Only cars and heavy goods vehicles are considered here, not vans. Taxes and subsidies are not included. For hybrid and electric vehicles the same price reduction due to an increase in scale is assumed as in the EUR scenario. This shift to new technologies ensures an annual additional cost as regards the purchasing price for cars of 81 million euro in 2030. For heavy goods vehicles this additional cost is 48 million euro in 2030. It is possible that the purchase price of these technologies will decrease more sharply in the future than is currently assumed: they may experience a production at a larger scale and there will be more competition than in the EUR scenario. The total energy cost is lower in 2030 in the VISI scenario compared to the EUR scenario. For cars there is a 6 million euro profit, for heavy goods vehicles a profit of 193 million euro. In total the benefit for the VISI scenario compared to the EUR scenario as regards the shift to new technologies equals 69 million euro.

According to the VISI scenario the technology used not only changes but more efficient modes of passenger transport also become more important. On the one hand, the difference in the costs for the users is calculated for this package in relation to the EUR scenario and on the other hand also the costs for the government. It is cheaper for the consumer to use the bicycle or public transport. In total approximately 950 million euro is gained in 2030. The calculation does not take into account differences in time use, comfort, etc. The government loses tax income because there is less car traffic and has to pay out more subsidies because the proportion of public transport increases. This costs approximately 282 million euro in 2030. Any consequences for infrastructure costs, changes to subsidies, taxes required to realise the shift in mode and lower healthcare expenses have not been factored in.

The VISI scenario also assumes a reduction in the number of kilometres driven by trucks but does not stipulate the measures that realise this. It is therefore not possible to calculate a total costing for this scenario.

6.7 Conclusions for policy

Three scenarios have been formulated in the Environment Outlook 2030 for the transport sector, each with a different level of ambition for transport and environmental measures. The formulation of the policy relevant conclusions is based on these scenarios.

Although the REF scenario has already realised strong reductions in emissions, Flanders only achieves the indicative NEC target in 2020 for NMVOC. For NO_x the (recently approved) Euro VI-standard for heavy goods vehicles is important to achieve the indicative target. A further reduction of the sulphur content of shipping fuels in the EUR scenario adequately reduces the SO_2 emissions.

The policy of the EUR scenario is not sufficient to achieve the indicative target for the emissions of particulate matter (PM2.5). The measures taken mainly target a limitation of exhaust emissions. This results in the share of non-exhaust emissions rising sharply. Further research is required into the health effects of these particles and into policy measures to tackle these emissions.

To reduce greenhouse gas emissions the EUR scenario uses more biofuels. This results in the target for renewable energy being reached by 2020. The VISI scenario does not use biofuels because biomass can be used more efficiently in other sectors. This scenario does not achieve the target for renewable energy by 2020. After 2020 vehicles using electricity break through in this scenario. Together with the strong increase in the use of green power between 2020 and 2030 this results in a sharp increase in the share of renewable energy for transport in 2030. In the longer term electricity may compensate the lack of use of biofuels as regards renewable energy.

Road traffic is the main energy consumer with over 90 % and determines the energy performance of the transport sector. The stricter legislation on CO_2 emissions from new cars will result in more energy-efficient cars being brought onto the market. However to reduce the energy use and greenhouse gas emissions in transport, consumers and companies must also chose for more energy-efficient vehicles. The stimulation of eco-driving behaviour will also contribute to a further reduction in energy use and greenhouse gas emissions. Raising awareness makes it possible to stimulate these necessary changes in behaviour. In addition the government may also stimulate a shift to more energy efficient vehicles by using eco-taxation, in which vehicles are taxed in relation to their environmental performance.

Plug-in hybrids and electric vehicles have better environmental performance than the current diesel and petrol vehicles but are still too expense and only available to a limited extent. Further stimuli are required so that both types of vehicles may break through. More research into these alternative motor systems is essential to come to an acceptable market price as quickly as possible and to increase the driving range. The number of charging points must also be expanded. *Smart grids* offer a solution to electric driving. They ensure that hybrid and electric vehicles can charge up without any problem with (green) power via the electricity grid at the most economical moments for the grid and the user.

In addition to technological measures transport measures also contribute to the reduction in the emissions by the transport sector. The road-pricing system, as implemented here in the EUR scenario, has a limited impact on the road traffic. Additional measures as regards a shift of mode and improvement of efficiency in the VISI scenario have a more limiting effect on the road traffic. Nevertheless the road traffic remains higher than today. In order to reduce the total greenhouse gas emissions in Flanders adequately, it is advisable that the transport sector makes efforts that go further. Flanders hereby has a need for a long-term vision on the organisation of transport. Cooperation between numerous policy sectors is essential to combine environmental, planning and economy aspects. The future Flanders Mobility plan already takes this need for harmonisation into account.

ENDNOTES

1 Maritime shipping only includes ‘internal’ maritime shipping. This is the traffic of all ships that sail between Flemish ports.

2 Air transport, unless otherwise stated, includes both national and international flights that depart and/or arrive at a Flemish airport. Only emissions on take-off and landing are included in the calculations, no emissions during the flight.

LIKE TO KNOW MORE?

If you would like to know more, you can refer to the scientific reports which form the basis for this chapter:

De Vlieger I., Pelkmans L., Schrooten L., Vankerkom J., Vanderschaeghe M., Grispen R., Borremans D., Vanherle K., Delhaye E., Breemersch T. & De Geest C. (2009) Transport: Reference and Europe scenario. Scientific report, MIRA 2009, VMM, www.milieurapport.be.
Delhaye E., Van Zeebroeck B. & De Geest C. (2009) Transport: Visionary scenario. Scientific report, MIRA 2009, VMM, www.milieurapport.be.

READERS

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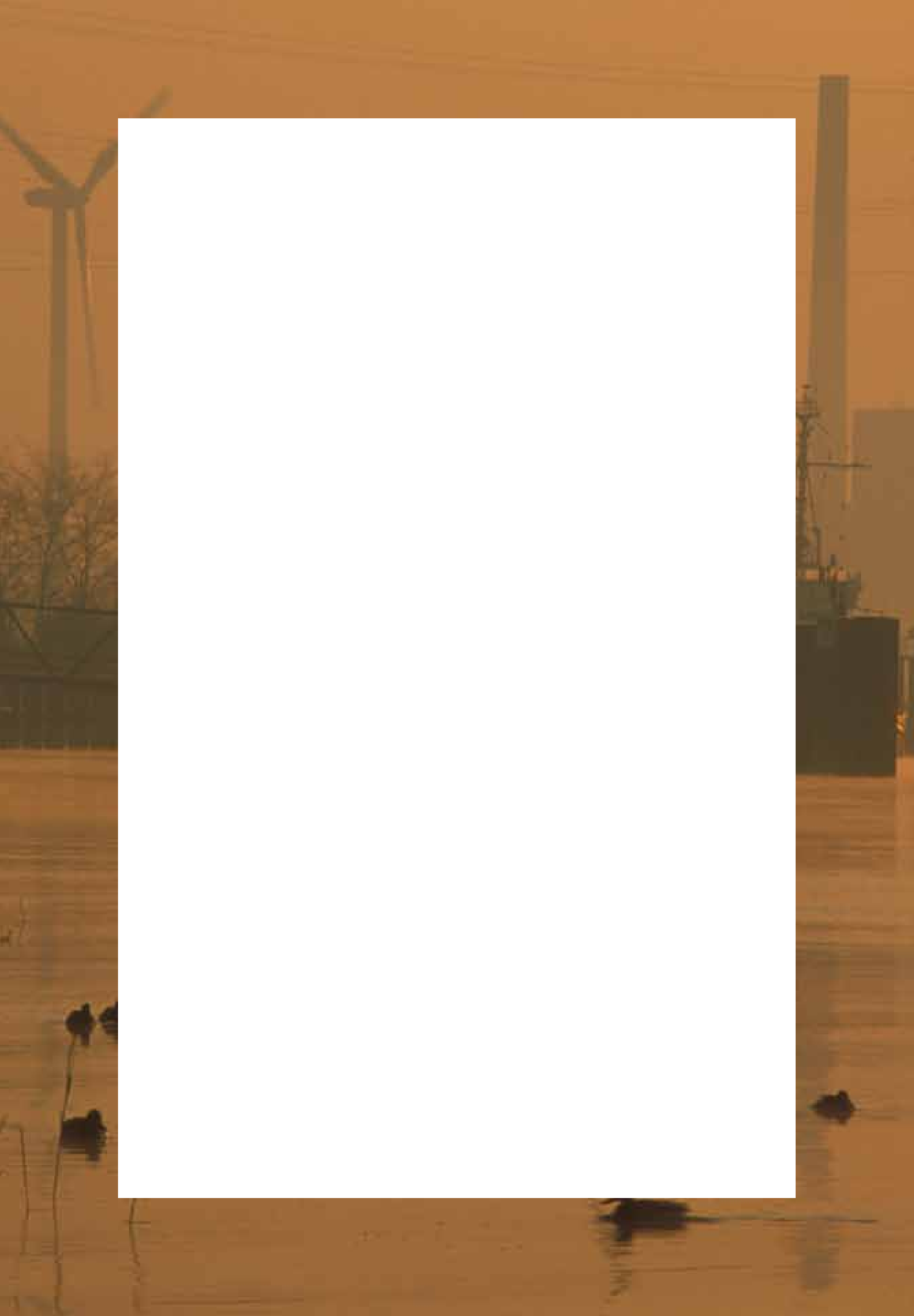
Jeroen Cockx, Environmental, Nature and Energy Policy Division, LNE Department
Caroline De Bosscher, VMM
Johan De Mol, **Enid Zwerts**, Institute for Sustainable Mobility, UGent
Wouter Florizoone, Bond Beter Leefmilieu Vlaanderen vzw
Luc Goubert, Belgian Road Research Centre
Marleen Govaerts, Mobility Policy and Traffic Safety Division, MOW Department
Luc Hens, **Levi Vermote**, Human Ecology Department, VUB
Luc Int Panis, VITO
Sofie Marivoet, Waterways and Sea Canal
Koen Miseur, Mobiel 21 vzw
Hans Tindemans, Mobility Council Flanders
Tania Van Mierlo, Air, Nuisance, Risk Management, Environment & Health Division, LNE Department
Thierry Vanelslander, Transport and Regional Economics Department, UA
Filip Vanhove, Transport & Mobility Leuven



7 Energy production

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Pieter Lodewijks, Transition, Energy and the Environment Unit, VITO

OUTLINES

- Despite a nuclear phase-out, Flanders will be able to meet its own electricity requirement while reducing greenhouse gas emissions related to electricity production. The full use of the potential of renewable energy sources is an essential condition, supplemented by subterranean CO_2 storage for coal and gas power stations after 2020.

- By 2030 the share of green power in the electricity use within Flanders will increase to 18 % if the current energy and climate policy is continued (reference scenario, REF), and to 36 % implementing the new European energy & climate policy (Europe scenario, EUR). In the visionary policy (VISI scenario) a cost efficient implementation of green power is even possible up to an approximate share of 70 % in the power production and 80 % in power consumption by 2030. The expansion and adaptation of the electricity grid necessary for this will require major investments.

- The support mechanism of green power certificates and guaranteed minimum prices particularly encourage offshore wind power and co-incineration of biomass. However, solar generated electricity only becomes relevant in the production of electricity if the international energy and climate policy is also made stricter, resulting in a higher CO_2 trading price within the European emissions trading system.

- An energy and climate policy that aims at a 20 % drop in greenhouse gas emissions in Europe by 2020 (the EUR scenario) or even by 50 % by 2030 (the VISI scenario) makes it possible to maintain the greenhouse gas emissions related to power production within Flanders at the 2006 level (in the EUR scenario) or to reduce it by two thirds (in the VISI scenario). This also allows air emissions to be reduced significantly. The emissions of particulate matter as a result of the (significantly) increased use of coal power stations in all scenarios are the exception.

- The switch to advanced catalytic and thermal cracking may especially result in energy savings in petroleum refineries in addition to the use of cogeneration of heat and power (CHP). The storage and distribution of natural gas requires an increased use of energy in all scenarios, even when combined with a decreased use of natural gas. The higher energy use is caused by an increase in the number of connection points and the corresponding length of the transport and distribution grids.

Introduction

The energy sector is responsible for the production and supply of energy to consumers. In Flanders this sector can be divided into three main parts:

- refining crude oil into petrol, diesel, heating oil, etc.;
- the storage, transport and distribution of natural gas;
- the production and distribution of electricity.

Fossil fuels (coal, petroleum, natural gas), nuclear fuels (nuclear power stations) and renewable sources of energy (wind, sun, biomass, biogas, etc.) are used to generate electricity in Flanders. The production of electricity through waste combustion is also included in the energy sector. The same is true for the simultaneous generation of useful heat and electricity in CHPs, even if those installations are operated by other sectors.

This chapter studies how the energy sector responds to a planned and to a stricter energy and climate policy and what the consequences are as regards the sector's own energy consumption and air emissions until 2030. This chapter first considers how the three scenarios are formulated and calculated in more detail. Then attention is paid to the development of activities within the energy sector and its own energy consumption. This chapter thereby also highlights the possible role of green power. Figures are then calculated concerning the impact on greenhouse gas emissions and the emissions of other pollutants. An indicative cost comparison of the scenarios is also studied. At the end of the chapter a number of conclusions are drawn concerning policy.

7.1 Principles of the Environment Outlook

Modelling

Activities within the energy sector and the corresponding energy consumption and emissions are calculated using the climate version of the Environmental Costing Model (Climate ECM). The model calculates how the energy sector can fulfil the energy demands from other sectors (households, industry, agriculture, transport, trade & services) at minimal costs. The scenarios do not consist of predetermined packages of measures. The model selects the most cost efficient package of measures itself. The model takes the costs for primary energy (e.g. coal or nuclear fuel), the investment costs and operating costs for all installations and potential reduction techniques and finally any taxes (such as a CO_2 price) or subsidies into account in this.

The measures available for the model to select are primarily intended to raise energy efficiency or to limit greenhouse gas emissions. The model does not include any measures with the primary goal of limiting emissions of other substances, such as sulphur dioxide or SO_2, nitrogen oxides or NO_x, particulate matter or PM, non-methane volatile organic compounds or NMVOC ... Major exceptions to this include:

- Electricity production for which the current emission ceilings for NO_x and SO_2 were taken into account according to the current Environmental Policy Agreement (EPA) with the sector. The current EPA runs until the end of 2009. The REF scenario maintains the current EPA ceilings until 2030. The EUR and VISI scenarios anticipate stricter ceilings from 2010.
- The reduction in bubble emission limits[1] for SO_2 and NO_x in refineries from 2010.

For the other subsectors the model does calculate the effect of energy and greenhouse gas measures on air pollutants from combustion processes, but not the effect of the specific policy on air pollution.

A few emission flows are not or only partially included in the model: e.g. PM emissions from CHPS or NMVOC emissions from refineries. These emissions are estimated separately, starting from existing scenario studies and do take account of specific measures for those other air pollutants.

Three scenarios

Differences between the three scenarios

In 2009 the European Union approved the so-called Energy and Climate package 2020. This package no longer stipulates specific greenhouse gas emission targets per country for the majority of installations in the energy sector. Those installations fall under the European emissions trading system (ETS) within which there is a market price for the emission of 1 tonne of CO_2 or 1 tonne of greenhouse gases. The price level will define where the reductions in emissions will be realised: reductions with a cost lower than the market price for CO_2 will be realised within the sector in Flanders itself. For the remaining emissions the sector must present sufficient emission rights.

Three scenarios have been formulated for the energy sector. These scenarios differ from each other as regards market price for the emission of CO_2 or greenhouse gases (TABLE 7.1). Those prices are derived from international studies and attuned to the levels of ambition in the three scenarios of the Environment Outlook 2030:

- The *reference scenario* (REF) starts from the current environmental policy, i.e. the legislation and regulations (e.g. including current covenants) already effective as of

April 1st 2008. The price for emission rights is only applicable to CO_2 emissions of combustion processes.

- For the *Europe scenario* (EUR) the price for emission rights is derived from the cost for the measures required to reduce greenhouse gas emissions from industrial installations in the EU by 21.3 % between 2005 and 2020. This price is applicable to all greenhouse gas emissions. The pricing level assumes that the emission rights of projects outside the EU27 shall also be offset to a limited extent.
- The *visionary scenario* (VISI) is constructed around the long-term targets for climate change. These require a reduction of greenhouse gas emissions of 60 % to 80 % by 2050, and a halving of the emissions by 2030 compared to 1990. The price of emission rights for this scenario is also applicable to all greenhouse gases and is based solely on internal reductions (within the EU27).

TAB. 7.1 *Price of emission rights in the REF, EUR and VISI scenarios (Europe, 2010-2030)*

(Euro/tonne CO_2-eq)	2010	2015	2020	2025	2030
REF	20.0	21.0	22.0	23.0	24.0
EUR	20.0	23.7	30.0	32.0	34.1
VISI	20.0	23.7	77.6	77.6	77.6

In 2008-2009 the market price fluctuated between 8 and 31 euro/tonne of CO_2.

Key parameters in the scenarios

Various assumptions are made in the scenario calculations. They relate to a number of key parameters, which play a crucial role in the final result. A few assumptions are considered briefly below:

- *Energy prices* are derived from the prices stated in Chapter 2 Socio-economic outlook. The fuel specific distribution costs within Flanders/Belgium were applied to prices for crude oil, natural gas and coal at the border.
- All scenarios correlate the production of electricity and storage and distribution of natural gas to the demand from the *other sectors* (households, trade & services, industry, agriculture, transport; see Chapters 3 to 6).
- All the scenarios integrate a phase-out of existing *nuclear power stations* as determined in current legislation (gradually between 2015 and 2025). The scenarios also do not foresee any construction of a new nuclear power station.
- Each type of installation for power production is characterised by a specific *life*. Decommissioned installations are replaced by new installations in relation to the demand for electricity. The model then selects between the following types of installations on the basis of cost efficiency and the development of new technologies: steam and gas turbines (STEGs), supercritical coal power stations, biomass co-incineration in coal power stations, cogeneration of heat and power (CHPs) with fossil fuels or biomass/biogas, onshore and offshore wind turbines and photovoltaic panels (PV).

- From 2022, coal power plants and STEGS may be equipped for CO_2-capturing and underground storage *(Carbon Capturing and Storage, CCS)*. This possibility only exists in the EUR scenario and the VISI scenario, up to a ceiling of 100 Mtonnes for the period between 2022 and 2030. CCS is not included in the REF scenario. This technique is currently still under development. New government initiatives are essential (e.g. subsidising pilot projects, setting up a sound legal framework) before CCS becomes a technology ready for use on the market. The captured CO_2 may be stored underground nationally or transported to neighbouring countries via pipelines (e.g. for storage in empty gas fields). The additional energy use required to apply CCS is also included in the calculations as is its effect on the emissions of air pollutants.
- *Renewable energy sources* are often available as a multiple of our actual energy needs, even in Flanders. However, the extent to which the market can usefully exploit those resources depends on a number of major limitations: availability of free space, efficiency of conversion techniques, cost of the technology required, etc. The priorities set and the level of ambition striven towards influence the impact of those limitations. For that reason the assumption of the potentials for renewable energy are different per scenario and per forecast year (TABLE 7.2).

TAB. 7.2 *Maximum usable capacity for power production from wind and solar energy in the REF, EUR and VISI scenarios (Flanders, 2010-2030)*

(MW_e)		2010**	2020	2030
REF	onshore wind	180	180	180
	offshore* wind	300	300	300
	photovoltaic	55	55	55
EUR	onshore wind	300	1 060	1 600
	offshore* wind	846	3 000	3 800
	photovoltaic	100	425	1 920
VISI	onshore wind	300	1 060	1 600
	offshore* wind	846	3 000	21 000
	photovoltaic	100	453	16 200

* Potential for the entire Belgian coastal region. 60 % of this was allocated to Flanders for the modelling.
** Table formulated on the basis of information available at the end of 2008. At the end of September 2009 the installed PV capacity in Flanders was already 178 MW_e and 224 MW_e in onshore wind turbines. At that time there were also already 30 MW_e installed in offshore wind turbines.
Source: MIRA/VMM and VITO based on Devriendt *et al.* (2005), De Ruyck (2006), EDORA/ODE/APERe (2007 & 2008), www.vreg.be, www.energiesparen.be

Biomass (including biogas) can also be used for power and/or heat generation: in pure biomass power stations, as well as for co-incineration in coal power stations or in so-called green CHPS. Use of biomass for co-incineration is technically limited to approximately 20 % (energy content), without major modifications to the existing power stations. Import of biomass is possible, although at a slightly higher price than nationally produced biomass. Indeed the biomass volume is very large when compared to the energy content, so that transport costs also quickly increase.

The potential for hydraulic power stations is negligible in Flanders: the installed capacity was only 1 MW_e in mid-2009, with few opportunities for expansion.

No significant contribution is to be expected by 2030 from other renewable sources of energy (e.g. wave and tidal energy) for Flanders. Therefore these are not considered in this chapter.

The model purely determines itself on the basis of cost efficiency whether the scenarios exploit the aforementioned potentials in whole or in part.

- The use of *green power certificates* (GPC) helps bridge the additional cost of green power production compared to conventional energy production. Issuing certificates per unit of green power produced decreases the net production cost of green power for the energy producer. While the cost for the certificates is borne by the end consumer of the electricity in relation to their consumption. Analogous to the green power system there is also a system for *cogeneration certificates*. Here a certificate is issued per unit of energy saved compared to the separate generation of power and heat. Both certificates play a key role in the Flemish energy policy and have been included in the model calculations. The price per certificate is the same in the three scenarios but falls over time as the additional cost of green power and CHP decreases gradually (TABLE 7.3). A separate framed section below calculates the effect of the change in 2009 to the minimum support for the various forms of renewable energy production.

TAB. 7.3 *Market price of green power certificates and CHP certificates implemented in the REF, EUR and VISI scenarios (Flanders, 2005-2030)*

(Euro/MWh)		2005	2010	2015	2020	2025	2030
CHP		40	40	36	33	30	27
Green power	onshore wind, biomass, hydropower	110	110	99	90	81	73
	PV	450	450	305	206	140	110
	offshore wind	109	109	99	89	81	73

- It was not possible to factor in the cost for *modifications to the electricity grid*. Nevertheless a far-reaching exploitation of decentralised electricity production (wind turbines, PV installations, CHPs, etc.) would require grid expansions and adjustments, which would entail investments.
- Only the VISI scenario implements a *price elasticity* of -0.3. This means that the demand for products under that scenario decreases by 0.3 % if the price increases by 1 %, e.g. influenced by the CO_2 prices in force.

7.2 Activities and the energy use of the energy sector itself

Energy production in Flanders

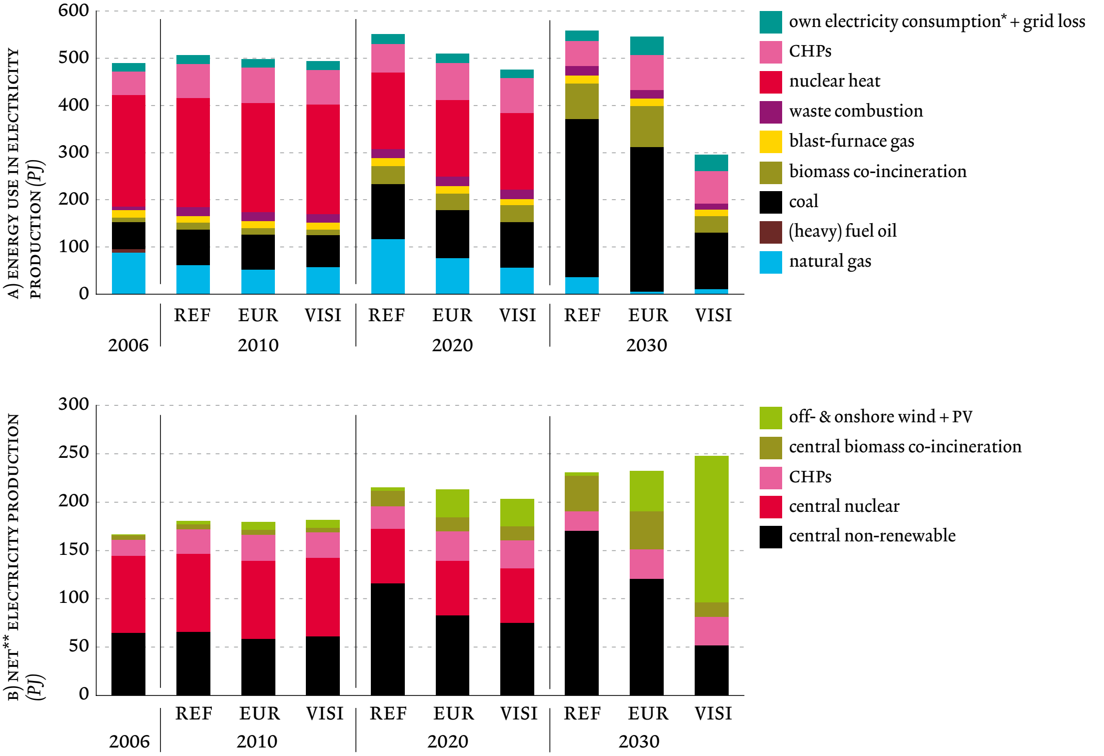
The demand for electricity in Flanders, but also the energy production and demand in other regions, determine the Flemish production of electricity. The electricity market is organised to a significant extent at a Belgian level. Energy prognoses for Wallonia and Brussels have been taken from the European Commission report in the context of the CAFE programme (see Chapter 9 Air Quality). The demand for electricity in those regions is considered equal in the REF and EUR scenarios. The price elasticity mentioned above impacts the demand in the VISI scenario. Electricity imports from neighbouring countries were kept at a constant 25 PJ for all scenarios based on the European Commission's forecasts for Belgium (Capros *et al.,* 2008). Until 2020 the amount of electricity produced in Belgium and the imports perfectly coincides with the demand for electricity in Belgium. From 2025 the electricity production in the VISI scenario is slightly higher than the actual demand in Belgium. The reasons for this are the continued use of certificates and the assumed, strong growth of the technical potential for green power production. This high investment in green power makes Flanders/Belgium a net electricity exporter (almost 35 PJ in 2025, almost 60 PJ in 2030). However, to meet demand at peak times, the use of power stations with fossil energy sources remains, together with the option of temporarily importing electricity.

The demand for electricity varies significantly between winter and summer, between day and night, working day and weekend. The modelling takes account of these fluctuations: the supply[2] and demand for electricity must be balanced at all times. The peak demand is particularly important for determining the production capacity.

FIGURE 7.1A shows the use of primary energy required for electricity production in Flanders. In addition to the use of nuclear power (48 %), electricity production in 2006 was primarily realised through the use of natural gas in large power stations (e.g. STEGS; 18 %) and CHPS (10 %). Coal (12 %) and co-incineration of biomass at coal plants (2 %) were used to a much lesser extent.

The electricity production of the nuclear power stations is mainly used to make it possible to meet the basic load of the electricity demand. Certainly in scenarios with higher CO_2 prices these are the 'cheapest' technology for the production of electricity. Insofar as nuclear power stations are still operational in accordance with the nuclear phase-out the three scenarios consequently also deploy them at maximum capacity. At the closure of the nuclear plants the Climate ECM primarily commissions new supercritical coal plants with a high electrical yield. CCS-technology may be applied to these plants from 2022 in the EUR and VISI scenarios. The coal plants are also typical basic load power stations, which are preferred to other types

FIG. 7.1 *Energy use for the production and distribution of electricity (A) and net power production (B) in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



* including the power required for CO_2 capturing and transport via CCS
** = gross electricity production in Flanders – the electricity producers own consumption – grid losses. This net production includes the (often decentralized) power production in households, trade & services, agriculture, industry and other subsectors of the energy sector.

of plants on the cost efficiency criterion. The use of biomass co-incineration also increases proportionately to the increase in the coal use. The model in all scenarios invests in biomass co-incineration approximately to the technical maximum due to the GPC and the CO_2 price imposed. The use of coal plants is lower in the VISI scenario than in the REF and EUR scenarios and consequently this is also true for biomass co-incineration. To a great extent, the VISI scenario meets the basic demand for electricity with offshore wind power.

Natural gas power stations (STEGs) are crucial for meeting the peak demand loads. These typical peak power stations have a short start-up but the fuel cost is higher. The expectation is that it will also be possible to equip the new STEG plants with CCS-technology from 2022, however, unlike the coal plants the use of this CCS-technique in gas plants only proves cost efficient in the VISI scenario.

CHP use increases in all scenarios although more emphatically in the EUR and VISI scenarios. Although CHPs still operated fully on natural gas (91 %) in 2006 and to a lesser extent on biomass (solid, liquid and gas; 5 %), the importance of biomass as a fuel increases to over 20 % for those CHPs in all scenarios in the future. The investments in natural gas based CHPs increase somewhat until 2015 but fall significantly after that point. Old CHPs are decommissioned after 2015 and investments in new CHPs are absent due to the relatively high investment costs, rising fuel prices and the falling value of certificates.

The lower section of FIGURE 7.1 shows the net power production in Flanders. While the production of green power through solar panels (PV) and wind turbines (onshore & offshore) remains limited in the REF scenario, these types of electricity generation rise strongly in the EUR and especially in the VISI scenarios. The higher potentials implemented by these two scenarios are the main cause but the use of GPC also plays a role. The rising CO_2 price throughout the scenarios does not constitute an essential extra stimulus for biomass co-incineration in coal plants and for investments in offshore wind energy. The certificates already make these technologies 'cost efficient'. In other words the Flemish Government has a strong instrument at its disposal in this certificate scheme through which to increase the share of green power in Flanders, independently of the price developments on the international CO_2 market. However, rising CO_2 prices are an additional stimulus for investments in PV cells.

'Central production' is the generation of power in a few major installations from which large amounts of power are released on the grid. The importance of this central production, initially with nuclear fuel and subsequently primarily with coal and, to a lesser extent, natural gas, gradually decreases in the EUR and VISI scenarios: from 89 % in 2006 to 69 % (in the EUR scenario) and 27 % (in the VISI scenario) in 2030. The often smaller scale decentralised production through CHPs, wind turbines or PV cells close to the consumer clearly gains in importance in those scenarios. The importance of central production continues to fluctuate around the 2006 level in the REF scenario.

The 2004-2009 Flemish Government Coalition Agreement set down the target that CHPs, including existing STEG plants should generate 19 % of the electricity supply by 2010[3]. In 2006 CHPs and existing STEGs already met 18 % of the energy production. By 2010 the three scenarios are close to the 19 % target but the share of CHP installations in power production decreases again thereafter (see above).

The role of green power

The breakthrough of green power is a major progress for Flanders and Belgium as regards the level of self-sufficiency but may certainly also significantly reduce the environmental pressure related to the production and use of power. For that reason this section considers the possibilities and limitations of green power in more detail.

FIGURE 7.2 shows the share of the green power produced in Flanders compared to the total Flemish *gross electricity use* (GEU). The GEU corresponds to the entire gross electricity production in Flanders and the imported electricity, minus the own exports of electricity. The own power use of the electricity sector and the grid losses are

FIG. 7.2 *Share of green power produced compared to the gross electricity use in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*

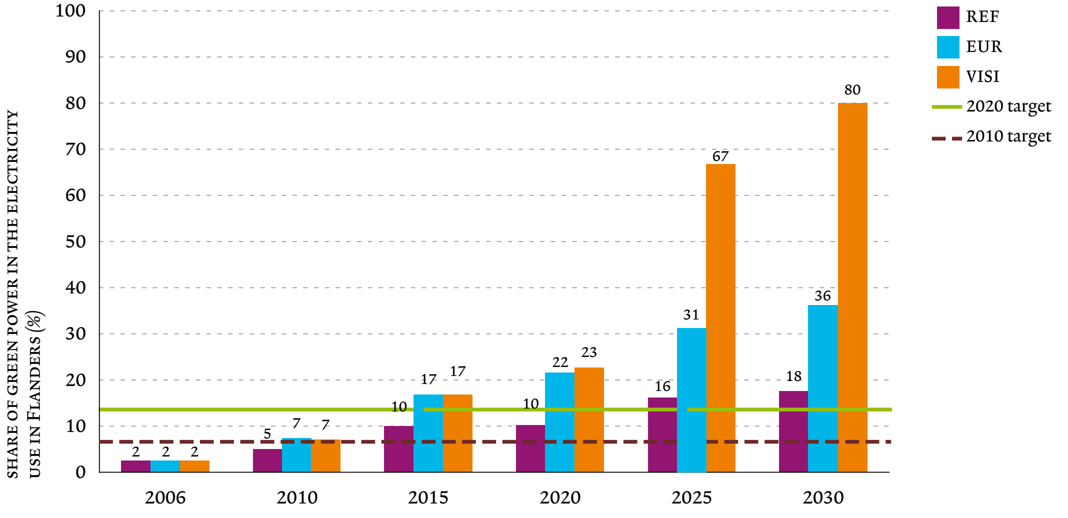
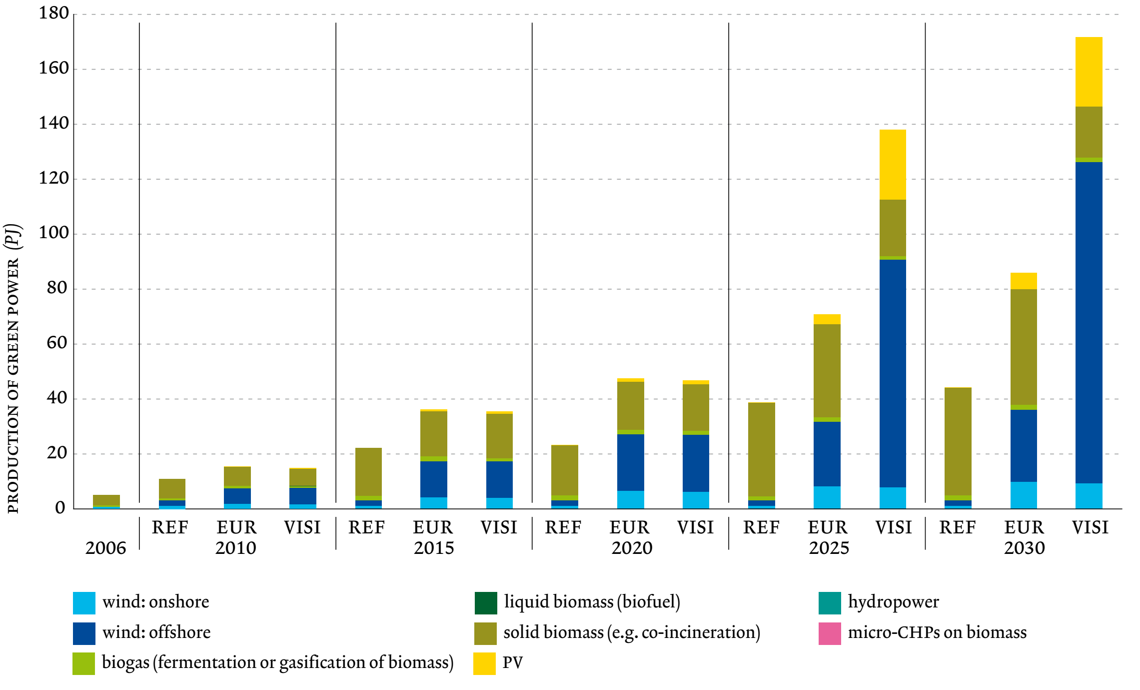


FIG. 7.3 *Detail of the production of green power in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



consequently also included in the definition of the GEU. The target of the Flemish Government[4] is to produce 6 % of the GEU from renewable sources of energy by 2010. Europe imposed a share of 13 % of *the gross energy use* from renewable sources on Belgium for 2020. This target has not yet been subdivided further to the three regions and is also not yet divided into the three components: green power, green heat/cooling and biofuels. For that reason FIGURE 7.2 takes the 2020 target as regards green power at a purely indicative level.

The REF scenario does not achieve the targets of 6 % by 2010 and 13 % by 2020. The production of green power in the EUR and VISI scenarios is equal until 2020. Both fulfil the 6 % target in 2010 and the indicative target of 13 % by 2020. The share of green power rises very sharply in the VISI scenario in 2025 and 2030.

The strong investment in the production of electricity from solid biomass over the years is striking in the REF scenario: up to 39.3 PJ in 2030 (FIGURE 7.3). The increased assumptions for the technical potential of wind and sun are clearly expressed in the results for the EUR and VISI scenarios. The generation of electricity through offshore wind turbines[5] increases to over 26 PJ in the EUR scenario by 2030 and to 117 PJ in the VISI scenario or 47 % of the total net electricity production. Flanders thereby comes close to the target put forward for 2020 in Denmark by 2030: i.e. increasing the share of wind energy to 50 %. Currently the share of wind energy in Denmark's electricity supply is already at approximately 20 %. The share of power from PV cells also rises very sharply in the VISI scenario: to over 25 PJ by 2030.

By 2030, offshore wind power generates a total of between 44 PJ (in the EUR scenario) and 195 PJ (in the VISI scenario) from the entirety of Belgian territorial waters and the Belgian exclusive economic area. The amount of power from onshore wind turbines in Flanders is estimated at 9 to 10 PJ by 2030, in both the EUR and VISI scenarios. Even if the production of power from wind energy thereby assumes major proportions, it is certainly not impossible. A recent report by the European Environment Agency (EEA) shows an even larger technical potential for offshore wind energy for Belgium of 774 PJ by 2030 (EEA, 2009). The same report concludes a 'competitive'[6] potential for onshore wind energy in Belgium of 43 PJ in 2020, and even 1 530 PJ by 2030.

Another EEA report allows the testing of the estimated use of biomass in this Environment Outlook 2030 (EEA, 2008). To determine the possible use of biomass, this EEA report takes account of the competition between power production, heat production and biofuels for transport. It also reserves the surface area on land for food production. In this way the EEA calculated that the most cost-efficient use of Europe's own biomass potential comes to an 18 % share for heating, 12.5 % for electricity production and 5.4 % for biological transport fuels by 2030. It also concluded that both from a financial standpoint and for combating climate change it is better to give priority to bio-energy for the generation of electricity and heat (particularly through CHP installations) rather than using biomass as transport fuel. The EEA report did not allow any biomass imports per member state unlike the basic principle maintained in the Environment Outlook 2030. In addition the EEA analysis did not take any account of a nuclear phase-out. Despite these limitations the EEA still concluded a green power production for Belgium originating from a purely 'Belgian' biomass, of 14 to 25 PJ by 2030. The results from the Environment Outlook 2030 indicate that, if 1) biomass imports were permitted, 2) the GPC are implemented and 3) the nuclear phase-out is carried through, then the production of electricity from biomass would be even higher in Flanders: at 41 PJ in the REF, 44 PJ in the EUR and 20.3 PJ in the VISI scenarios by 2030. The lower use of biomass in the VISI scenario is linked to the lower demand and the increased use of offshore wind and PV. Central production, in which biomass plays an important role in the form of co-incineration in the REF and EUR scenarios, decreases as a result.

The land use implications related to the use of PV cells and onshore/offshore wind turbines by 2030 remain reasonable in the three scenarios:

- In the EUR scenario each family must have 6 m² of *solar panels* available by 2030, this increases to 26 m² in the VISI scenario. In practice a lot of PV cells are also installed on office buildings, industrial halls, commercial spaces, etc. This means that the actual surface areas of PV cells to be installed per residence are lower than 6 or 26 m² respectively.
- Both in the EUR and VISI scenarios two wind turbines, each of 2 MW_e suffice on average per municipality to generate the required power from *onshore wind*. In practice wind turbines are concentrated in preferred regions (port areas, industrial areas, along major trunk roads, etc.) and in relation to wind speeds.
- Certainly the EUR scenario still remains within reason for *offshore wind*: twelve wind turbine farms[7] are required, while concrete plans for seven of these farms are already available by mid-2009 and four farms have even already received their domain concession. The 54 farms in the VISI scenario do entail a major challenge, both in the field of financing and grid stability and as regards harmonisation with other maritime activities (shipping routes, sand and gravel extraction, fishing, recreation, etc.) and nature management/protection. In order to allow the integration of large amounts of offshore wind energy on the electricity grid, the CREG in any event recommends that Belgium takes note of the studies and discussions at a European level concerning the possible construction of a direct current supergrid[8] in the North Sea (CREG, 2009).

In the Environment Outlook 2030 the use of diverse techniques to produce power – including power production from renewable resources – is evaluated on the basis of cost efficiency. This evaluation according to costs is realised from the standpoint of the power producer. This use of GPC reduces the net production cost for renewable energy for the producer, in which the end consumer of the electricity bears the cost of the certificates in relation to their consumption. To form an idea of the possible impact of GPC and guaranteed minimum prices on the energy invoice of an average family in Flanders, the cost for this was calculated per family. The implementation of certificates for PV, onshore wind, offshore wind, biomass, etc., means a cost per average family of approximately 32 euro, both in the EUR and the VISI scenarios in 2010. By 2020 this will have increased per family to 77 euro in the EUR scenario and 81 euro in the VISI scenario and by 2030 respectively to 106 and 243 euro per family. These amounts – which are certainly not negligible – are the same level as the difference in the price for power families experienced between 2006 and 2008 as a result of the increasing prices of fossil energy sources on the international energy markets. The 2008 Market survey report by the VREG indicates that an average family spent approximately 150 euro extra on an annual basis on electricity compared to the beginning of 2006 (VREG, 2009). The certificate prices do not include all the added costs for the generation of such quantities of green power and putting these on the grid (e.g. the costs for the grid modifications are not included). However one can state that these costs may be justified. By 2020 and certainly by 2030 renewable energy sources

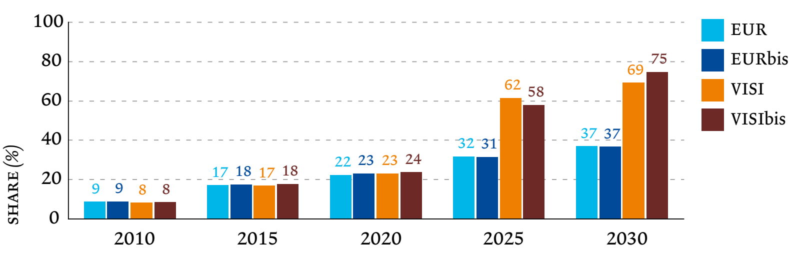
Effect of the new regulation for green power certificates

In 2009 the Flemish Parliament approved an amendment to the Electricity Decree and the Flemish Government changed its decision on the promotion of electricity generation from renewable energy sources. As a result the minimum support for diverse forms of renewable power production changed: amongst others a gradual decrease in the support for PV and a slightly higher compensation for onshore wind turbines. From now on, the co-generation of biomass in coal plants is also halved in the certificate regulation. These amendments could not be foreseen when the majority of the scenario calculations were carried out for the Environment Outlook 2030. Nevertheless an estimate of the effect of the amended prices for green power certificates (GPC) on power production in Flanders was made in a separate calculation of the EUR scenario (EURbis) and the VISI scenario (VISIbis). The main difference between the EUR/VISI scenarios on the one hand and the EURbis/VISIbis scenarios on the other is in the use of coal and natural gas for power production. The halved certificate value for co-incineration in coal plants decreases investments in new coal plants and increases the use of natural gas power stations. The difference between the EUR/VISI and EURbis/VISIbis in the use of biomass remains limited in all forecast years and is even often slightly higher in the bis scenarios. Use of biomass still remains a cost efficient method of electricity production with the new certificate prices. This is true both for co-incineration in coal plants and for plants that operate on 100 % biomass. Sharply reduced guaranteed certificate values for PV installations do not show any difference between EUR and EURbis but do result in a major insufficient use of the PV potential present in VISIbis during the 2025 and 2030 period. Whereas over 25 PJ of electricity is generated annually with PV cells in that period in the VISI scenario, this is only 1 PJ in VISIbis. Increased use of offshore wind turbines more than offsets this by 2030 however. The figure below illustrates the (limited) differences for the share of green power in the total net power production in Flanders.

In the meantime Flanders also has a specific GPC target for 2020. By that year, electricity suppliers must be able to submit GPCs for 13 % of the power supplied. To test this target, the production of electricity in offshore wind farms was not included. In addition supplies to major electricity consumers were partially exempted. Taking this into account, the green power production modelled (excluding offshore wind) extrapolated to the certificated supplies results in a 17.6 % share in the EUR and

18.0 % in the VISI scenario in 2020. The 2009 amended certificate regulation reduces these shares for 2020 to 14.4 % in the EURbis and 14.7 % in the VISIbis scenarios. However both still meet the GPC target of 13 %.
The average cost per family for the use of GPCs will also be 4 to 20 euro lower per annum as a result of the amended certificate regulation. In the 2020-2030 period the cost per family and per annum increases in the EURbis scenario from 73 to 86 euro and in the VISIbis scenario from 75 to 233 euro. In the EUR and EURbis scenarios the impact of PV cells and wind turbines on land use remains the same. There is a significant difference between VISI and VISIbis, which purely due to the shift already mentioned from PV to offshore wind after 2020. Where up to 26 m² of solar panels still had to be installed on every family residence by 2030 in the VISI scenario, this is limited to 1 m² in the VISIbis scenario. In addition the VISI scenario also anticipates an increase in the number of offshore wind turbine farms from 10 in 2020 to 54 by 2030. In VISIbis this increases even further from 10 in 2020 to 66 by 2030. This means an even larger challenge as regards financing, grid stability, harmonisation with other maritime activities, nature management and protection. The number of onshore wind turbines per municipality by 2030 is maintained at two in the EURbis and VISIbis scenarios.
The amended certificates regulation also has an impact on greenhouse gas emissions. A comparison between EUR and EURbis shows that in 2025 and 2030 the emissions for power production in the EURbis scenario was respectively 16 % to 3 % higher than in the EUR scenario. This may be explained by the increased use of natural gas (without underground CO_2 storage) and the decrease in coal use (for which underground CO_2 storage already proves cost efficient in that period). There is hardly any difference in the greenhouse emissions between VISI and VISIbis because CCS is used there both for coal and gas power stations under the stimulus of the higher CO_2 price.

Share of green power in the total net power production in the various scenarios (Flanders, 2010-2030)



provide a major contribution to the total power production within Flanders. Their share in the production mix for electricity would increase to 22-23 % by 2020 and to 37-69 % by 2030, in the EUR and VISI scenarios respectively.

Crude oil refinement

The production of refined petroleum derivatives in Flemish refineries is only partly determined by the demand for petroleum products in Flanders itself. In the Environment Outlook 2030, the production in refineries consequently does not follow the demand for petroleum products in other sectors. The REF and EUR scenarios assume for the refineries that production remains *constant* until 2030 at the 2006 level. Analogous to the industry subsectors (see Chapter 4) the *elastic demand in the VISI scenario* results in a lower production level. Production in the 2010-2015 period is 14 % lower on average than in the REF and EUR scenarios and 19 % lower on average between 2020 and 2030.

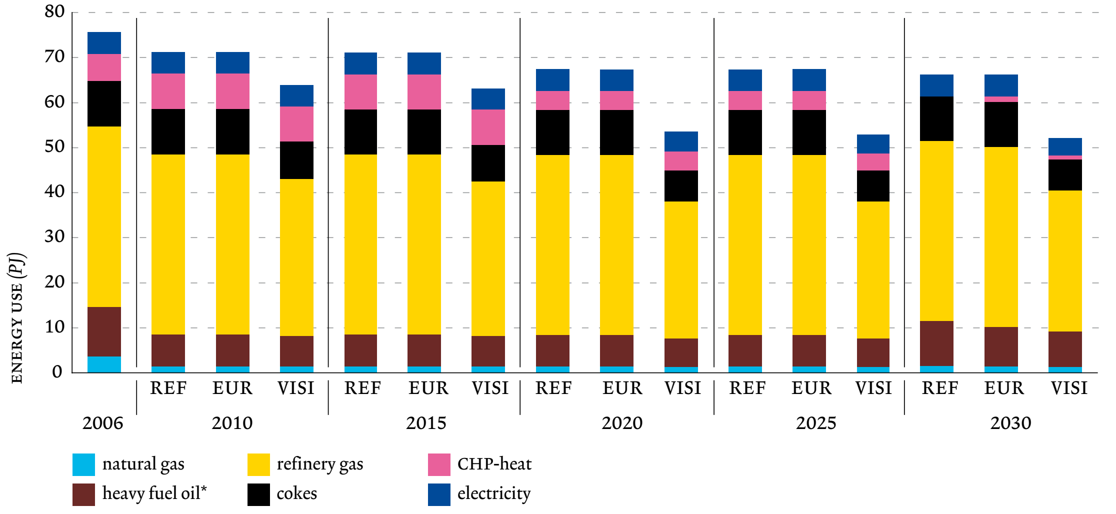
The calculations for refineries do take account of the *fuel characteristics* implemented by the various scenarios for the different sectors. In this way a lower sulphur content in the end products often requires a higher use of energy in the refineries, crucial to the further desulphurisation of refined products and for sulphur recovery[9]. Sulphur content of the crude oil used in refineries is also generally of decisive importance in the estimation of the own use of energy. Flemish refineries now already use relatively heavy crude oil with a higher sulphur content. Consultation with the sector has shown that the proportion of heavy crude oil will increase further.

Between 2006 and 2010 the energy use in this subsector decreases (FIGURE 7.4). This drop is due to the planned investment in a CHP in one of the four Flemish refineries, which has been realised in the meanwhile. The use of heavy oil in that refinery is reduced almost to zero as a result. The CHP uses natural gas but analogous to the other (sub)sectors this consumption is categorised under the electricity production subsector.

The use of *CHPs* in refineries is phased out completely in the REF scenario by 2030. After their technical life of 20 years the CHP installations are decommissioned. Due to the decreased certificate value this scenario does not then reinvest in CHP turbines. Under the impact of the higher CO_2 price the EUR and VISI scenarios do implement a limited investment in new CHPs.

Amongst others advanced catalysts make catalytic cracking[10] possible (from 2015) and the replacement of distillation processes through controlled thermal cracking (from 2020) for further energy savings. The reduction potential of the latter technology is estimated as being particularly high: 15 % energy savings compared to existing distillation processes at equivalent costs.

FIG. 7.4 *Energy use of the refinery subsector in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



* including small amounts of ordinary heating oil and naphtha

Storage, transport and distribution of natural gas

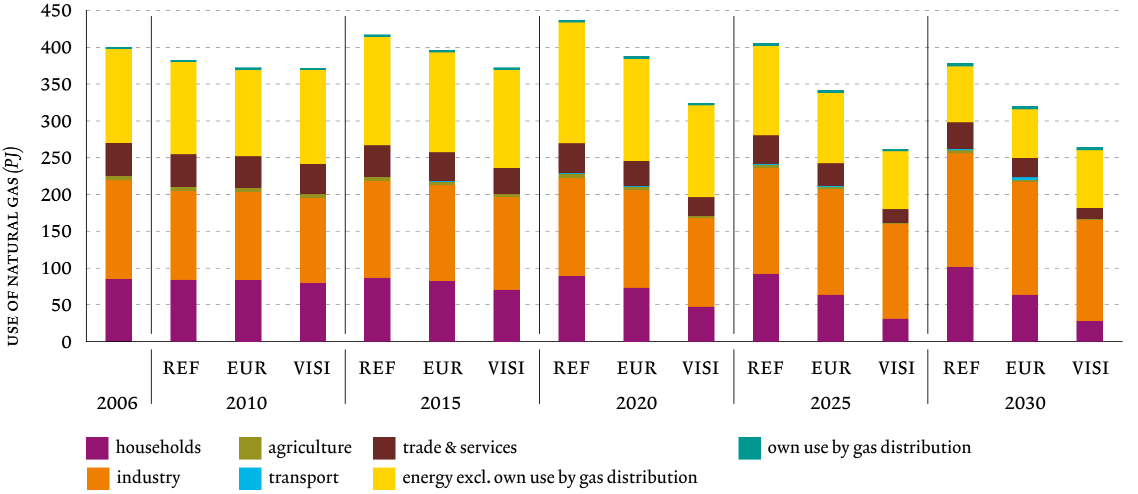
The storage and distribution of natural gas is attuned to the total natural gas use in Flanders. FIGURE 7.5 illustrates this natural gas use for all sectors together. After a slight drop in the use of gas in the REF scenario for 2010, this increases until 2020. From 2025 the natural gas consumption again decreases in the REF scenario. In the EUR scenario natural gas use was already lower in 2010 than in 2006, and then decreases sharply after 2020. In the VISI scenario the use already decreases significantly in 2020 to result in 2025 in a natural gas use that is only 65 % compared to the level in 2006. The sharpest decreases can be seen in electricity production, households and the trade & services sectors (also see Chapters 3 to 6).

The subsector's own energy use in the storage and distribution of natural gas mainly relates to:

- operating compressors to ensure the pressure required on the natural gas pipelines;
- losses during repairs and maintenance to the distribution grid and continuous leakage of natural gas throughout the pipelines.

The number of connection points and the length of the transport and distribution grids are the most decisive factors in this. Both factors relate to the gas use by other sectors. The sector's own energy use almost exclusively concern natural gas, and increases systematically in the three scenarios: from 2.4 PJ in 2006 to 4.6 PJ in 2030 in the REF and EUR scenarios and to 4.0 PJ in the VISI scenario.

FIG. 7.5 *Natural gas use in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



7.3 Greenhouse gas emissions

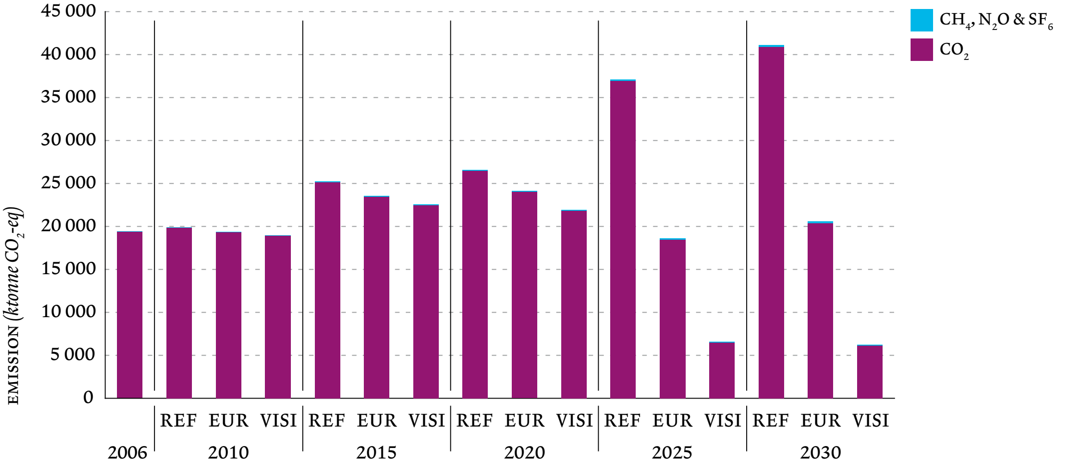
Electricity production

The greenhouse gas emissions in the production of electricity almost entirely consist of carbon dioxide or CO_2 (FIGURE 7.6). In 2015 the greenhouse gas emissions in the production of electricity increase considerably through the use of a new coal plant. This is a direct result of the gradual phase-out of nuclear power stations between 2015 and 2025. This development continues further in the REF scenario due to the major investments in new supercritical coal power stations. The use of coal triples between 2020 and 2030 (from 57 PJ in 2006 to 116 PJ in 2020 and 334 PJ in 2030), resulting in a sharp increase in CO_2 emissions.

The Flemish electricity production in the EUR scenario is at the same level as in the REF scenario in 2015 and 2020. Nevertheless the greenhouse gas emissions are 2.5 Mtonnes CO_2-eq lower on average. The reason for this is the increased use of renewable sources of energy. In 2025 and 2030 there is a very sharp reduction of greenhouse gas emissions although the use of coal is almost at the same level here as in the REF scenario. The main difference is the use of CCS technology in new supercritical coal plants operational from 2025: approximately 17 to 18 Mtonnes of CO_2 are captured in this way in the EUR scenario.

In the VISI scenario both the demand and production of electricity in the 2015-2020 period are lower than in the other two scenarios. This explains the lower greenhouse gas emissions in that period. In addition the use of offshore

FIG. 7.6 *Greenhouse gas emissions through the production, transmission and distribution of electricity in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*

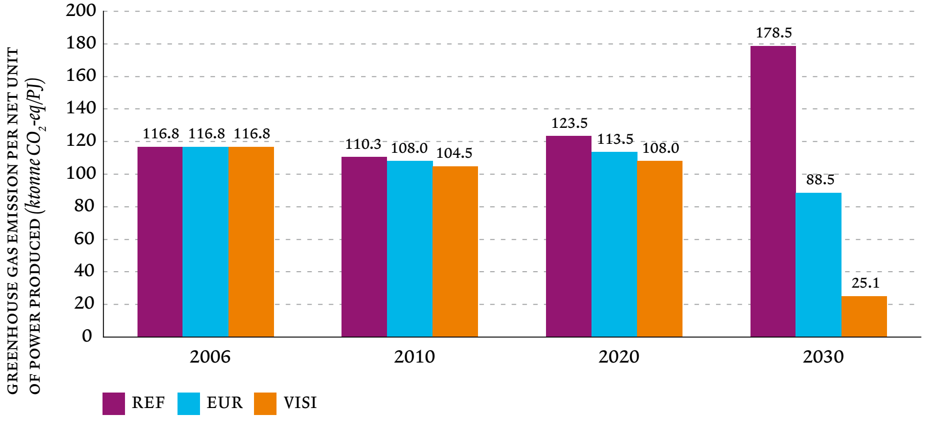


wind turbines and PV cells is estimated at a significantly higher level than in the EUR scenario between 2025 and 2030. This can also be seen from the greenhouse gas emissions. Use of coal between 2025 and 2030 remains limited to approximately 120 PJ, which is far below the level in the REF and EUR scenarios. The use of natural gas also decreases sharply in the VISI scenario but remains sufficient to meet the peak demand for electricity. Under the impact of the higher CO_2 price this scenario not only operates the CCS technique in the new supercritical coal plants from 2025 but also in gas power stations (STEGS) and coal plants already installed from 2015[11]. The annual captured amount is slightly lower however (i.e. 15 Mtonnes) than in the EUR scenario, because the VISI scenario invests slightly less in new coal power stations.

The development in FIGURE 7.6 is not only determined by the technologies used but also through the different amounts of electricity produced in each scenario. By expressing the greenhouse gas emissions per amount of power produced, a clear image is formed of the effect of the various production techniques (FIGURE 7.7).

In the REF scenario the sharp increase between 2020 and 2030 caused by the use of new supercritical coal plants due to the complete phase out of nuclear power and the lack of the CCS option is striking. Despite the sharp increase in absolute CO_2 emissions in the REF scenario between 2010 and 2015, the proportion of greenhouse gases per unit of power increases less. This is the result of investment in a new coal plant but with a significant level of co-incineration of biomass, which is CO_2 neutral. The ratio between the emissions and net power production is lower for all surveyed years in the EUR and VISI scenarios than in 2006. The main reasons for this are the increased use of renewable energy sources and the decision to implement CCS from 2025.

FIG. 7.7 *Greenhouse gas emissions per net unit of power produced in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



Refineries

The decreased energy use (FIGURE 7.4) between 2006 and 2010 is hardly noticeable in the evolution of greenhouse gas emissions. This is because the emission factors used for the various fuels for 2006 (sector specific[12] factors) and the years following it (average factors for this subsector) are different. In the 2010-2030 period the evolution of the greenhouse gas emissions by refineries shows a progress similar to that of their energy use.

Natural gas storage and distribution

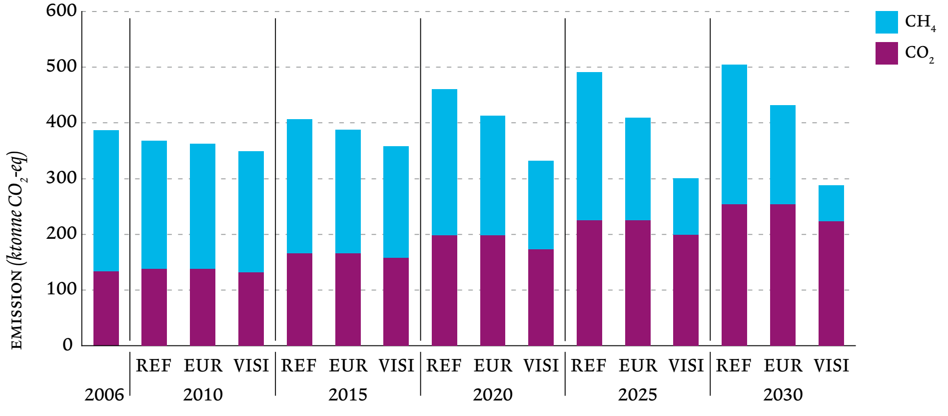
Gas distribution causes carbon dioxide (CO_2) and methane (CH_4) emissions:

- The energy use in the compression and decompression installations produces CO_2 emissions.
- CH_4 emissions are released as natural gas leaks, especially in the use of cast iron gas pipelines.

Use of cast iron pipes has been decreasing annually for a while as these are systematically replaced by the much less permeable plastic pipelines. The historic trend has been included in the model calculations, which results in an almost complete replacement of cast iron pipelines by 2010. A number of very large diameter (40-50 cm) pipes cannot be replaced by plastic pipes.

The replacement of cast iron pipelines results in a further decrease in CH_4 emissions between 2006 and 2010, the main component of natural gas (FIGURE 7.8). After 2010 the development of CH_4 emissions corresponds to the natural gas consumption in Flanders.

FIG. 7.8 *Greenhouse gas emissions due to storage and distribution of natural gas in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



Both the REF and EUR scenarios assume a further expansion of the natural gas distribution network, resulting in an increase in the number of compression and decompression stations. The CO_2 emissions of natural gas distribution increase as a result. In the VISI scenario the increase of CO_2 emissions is limited due to a lower use of natural gas in the other sectors.

7.4 Emissions of acidifying substances, ozone precursors and particulate matter

This Environment Outlook discusses the emissions of other substances into the air per environmental topic to which those substances contribute. Concretely this relates to emissions of:

- acidifying substances: nitrogen oxides (NO_x), sulphur dioxide (SO_2) and ammonia (NH_3);
- ozone precursors: non-methane volatile organic compounds (NMVOC), NO_x, methane (CH_4) and carbon monoxide (CO);
- particulate matter: total matter, PM10 (particles with a diameter <10 µm) and PM2.5 (particles with a diameter <2.5 µm).

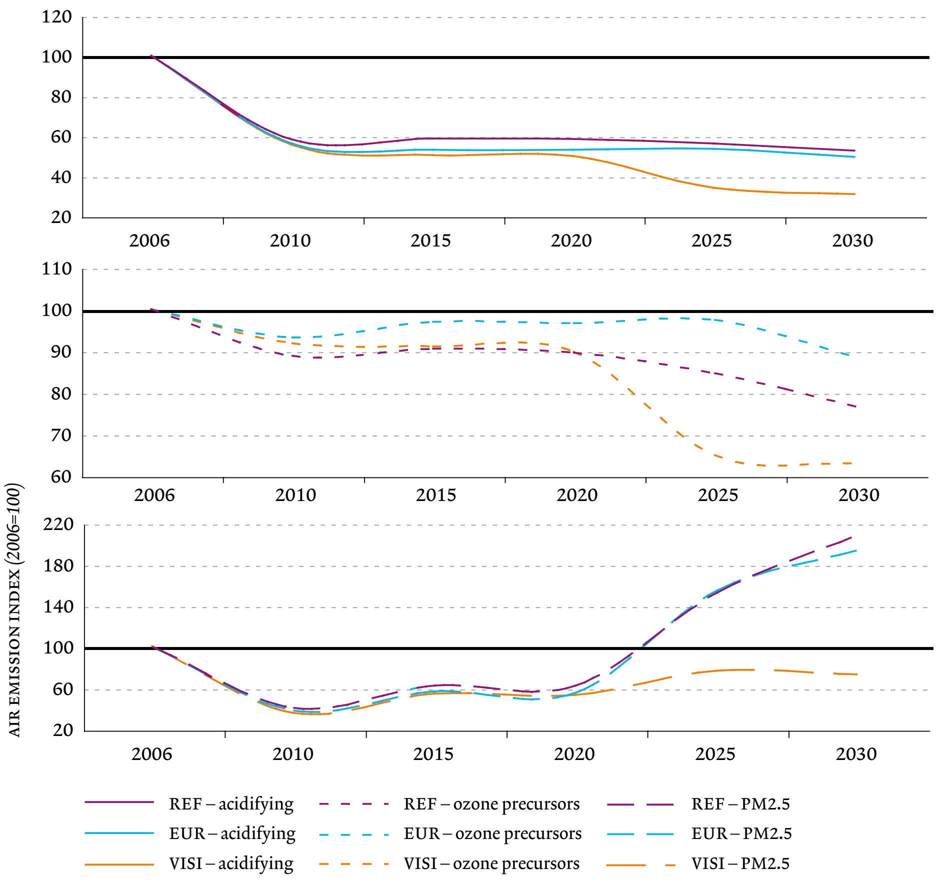
Electricity production

In all scenarios emissions of acidifying substances and ozone precursors (FIGURE 7.9) decrease. The reasons for this are the decision to use different plants and fuels, the ceilings implemented[13] for NO_x and SO_2 emissions. NH_3 emissions are negligible in electricity production. In 2006 SO_2 was still the main component in emissions of acidifying substances. However from 2010 NO_x clearly gains the upper hand in the three scenarios with shares of acidifying emissions:

- to 65 % in 2010 and 61 % in 2030 in the REF scenario;
- from 70 % in 2010 to 76 % in 2030 in the EUR scenario;
- from 70 % in 2010 to 86 % in 2030 in the VISI scenario.

The difference between the REF scenario on the one hand and the EUR and VISI scenarios on the other are particularly influenced by the use of the CCS technique[14] in the EUR and VISI scenarios from 2025. This technique also results in a further reduction of SO_2 emissions. NO_x emissions originate to a significant extent from CHP installations. The use of CHPs consequently also has a large impact on the total NO_x emissions in the production of electricity in Flanders. In this way the share of NO_x originating from CHPs increases from 50 to 70 % of NO_x emissions for electricity production after 2010 in the EUR and VISI scenarios. Only low cost efficient post process techniques can reduce the NO_x emissions with the use of CHPs.

FIG. 7.9 *Emissions of acidifying substances, ozone precursors and particulate matter due to electricity production in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



The contribution of electricity production to the ozone issue is almost entirely determined by the NO_x emissions. The share of NO_x in the emissions of ozone precursors is larger than 95 % for all surveyed years and in all scenarios. As mentioned, the use of CHPs plays an important role in the development of NO_x emissions, in addition to tighter emission ceilings.

There is a striking increase in emissions of particulate matter after 2020, especially in the REF and EUR scenarios. This is caused by the decision to use coal power stations with a further phase-out of nuclear power stations. The far-reaching departicularization and desulphurisation in the new coal plants do not suffice to absorb the increased use of coal in electricity production as regards the smallest and most harmful particles. The noticeably lower emissions of particles (but also of various other pollutants) in the VISI scenario in the period between 2025 and 2030 is mainly due to the intensive use of renewable energy sources. The use of post process CCS does not have a significant effect on particle emissions.

The amount of electricity produced in Flanders differs depending on the scenario. This naturally directly influences the total emissions for electricity production. By expressing the emissions of acidifying substances, ozone precursors and particulate matter per unit of net[15] electricity generated in Flanders the impact of the composition of the production park becomes even more apparent. FIGURE 7.10 clearly illustrates that the air polluting emissions produced per unit of power and probably also consumed in Flanders:

- decreases by a third or even more in the three scenarios compared to the 2006 base year and this is applicable to all the years forecast in the 2010-2030 period.
- are often lower in the EUR scenario than in the REF scenario, but that the VISI scenario alone truly scores better by 2030 than the REF scenario in equal forecast years.
- systematically decrease further in time in all the scenarios. Particle emissions form the exception to this, which increase again from 2020, particularly due to the increased use of coal power stations (whether or not with CCS).

Refineries

The emissions of acidifying substances, ozone precursors and particulate matter from refineries do not show the same development as the use of energy and/or greenhouse gas emissions. This is primarily due to the fact that NO_x and SO_2 emissions from refineries, unlike CO_2 emissions, also partly originate from chemical processes and are consequently not purely the result of combustion processes. NO_x and SO_2 emissions from refineries are regulated by the bubble concept. The NO_x and SO_2 emission limits thereby relate to the entire refinery and consequently include both the combustion and processing installations.

SO_2 emissions show a significant drop between 2006 and 2010 due to a pronounced switch from heavy fuel oil (rich in S) to gas (S free). The measures taken to fulfil the emission limits have a similar effect on emissions of particulate matter. Emis-

FIG. 7.10 *Emissions of acidifying substances, ozone precursors and particulate matter per net unit of power produced in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*

sions of the majority of parameters increase again after 2015. The main reason for this is that the existing and new CHPs have a 20-year life and are consequently decommissioned from 2025 (or earlier for existing installations). Those CHPs are not replaced by new CHPs because this would no longer be the optimal solution as regards to cost, but by ordinary boilers instead.

Despite constant production in the REF and EUR scenarios, FIGURE 7.11 shows a sharp fall in all emissions in the 2006-2010 period. The emissions significantly increase again thereafter but still remain under the starting level from 2006 until 2030. The EUR scenario only becomes distinct from the REF scenario in the period after 2025. Partly due to the effect of price elasticity at the production level the emissions in the VISI scenario are clearly below those of the other two scenarios in all forecast years and for all substance groups.

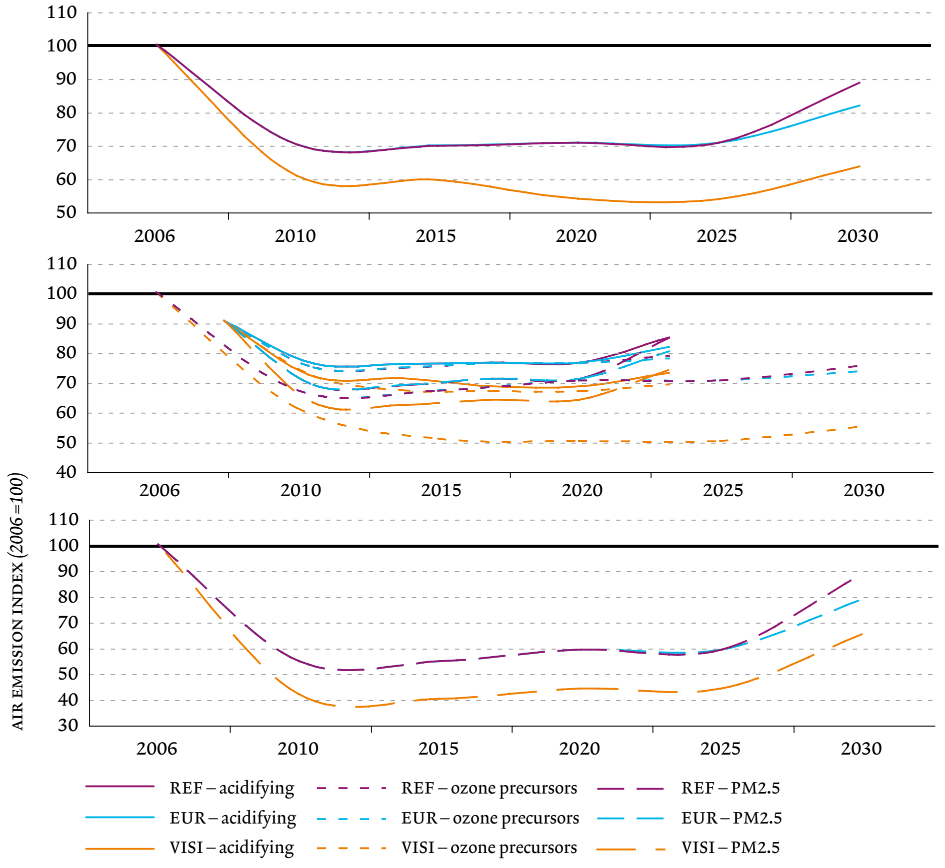
Natural gas storage and distribution

As regards natural gas storage and distribution, only CH_4, NMVOC and NO_x emissions are not negligible compared to the total energy sector. CH_4 emissions have already been discussed with the greenhouse gases.

The NMVOC emissions increase slightly under the REF scenario by 6 % between 2006 and 2030. However they decrease by 31 % and 67 % respectively in the EUR and VISI scenarios. This is due to the changed use of natural gas in other sectors. The share of this subsector in the total NMVOC emissions for the energy sector decreases as a result, from 26 % in 2006 to 22 % (in the EUR scenario) and 15 % (in the VISI scenario) in 2030.

The evolution of NO_x emissions is primarily determined through the use of energy in compression and decompression stations (for which the scenarios do not foresee any tightening of the emission limits). These emissions double by 2030 in the three scenarios. The share of this subsector in the total NO_x emissions for the energy sector thereby increases from 2 % in 2006 to approximately 7 % in 2030.

FIG. 7.11 *Emissions of acidifying substances, ozone precursors and particulate matter by refineries in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



7.5 Cost comparison of the scenarios

Three cost factors

The model implemented makes it possible to compare the costs of the REF, EUR and VISI scenarios. In this comparison the annual *system cost* of the REF scenario in 2010 is equated to 100 %. This system cost includes:

- the discounted annual investment costs (i.e. the additional cost compared to the standard alternative available);
- the annual operating costs/savings from measures to reduce greenhouse gases and energy savings;
- the annual fuel costs.

However the system cost is not the entire cost for keeping production operational. For instance the purchasing costs for raw materials (e.g. crude oil for refineries) are not included in the system costs.

The costs for greenhouse gas emissions, due to the *CO_2 cost* imposed in the scenarios, are shown separately in the graphs. This CO_2 cost may be considered an opportunity cost: the cost of a financial choice, expressed in terms of the best 'opportunity lost'. This is equal to the CO_2 price multiplied by the remaining CO_2 emissions by the sector concerned, after implementation of the reduction techniques until the moment the cost for additional emission reductions is equal to the market price for CO_2. The larger the remaining greenhouse gas emissions, the higher the opportunity cost. The costs for the implementation of emission reducing measures are already included however in the system cost reported.

The REF and EUR scenarios assume that the demand for products and the level of activity will not change as a result of the increased costs resulting from the climate policy. However in the VISI scenario an elastic demand is assumed in which demand for products and consequently also for energy decreases if the price rises (see above). A decreased demand consequently results in a lower system cost: lower technology and fuel costs because production is significantly lower. In that case there is an issue of increased *loss of wealth,* to be considered as loss of income.

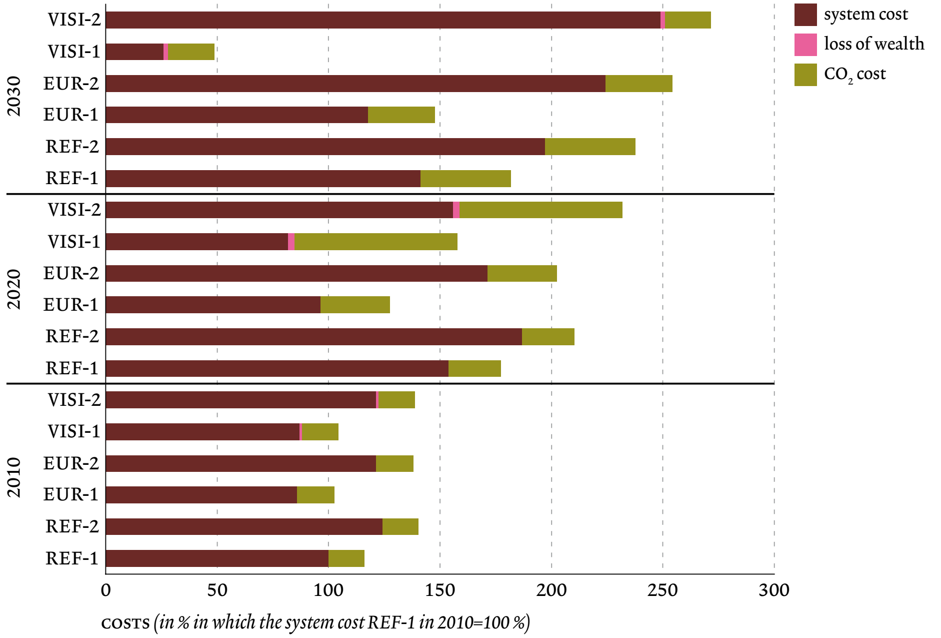
The relative costs for the three scenarios for electricity production and refineries are discussed below. The costs connected to the storage and distribution of natural gas are not included in the Climate ECM but are considerably lower.

Electricity production

A distinction has been made for the electricity sector between the annual costs inclusive and exclusive of the return from CHP and green power certificates (FIGURE 7.12). The certificates ensure that the sector – investors in installations for energy production – faces lower net production costs for power from CHP-installations or from renewable sources of energy. The cost for the certificates may be considered a part of the production costs for power that are not borne by the power producers themselves but by Flemish society. Even if the price for the certificates systematically decreases, the VISI scenario clearly shows that the annual system cost decreases significantly, to far below the level in 2010. The reason for this is the large-scale use of wind turbines and PV installations by 2030. A more intensive use of renewable energy sources also ensures a sharp decrease in the CO_2 costs in the 2020-2030 period. Any loss of wealth as a result of price elasticities in the VISI scenario always remains limited.

When the returns from the certificates are no longer taken into account, the costs look very different. Although the annual costs in the EUR and VISI scenarios fall compared to the REF scenario when the certificate returns are factored in, without those returns the annual costs increase between 2010 and 2030. The production of electricity in Flanders is slightly lower until 2020 in the EUR and VISI scenarios compared to the REF scenario. The total annual system cost is consequently also lower

FIG. 7.12 *Annual relative costs for electricity production, transmission and distribution in the REF, EUR and VISI scenarios (Flanders, 2010-2030)*



1: Yield of GPC and CHP certificates allocated to electricity producers
2: Yield of GPC and CHP certificates not allocated to electricity producers

in these years in the EUR and the VISI scenarios. After 2020, the gross production of electricity in Flanders in the EUR and VISI scenarios then increases beyond that in the REF scenario. This gross production furthermore also includes the additional own use of electricity for the application of the CCS-technique. The annual costs consequently also increase. However this increase is not proportionate to the increase in the production of electricity as a result of the intensive investments in renewable sources of energy.

Refineries

The annual system costs for the REF and EUR scenarios are equal until 2025. While the energy use decreases in both scenarios, the annual costs increase due to the increased fuel costs. In 2030 the annual costs in the EUR scenario are slightly lower than in the REF scenario. This is due to the larger investment and use of CHPs for which the costs are allocated to the electricity sector.

The CO_2 cost for the refineries subsector is significant compared to the system cost. In the REF scenario this increases from 42 % to 53 % between 2010 and 2030 compared to the system cost in 2010 (=100 %). In the EUR and VISI scenarios the CO_2 price is still significantly higher than in the REF scenario from 2015 and certainly from 2020. From 2020, the annual CO_2 cost is even higher than the annual system cost in the VISI scenario. The cost of the loss of wealth due to a decreased demand and production in the VISI scenario amounts to 4.8 % on average.

7.6 Conclusions for policy

At the phase-out of nuclear power stations in Belgium, the energy sector will face a major challenge. Scenarios with a stricter energy and climate policy for the 2010-2030 period indicate that it is possible to attune the national energy production further to the national energy demand. This is possible without any major negative repercussions to environmental themes such as climate change, acidification or the ozone issue. A crucial condition for this is a strong intensive use of renewable energy sources (wind and solar energy and also biomass), supplemented in due course with the implementation of CO_2 capture and underground storage (CCS).

Especially as regards the use of renewable energy sources, the level of ambition focussed on will define the end result to a significant extent. The VISI scenario shows that green power (including offshore wind) can be used cost efficiently up to a share of approximately 70 % of the total net energy production by 2030. It is crucial that green power certificates and guaranteed minimum prices bridge the additional cost as long as green energy production costs more than conventional energy production. These support mechanisms are borne by society, each in proportion to one's own energy consumption. Considering the significant contribution the various scenarios expect from biomass, sustainability criteria are required for the use of (imported) biomass. The amounts of biomass used exceed the national availability for energy purposes and may otherwise constitute a threat to food supply, biodiversity, etc.

The application of CCS – only to be expected on a large scale after 2020 – primarily requires the timely development of a sound legal framework. This must deal with the purity of the emission flows to be stored and certainly also with guarantees and responsibilities in the longer term. Research into the possibilities of CCS is being given a major place by Europe, amongst others in the Seventh Framework Programme for Research and Innovation (FP7, 2007-2013) and in the Strategic Energy Technology Plan (SET plan). Support for pilot projects may also be considered by Flanders or Belgium to help the development of this technology.

Furthermore, the switch from a predominately centralised electricity production (in a few large power stations) to a gradually more decentralised power production (wind turbines, PV cells, CHP installations, etc.), will require major investments. These investments are primarily required for the modification of the electricity grid and for the temporary storage of electrical energy at times of overproduction. Such storage could for instance be realised in the form of hydrogen gas (H_2) or in batteries. This may be combined with the introduction of H_2 cars and/or fully electric cars. This need for temporary energy storage is all the more important for the integration of energy yields from offshore wind farms, where there is also a major challenge for harmonisation with other maritime activities (shipping routes, sand and gravel extraction, fishing, recreation, etc.) and with nature management and protection. Connecting the Belgian electricity grid to a future European super grid in the North Sea should also be considered with a view to the security of the supply.

The scenario results indicate that only limited reductions in emissions may be realised for the oil refineries after 2010 through the modification of existing installations. Only fundamental changes to the production processes – which are currently not applied anywhere on an industrial scale – could significantly decrease the use of energy in this subsector and the corresponding emissions. In addition the rise of bio fuels also offers possibilities. Research into second-generation biofuels (from residual flows, such as harvest residue or wood waste) or even third generation (e.g. recovered from algae farming) particularly deserves further support.

It is also not or hardly possible to reduce emissions connected to the storage and distribution of natural gas between 2010 and 2030. However, cost efficient reductions of emissions realised by households and trade & services due to the switch from coal and heating oil to natural gas more than compensate for this. In the longer term the addition of biogas may also offer an option to lower the environmental impact of natural gas distribution.

END NOTES

1 A bubble emission ceiling is applicable to the total flow of flue gas emissions in a company.
2 Supply = own production + import - export.
3 The STEG installations were categorised under central electricity production in Figure 7.1 however.
4 This target is amended for large consumers (also see the framed section below) in the Flemish Electricity Decree. Figure 7.2 is based on the European definition for GEU and was consequently not amended for large consumers.
5 The figures here only relate to a fraction (60 %) of the offshore power generation awarded to Flanders.
6 In the EEA study defined as 'with an average production cost below 5.5 cents/kWh'.
7 5 MW_e capacity per turbine, which supplies an annual average of 16.7 GWh power. 1 wind farm = ~ 60 turbines (cf. C-Power).
8 European network of underground and under-sea high voltage lines, more powerful and longer than the current overhead networks. This type of network would make it possible to stabilise an electricity supply from green power by bridging large distances between places where green power may be produced and places where power is used.
9 The removal of H_2S from diverse gases formed during the refining process before those gases are used as fuel in the refinery itself.
10 The fractioning of long carbon chains from crude oil to transform heavy, more viscous components into lighter liquid or gaseous products. This may be realised simply through the provision of heat (thermal cracking) or through the use of catalysts (catalytic cracking) that accelerate the process.
11 It is assumed that the CCS technique will only be available after 2022. The Climate ECM factors in an additional investment for the subsequent modification of existing plants.
12 These factors may differ annually. For example there is the emission factor for refinery gas depending on the composition of this gas. However default emission factors had to be used for the model calculations (2010-2030 period) because the changing specific composition, year by year is impossible to predict.
13 The current EPA runs until the end of 2009. The current EPA ceilings are maintained in the REF scenario. The EUR and the VISI scenarios foresee stricter ceilings from 2010.
14 Not available for the REF scenario and in the years 2006-2020.
15 Excluding own use within the electricity sector and excluding grid losses. Account has been taken of all forms of electricity production (central production, CHPs, waste incineration, green power) in Flanders, both within the energy sector and in other sectors.

LIKE TO KNOW MORE?

If you would like to know more, you can refer to the scientific report which forms the basis for this chapter:

Lodewijks P., Brouwers J., Van Hooste H. & Meynaerts E. (2009) Energie- en Klimaatscenario's voor de sectoren Energie en Industrie. Scientific report, MIRA 2009, VMM, www.milieurapport.be.

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Devriendt N., Dooms G., Liekens J., Nijs W. & Pelkmans L. (2005) Prognoses voor hernieuwbare energie en warmtekrachtkoppeling tot 2020, VITO, 168 p.
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EEA (2008) Maximising the environmental benefits of Europe's bioenergy potential. European Environment Agency, 94 p.
EEA (2009) Europe's onshore and offshore wind energy potential up to 2030. An assessment of environmental and economic constraints. European Environment Agency, Technical report No 6/2009.
VREG (2009) Marktrapport 2008 (figure 5 on p. 22).

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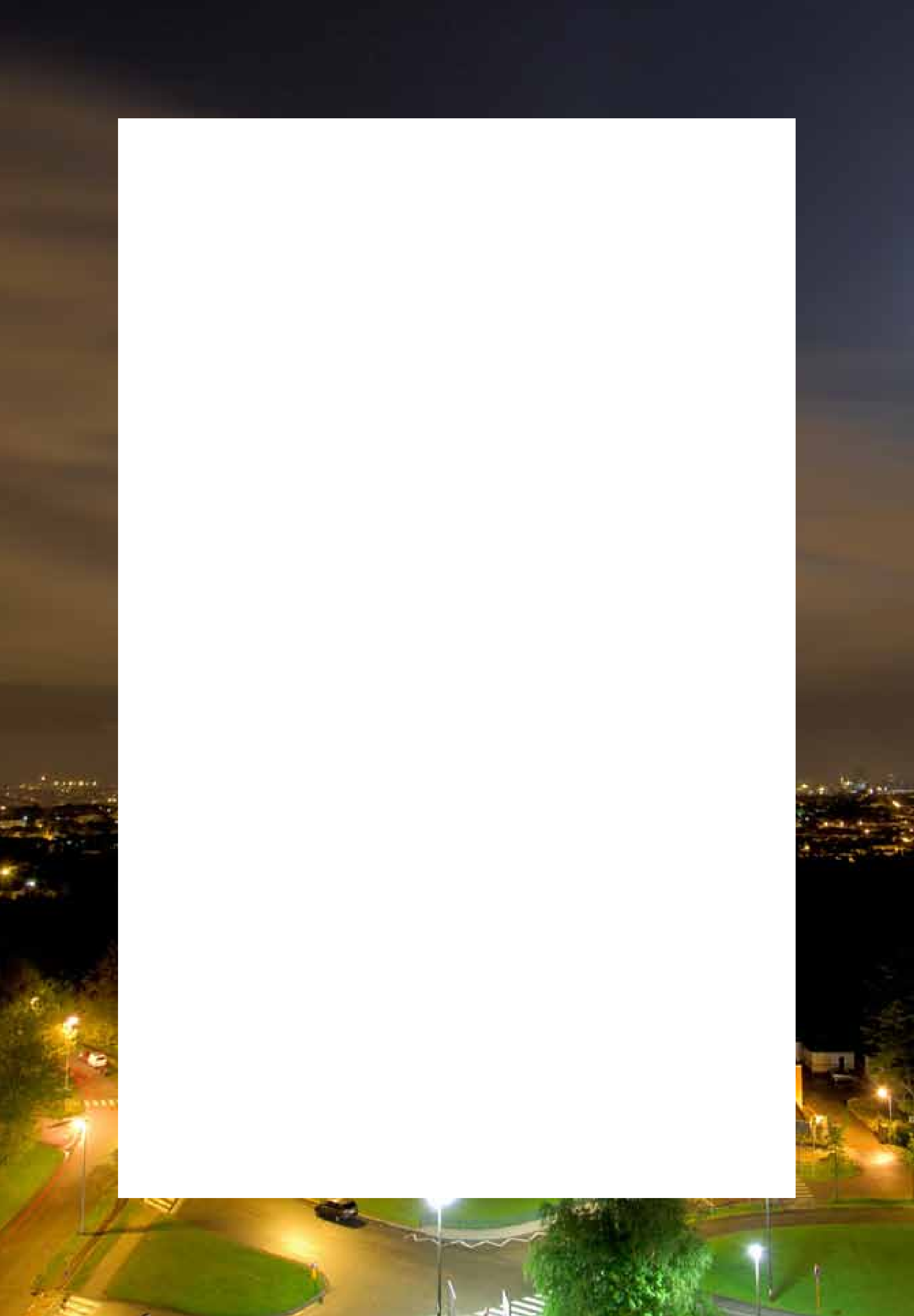

8 Energy use and greenhouse gases

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OUTLINES

- The measures in the visionary scenario (VISI) ensure a decrease in the use of energy in Flanders by 20.6 % in 2020 compared to the reference scenario (REF), which is based on an unchanged policy. Flanders can only meet the European target of a 20 % increase in energy efficiency through the VISI scenario. Households and the energy sector can realise the largest savings.

- By 2020 the share of renewable energy sources in the gross final use of energy is respectively 8.7 and 9.2 % for the Europe (EUR) and the VISI scenarios. Europe imposed a target of 13 % on Belgium but the regions have not yet reached any further agreements concerning its realisation.

- The sectors that fall under the European Emissions Trading Directive (primarily the industry and energy production sectors) cannot bring their joint greenhouse gas emissions below the 2006 level at the CO_2 prices forecast. This is because there would be insufficient cost effective national measures available. These sectors could fall back on purchasing emission rights.

- The sectors that do not fall under the Emissions Trading Directive (households and the majority of trade & services, agriculture and the transport sector) can reduce the greenhouse gas emissions by 23 % (EUR scenario) to 32 % (VISI scenario) by 2020. Europe has given a reduction target for Belgium of 15 % compared to 2005.

- Despite good growth figures for renewable energy, fossil energy sources dominate in the energy mix of all scenarios. Intensive energy savings are an important lever to increase the share of renewable energy sources.

Introduction

The European Union put forward the following ambitious threefold targets by 2020 for the EU27 in the European Energy and Climate Package:

- A reduction of energy use by 20 % through a more efficient use compared to the level expected in 2020 with an unchanged policy.
- An increase of up to 20 % in the share of renewable energy sources in the gross final use. For transport a specific target of at least 10 % renewable energy is applicable (biofuels but also green power and others) on the total energy use for transport.
- A reduction of greenhouse gas emissions by at least 20 % compared to 1990. The EU has committed to increasing this figure to 30 % with an equivalent effort by other developed countries and with an adequate contribution by economically more advanced developing countries according to their own responsibilities and possibilities.

The EU is giving the international community a strong signal by imposing this threefold target on itself independently of the rest of the world. In view of this European target, this chapter describes the possible developments of energy use and greenhouse gas emissions for Flanders for three future scenarios with increasing levels of ambition:

- The REF scenario continues the current environmental policy (as of 1 April 2008) unchanged until 2030.
- The EUR scenario includes measures and instruments needed to meet the medium-term targets of the European environmental policy mentioned above.
- The VISI scenario is based on additional measures to find a sustainable solution to environmental issues. The measures chosen are intended to realise a reduction of emissions by 60 to 80 % for greenhouse gases by 2050, with a halving of the emissions by 2030.

This chapter offers an overview of the impact of the assumptions and policy choices made by bundling data from the previous sector chapters. The sector-specific models start from the basic assumptions of the Federal Planning Bureau (see Chapter 2 Socio-economic outlook) and are supplemented by more detailed sector-specific assumptions (e.g. future activity, market operations, possible policy measures and their potential). For an overview of the assumptions, policy choices and model characteristics the text refer to the sector chapters and their respective scientific reports. The results from the sector chapters that follow from all these bottom-up assumptions and policy choices made can be found in the key set of the Environment Outlook 2030 at www.milieurapport.be.

This chapter considers the gross domestic energy use, the gross consumption of renewable energy sources, greenhouse gas emissions and energy intensity and carbon intensity. Where possible the results are viewed in the light of the European 20-20-20-targets. Because a lot of legal reporting requirements and testing frameworks for the period after 2012 are still under development, it was necessary to make a number of additional, but explicit assumptions. Finally this chapter highlights a few conclusions and recommendations.

8.1 Energy use

Gross domestic energy use

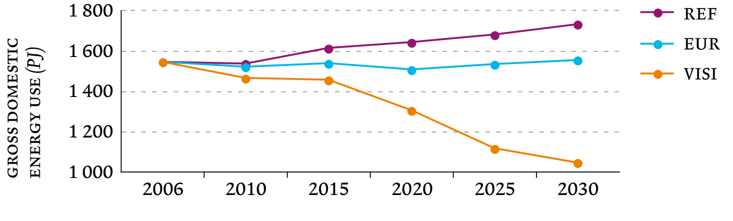
The gross domestic energy use (GDE) describes the total energy required to fulfil the national energy demand and the non-energetic use of energy carriers. It is the sum of all primary energy production in Flanders (e.g. wind, PV, solar boilers, etc.) and imported energy (e.g. coal, gas, nuclear fuel, etc.) decreased by exports of energy and fuel for international ship and aviation bunkers.

All scenarios start with a GDE of 1 541 PJ in 2006[1]. The energy use in the REF scenario first decreases slightly until 2010, but growth then rises sharply. In 2020 it is 6.6 % and in 2030 12.8 % higher than in 2006. The energy use in the EUR scenario fluctuates around the 2006 level: 2.4 % lower in 2020 and 0.6 % higher in 2030. Only the VISI scenario can structurally limit the energy use by 16 % in 2020 and even 32 % in 2030 (FIGURE 8.1).

The European energy efficiency action plan[2] aims at a 20 % reduction of the GDE by 2020 compared to the evolution with an unchanged policy, which is the 2020 REF scenario here. The energy savings are 8.3 % in the EUR scenario and 20.6 % in the VISI scenario compared to this reference energy use in 2020. Only the VISI scenario manages to meet the European target.

In 2006 the annual energy use per capita in Flanders was 254 GJ. This approximately corresponds to the energetic value of 6 000 kg oil or 6 to-eq. In the EU only Luxembourg and Norway have a higher per capita use of energy. The trends assumed in the scenarios for population growth, family shrinkage and industrial growth make energy use shoot up. Flanders can counter this growth to a large extent through an energy savings policy. After an initial drop around 2010, energy use per capita increases again in the REF scenario by half a percent in 2030 com-

FIG. 8.1 *Gross domestic energy use in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



pared to 2006. There is a continuous decrease however in the EUR scenario until 2020. Energy use per person stabilises afterwards at 10 % below the level of 2006. Energy use per capita in the VISI scenario is 22 % lower in 2020 and 39 % lower in 2030 compared to 2006.

Gross domestic energy use per sector

FIGURE 8.2 illustrates the development of GDE per sector. The households sector has an exceptionally large potential for energy savings. Of course an appropriate policy is required for this. The energy sector is only able to beat the energy savings of households in the VISI scenario. However much further-reaching measures will be required to turn the tide of industrial energy use than those modelled in that chapter.

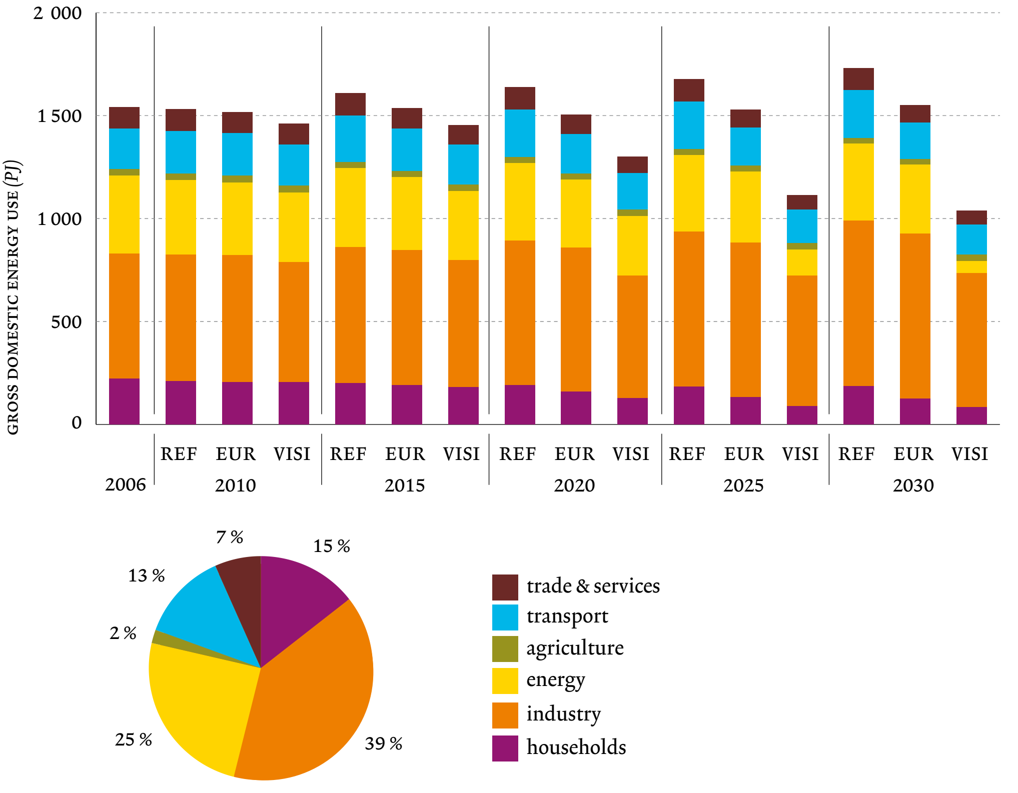
The share of the agriculture, transport and trade & services sectors in the GDE remains almost constant between 2006 and 2030. The share of the households decreases to 11 % in the REF and 8 % in the EUR and VISI scenarios. Industrial use of energy not only takes the lion's share of the GDE, it also rises the strongest. In the VISI scenario, industry is responsible for 63 % of the total energy use in 2030, whereas this was only 39 % in 2006. This relative increase is the result of the major energy savings in all other sectors, with energy production in the lead. This sector only represents 6 % of the total energy use in the VISI scenario in 2030, it has a 22 % share in the other scenarios.

The energy use in the *households* sector is 224 PJ in 2006. It is the only sector in which a reduction in energy consumption is achieved in all scenarios and in almost every year (except in the REF MIN scenario, calculated in Chapter 3 Households and trade & services). So the households sector succeeds in reducing its initial energy use in 2030 by 16 % in the REF scenario and by 43 % in the EUR scenario. The VISI scenario that strives for energy neutrality through new forms of housing, can already realise this 43 % reduction by 2020 and can even decrease energy use by 62 % by 2030. This is possible because the energy quality of existing homes is relatively low in Flanders. An improvement of the level of insulation of the roofs and windows could, for instance, already have a relatively major impact.

Industry's energy use was 607 PJ in 2006. This includes both energetic and non-energetic use of energy carriers[3]. As a result of the economic growth projections for the majority of subsectors this energy use increases by 32 % in 2030 in both the REF and EUR scenarios. The VISI scenario assumes that the increasing fuel prices and CO_2 prices may impact the production level. The higher CO_2 prices slow down economic growth somewhat, which ensures that industrial energy use fluctuates around the 2006 level for longer. In 2030 its energy use is only 7 % higher than in 2006. Industry is the only sector in which none of the scenarios researched were able to reduce the energy use structurally below the 2006 level.

The energy use of the *energy sector* depends on the demand from other sectors, on the fuel mix and the techniques applied. In this way it was 380 PJ in 2006. Both

FIG. 8.2 *Gross domestic energy use per sector in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



share of the sectors in the gross domestic energy use in 2006

in the REF and EUR scenarios the energy use is subject to a fluctuating and ultimately decreasing trend. Compared to 2006 it falls by 2 % in 2030 in the REF scenario and by 12 % in the EUR scenario. In the VISI scenario the energy use of the energy sector finally decreases by 84 % compared to 2006. This reduction is due to the more efficient use of conventional electricity power stations, and particularly to the use of renewable energy sources for which the transformation losses do not have to be taken into account.

The *agriculture sector* shows a deviating development compared to the other sectors. Starting from 32 PJ in 2006 the energy use in the REF scenario decreases by 14 % in 2030 due to lower activity. The reduction in the EUR scenario is less pronounced with 8 %. In the VISI scenario the energy use returns to the 2006 level by 2030. This stabilisation is entirely attributable to the increased energy intensive activities in greenhouse farming.

The energy use for *transport* (excluding international bunkers) is 195 PJ in 2006. In the REF scenario this increases without interruption to 19 % in 2020. Energy use stabilises after that primarily due to increased efficiency in passenger transport. This energy use also rises initially in the EUR scenario. However by 2020 it is again at the 2006 level. By 2030 energy use decreases by 9 % compared to 2006. The increased share of hybrid cars plays the most important role in this reduction in addition to the stricter requirements for new vehicles. Initially there is also a limited increase in the VISI scenario but the level of use already drops below the 2006 level by 2015. The use then decreases further structurally: by 2030 energy use has decreased by 24 % compared to 2006. The more intensive use of plug-in hybrids and improvements to efficiency in freight transport are the main reasons for this.

The energy use of the *trade & services* sector is 104 PJ in 2006. The REF scenario just fails to realise a decrease in energy use by 2030. A reduction by 21 % is possible in 2030 in the EUR scenario amongst others due to the accelerated demolition of existing buildings and the stricter and more widely applied energy performance standards for new construction. The VISI scenario, which strives for energy neutrality, succeeds in decreasing energy use by 36 %.

Gross domestic energy use per energy source

FIGURE 8.3 shows the GDE per energy source. The figures for the GDE are visualised in such a way here that a distinction can be made between:

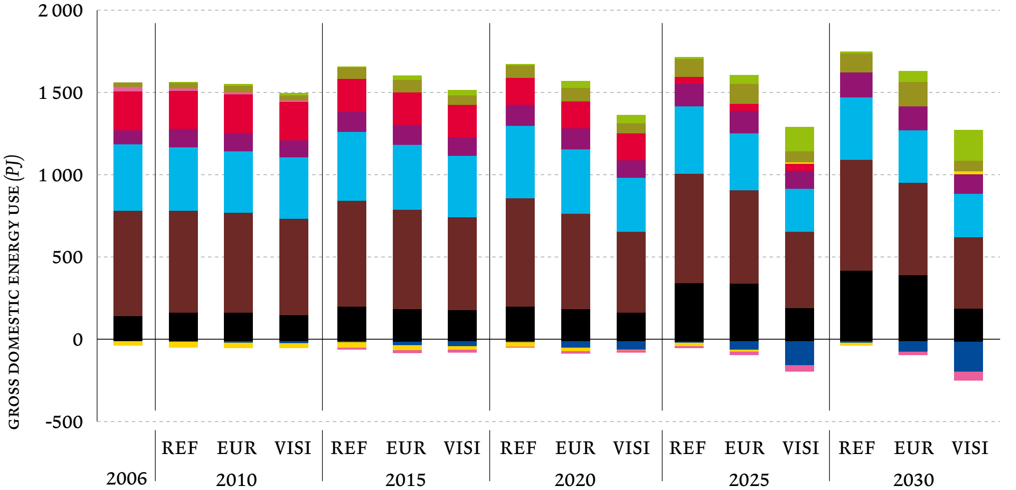
- Energy imports and exports. The 'import/export electricity & hydrogen' includes the difference between electricity demand and production. In other words this is the net energy exchange from Flanders with other regions and with neighbouring countries. This category is also multiplied by the imported energy carrier hydrogen.
- Renewable energy from biomass (green heat, power from green CHPs, biofuels for transport) and renewable energy not originating from biomass, called 'net renewable energy extract excluding biomass'. (electricity from wind, water, PV... and heat from heat pumps, solar boilers, etc.)[4] here.
- Use of heat and export. The figures below zero express the heat measured but not used in Flanders unlike positive figures.

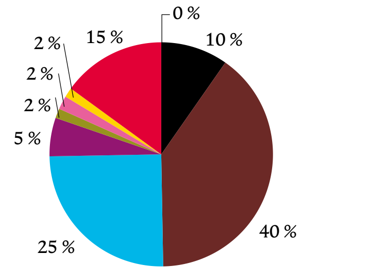
Another basis for comparison was required to express the share in percentage of the energy sources in the total mix due to the 'negative' export figures. After all 'exported energy' also requires input of energy sources for their generation. This exported energy is not included in the GDE figure however. For that reason the share of each energy source was expressed compared to the total of the sources of energies used.

The share of each energy source in the energy mix is governed to a significant extent by the assumptions concerning the price of fossil energy sources, the growth of renewable energy and the phasing out of nuclear power stations in the 2015-2025 period.

With the gradual phasing out of the nuclear power stations both the REF and EUR scenario primarily use coal to cover the increased energy requirements. In ad-

FIG. 8.3 *Gross domestic energy use by energy source in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*





share by percentage of the various energy sources compared with the total energy used in Flanders in 2006

The total of the energy sources used is the sum of the absolute values in the figure above. The 'renewable energy use (excl. biomass)' category is included negatively to prevent it from being counted twice.

dition the use of biomass also increases sharply in both scenarios. In the VISI scenario the use of coal increases to a much more limited extent by 2030. This scenario is characterised by major energy savings by consumers and a strong growth of non-biomass based renewable energy. Offshore wind energy breaks through particularly. Because the VISI scenario avoids the use of biofuel in transport (see below), the share of biomass is also much smaller than in the other two outlooks.

Fossil energy sources continue to dominate the energy mix in all scenarios. The dependency on fossil energy sources is the largest in the REF scenario. In this scenario its share of the total energy sources used in 2030 is 92 %. In 2006 it had an 80 % share. The dependency on fossil energy sources in 2030 stops at 90 % in the EUR scenario and

88 % in the VISI scenario. In absolute terms use is 21 % lower in the VISI scenario in 2030 compared to 2006. This is predominately due to a much lower energy demand.

In absolute figures *renewable energy* experiences a significant and almost linear growth in all scenarios In 2006 the amount of gross renewable energy was estimated at almost 26 PJ. In 2030 this has multiplied by five in the REF scenario. It is more than eight times larger in the EUR scenario and almost fourteen times greater in the VISI scenario (also see below).

These growth figures, despite energy saving efforts, mean that Flanders remains highly dependent on imports from abroad for energy provision in all the scenarios.

8.2 Renewable energy

Gross final energy consumption from renewable sources

The European directive for the promotion of the use of energy from renewable sources[5] expects that Belgium will increase its share of renewable energy to 13 % in the gross final consumption of energy by 2020. At least 10 % of the consumption by transport must come from renewable sources by 2020[6]. The regions have not made any further agreements concerning the realisation of these Belgian targets.

The gross final energy consumption from renewable sources[7] comprises (FIGURE 8.4):

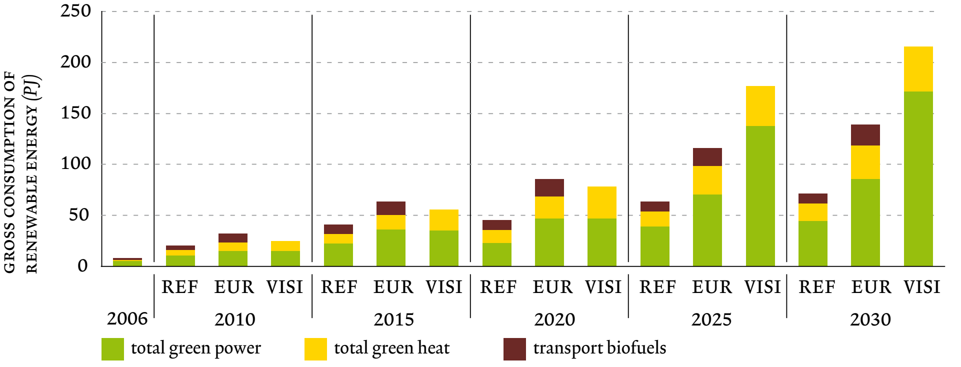
- energy consumption from renewable sources in transport[8];
- the gross consumption for heating and cooling from renewable energy sources;
- the gross consumption of electricity from renewable energy sources.

The use of *biofuels by transport* was 2 PJ in 2006 and almost five times more in 2020 in the REF scenario. The use of biofuels increases from 17 PJ in 2020 to 20 PJ in 2030 in the EUR scenario. The VISI scenario assumes that other sectors can use biomass more efficiently and consequently does not use any biofuels[9].

Amongst others, photovoltaic cells (PV), wind, wave and water power and biomass can produce *green power*. Green power production grows strongly in all scenarios. Starting from 5 PJ in 2006 there is five times more green power production in 2020 in the REF scenario and nine times more in the EUR and VISI scenarios. There is a particularly strong growth after 2020 in the VISI scenario. Compared to 2006 the production in 2030 has increased by a factor of 9, 17 and 33 respectively for the REF, EUR and VISI scenarios. A more detailed discussion of green power production is given in Chapter 7 Energy production.

Green heat and cooling is the sum of energy originating from solar boilers, heat pumps, geothermal heat and heat produced from biomass (e.g in bio-CHPS). Green heat and cooling experience almost linear growth in the three scenarios with a higher level of ambition in each scenario. Due to the very modest situation at the start for green heat production in 2006 of only 0.75 PJ, spectacular growth may be registered.

FIG. 8.4 *Gross final energy consumption from renewable sources in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



The production increases by a factor of 16, 28 and 42 respectively for the REF, EUR and VISI scenarios in 2020. This is even a factor of 23, 44 and 59 for 2030.

The energy consumption from renewable sources must be tested in accordance with the European directive against the *gross final energy consumption*. This is the total of the energy resources supplied for energy purposes to all sectors without the energy sector (electricity and refineries). The use of electricity and heat by the energy sector itself and the grid losses with the production and distribution of electricity and heat also fall under this gross consumption. The non-energetic consumption of energy carriers by industry is not included.

The share of green power, green heat/cooling and biofuels together increases significantly in the three scenarios in relation to the gross final energy consumption by 2020. If the renewable energy target for Belgium (13 %) should remain applicable unchanged to Flanders, the EUR scenario just reaches the target with a delay by 2030. The VISI scenario would exceed the target between the period 2020 and 2025. The REF scenario halters at 4 % in 2020. In the scenarios studied Flanders should have to appeal to the purchase of guarantees from abroad to comply with the stipulations of the European directive in any event. At the start of the Environment Outlook 2030 the potential on the use of green heat in Flanders and especially within the industrial sector had been inadequately charted. This may offer an opportunity still to reach the 2020 targets internally.

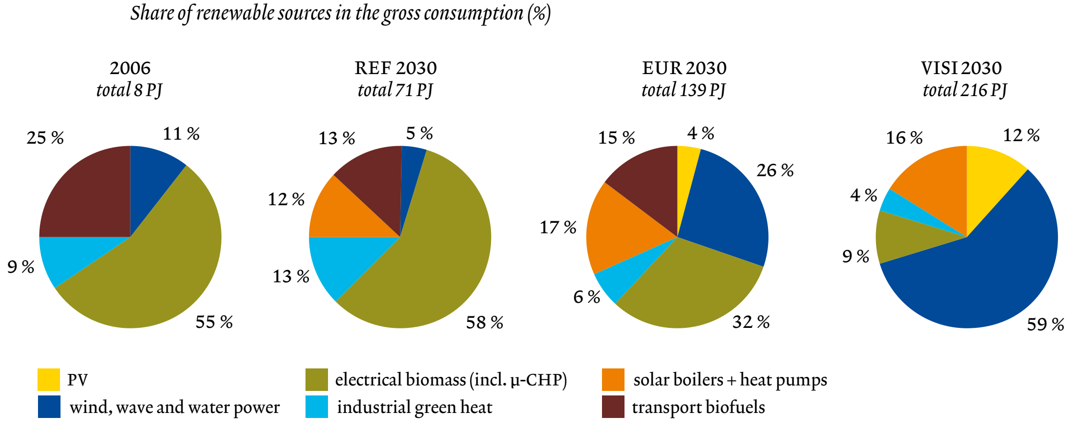
TAB. 8.1 *Use of renewable energy sources compared to the gross final energy consumption in PJ in the REF, EUR and VISI scenarios (Flanders 2006, 2020, 2030)*

	2006	2020 REF	2030 REF	2020 EUR	2030 EUR	2020 VISI	2030 VISI
Total green power	5.2	23.4	44.3	47.5	85.9	46.9	171.8
Total green heat	0.7	12.1	17.4	21.0	32.6	31.3	44.0
Transport biofuels	2.0	9.6	9.3	16.8	20.3	0.0	0.0
Use of renewable energy	7.9	45.2	71.0	85.3	138.9	78.2	215.8
Gross final energy consumption	*995.2*	*1 064.8*	*1 120.9*	*974.9*	*982.4*	*853.8*	*817.0*
Renewable energy	0.8 %	4.2 %	6.3 %	8.7 %	14.1 %	9.2 %	26.4 %

Gross final energy consumption from renewable sources by energy source

The categorisation of renewable energy sources according to green power, green heat/cooling and bio fuels gives an insight into the form in which renewable energy is used (FIGURE 8.5). By zooming into the origin, it becomes clear that the various forms of biomass (with electrical biomass taking the lead, followed by industrial green heat and bio fuels) continue to make the largest contribution to renewable energy use until 2030 in the REF scenario. The share of biomass decreases in the EUR scenario, particularly to the benefit of wind and solar energy. The share of bio fuels for transport gradually decreases, whereas that of solar boilers and heat pumps increases to 17 % in 2030. In the VISI scenario, wind, wave and water power primarily take the foreground. Together with solar boilers, heat pumps and PV power they account for 86 % of the consumption in 2030.

FIG. 8.5 *Gross energy consumption from renewable sources according to origin in the REF, EUR and VISI scenarios (Flanders, 2006 and 2030)*



8.3 Greenhouse gases

Greenhouse gas emissions

FIGURE 8.6 compares the emissions from the range of greenhouse gases (CO_2, CH_4, N_2O, SF_6, PFCs and HFCs) for the three scenarios. In addition to emissions from the sectors, account is also taken of the net absorption of greenhouse gases as a result of land use (sinks). This estimate is realised on the basis of the changing land use due to the Space Model (see Chapter 10 Land use).

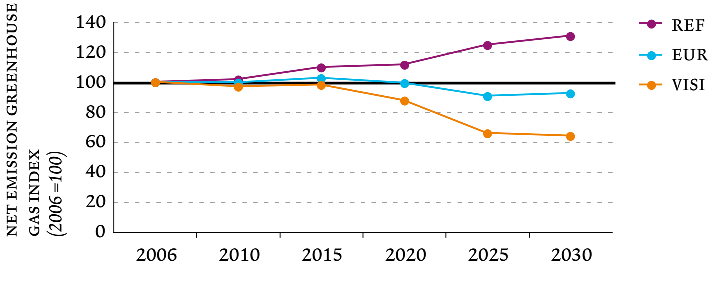
Starting from emissions of 84 489 ktonnes CO_2-eq[10] in 2006, the greenhouse gas emissions grow almost continuously in the REF scenario. The total emissions are 12 % higher in 2020 and even 31 % higher in 2030 compared to 2006. In the EUR scenario the greenhouse gas emissions fluctuate around the 2006 level until 2020 and then end up 8 % lower in 2030. In the VISI scenario the emissions fall immediately and particularly sharply after 2015. In this way the VISI scenario shows emission reductions of 12 % in 2020 and 36 % in 2030. This means Flanders is still a long way from halving greenhouse gas emissions by 2030. This is the target in the VISI scenario as a step towards an international 60 to 80 % reduction of emissions for the industrialised world by 2050.

In 2006 the annual greenhouse gas emissions per person in Flanders were 14 tonnes CO_2-eq. This figure makes the Flemish citizen one of the main emitters of Europe, after the Finnish, Irish and Luxembourg citizens. As a comparison, an American citizen emits 19 tonnes a year on average, a Nepalese citizen 0.1 tonnes. The greenhouse gas emissions per capita are often used in international climate negotiations as a measure of fairness of the reduction efforts per country. In 2030 the greenhouse gas emissions per person will be 16 tonnes (REF), 11 tonnes (EUR) and 8 tonnes (VISI) in Flanders.

Greenhouse gas emissions by sector

Although energy use is the main cause of greenhouse gas emissions (GHG), the development of the greenhouse gas emissions develops very differently spread over

FIG. 8.6 *Net greenhouse gas emissions in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



the sectors (Figure 8.7), compared to the development of GDE by sector (Figure 8.2). Amongst others, this shows the importance of the significant use of renewable energy sources supplemented by underground CO_2 storage in coal and gas plants after 2020. In addition the practical use of residual heat and the conversion to low carbon fuels in households also plays an important role.

The EU implements a dual approach for the division of the 20 % emission reduction target. The EU allocates a target to each member state for sectors that do not fall under the emissions trading system (ETS). Installations in sectors that do fall under emissions trading, are confronted with a market price for the right to emit one tonne of greenhouse gases. The pricing determines where the emission reductions take place: reductions that cost less than the market price for CO_2 will be realised within the sector in Flanders itself. For the remaining emissions, the sector must submit sufficient emission rights.

Non-ETS sectors

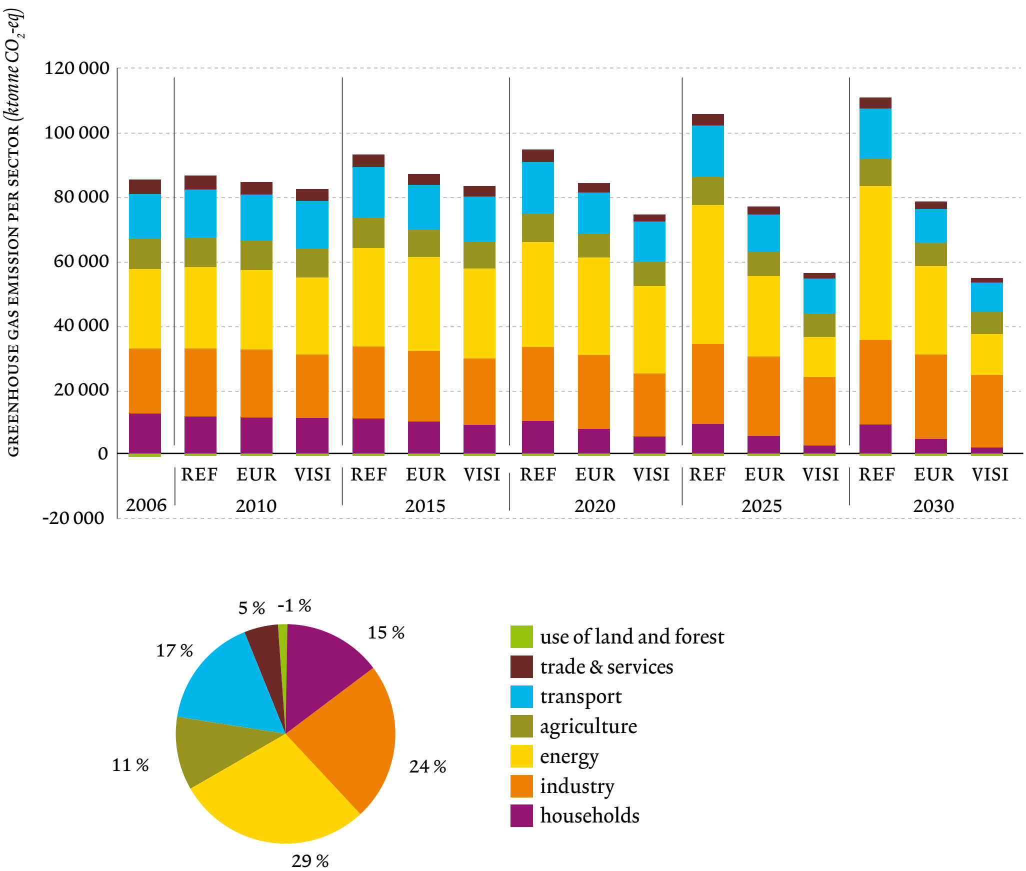
The sectors that do not fall under emissions trading, the non-ETS sectors include households and the majority of transport, agriculture and trade & services. Europe[11] imposes an obligatory reduction of 15 % by 2020 compared to 2005 on Belgium. An agreement had not yet been reached at the date of publication concerning the division of this target across the regions and the federal government. For that reason this report takes the 15 % target as indicative for Flanders and is compared with 2006. This target is achieved both in the EUR scenario (-23 %) and the VISI scenario (-32 %). In the REF scenario this reduction remains limited to 4 % in 2020. The decreasing trend continues until 2030, with a limitation of emissions of 10 % in the REF, over 39 % in the EUR, and even to 52 % in the VISI scenario.

The *households* sector can realise sharp reduction percentages in all scenarios between 2006 and 2030: 27 % in the REF, 63 % in the EUR and even 84 % in the VISI scenario. In the first two scenarios this sector also realises the largest reduction in emissions in absolute figures. The energy sector only overtakes the households sector in the VISI scenario. The fact that the total GHG emissions of households is below 9 % in 2030, testifies to the large reduction potential in this sector.

The *agricultural emissions* also decrease in all scenarios compared to 2006, respectively by 11, 22 and 25 % in the REF, EUR and VISI scenarios in 2030. Their share in the total emissions decreases slightly in the REF and EUR scenarios to 8 – 9 % but is slightly higher (at 13 %) in the VISI scenario. Energy use decreases less sharply here than in the other sectors.

Emissions by the *transport sector* initially increase in all scenarios. The turning point is reached in the REF scenario in 2020. The emissions are still 10 % higher than in 2006 by 2030. In the EUR and VISI scenarios the transport emissions already peak in 2010 and are then respectively 25 and 36 % lower by 2030 than at the start in 2006.

FIG. 8.7 *Greenhouse gas emissions per sector in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



share of the sectors in the total greenhouse gas emissions in 2006

Transport's share in the total GHG emissions decreases slightly in the REF and EUR scenarios to 14 % and remains constant at 17 % in the VISI scenario. Road traffic is also responsible in the future for the largest share of GHG emissions within the transport sector.

As with the households the GHG emissions also decrease in the *trade & services* sector from the beginning in all scenarios. In 2030 their emissions are 21, 51 and 70 % lower than in 2006. Thanks to the measures taken, Trade & Services remains the sector with the lowest emissions with percentage shares in the total emissions of 3 % in the REF and EUR scenarios and only 2 % in the VISI scenario.

ETS SECTORS

The joint GHG emissions of the MIRA sectors industry and energy rise by 24 % by 2020 in the REF, 19 % in the EUR and 9 % in the VISI scenarios compared to 2006. By

2030 these national ETS emissions will have increased further in the REF and EUR scenarios by 66 % and 20 % above the starting level respectively. The ETS sectors will only be able to reduce their emissions through national measures by 21 % to below the 2006 level after 2020 and only in the VISI scenario. This reduction is due to a large extent to the energy sector.

The *energy sector* is the main source of greenhouse gas emissions in 2030 in the REF scenario with a 43 % share of the total GHG emissions. While the GDE of this sector decreases slightly between 2006 and 2030, the absolute greenhouse gas emissions (+95 %) double. This can primarily be explained by the increased use of coal and gas power stations in the phase-out of nuclear installations. Electricity production at the nuclear power station is almost CO_2 free, whereas natural gas and certainly coal are characterised by a higher CO_2 emissions factor. The emissions also increase in the EUR scenario by 12 % compared to 2006, whereas the GDE decreases by the same percentage. The increased use of coal also affects the emissions here. An increased use of renewable energy sources and the introduction of CO_2 capture and underground storage[12] (CCS) after 2020 make it possible to limit the increase in CO_2 emissions. The energy sector can almost halve their emissions in the VISI scenario, especially by investing strongly in renewable energy.

Industrial GHG emissions have a relatively constant increasing trend in all scenarios due to the economic growth forecasts. In the 2006-2030 period the emissions rise by 30 % both in the REF and EUR scenarios. The increase in emissions are limited to 12 % in the VISI scenario as a result of the high prices on the CO_2 market. This makes *industry* the only sector unable to reduce the emissions to under the 2006 level through national measures in any of the scenarios.

In 2006 the ETS sectors were responsible for 48 % of the total GHG emissions. In 2020 this share rose to 59 % for the REF and to 63 % for the EUR and VISI scenarios.

The European Emissions Trading Directive[13] stipulates that the communal emissions of all European installations that fall under the emissions trading system must be 21 % lower by 2020 than in 2005. Although smaller industrial installations (under certain conditions) may fall outside the scope of this directive, this analysis considers the whole of the industry and energy sectors as being ETS sectors. CO_2 market prices derived from international studies have been used for these ETS sectors and they have been adjusted to the level of ambition of the three scenarios in the Environment Outlook 2030. Insufficient cost-effective national measures have proven available to bring the communal GHG emissions of the Flemish industry and energy sectors below the 2006 level at these CO_2 prices. These sectors may comply with the European directive by purchasing emission rights within the European emissions trading system in addition to the implementation of measures that do prove cost effective.

Greenhouse gas emissions by greenhouse gas

Figure 8.8 illustrates the total net greenhouse gas emissions, divided by greenhouse gas CO_2, CH_4, N_2O and F gases (SF_6, HFCs and PFCs) and expressed in CO_2 equivalents.

The three main greenhouse gases, CO_2, N_2O and CH_4, continue to dominate in all the forecast years. In the REF scenario the share of the main greenhouse gas CO_2 in the total emissions increases to 91 %. The CO_2 share in the EUR scenario decreases to 88 % in 2030 and to 84 % in the VISI scenario.

In absolute terms CH_4 contributed the most to GHG emissions in 2006 after CO_2. Methane emissions were limited in all scenarios compared to 2006. After an initial decrease to 2010 the N_2O emissions rise again. In the EUR and VISI scenarios these emissions do remain under the 2006 level. F gas emissions remain very limited despite their increase until 2030.

FIG. 8.8 *Greenhouse gas emissions per greenhouse gas in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*

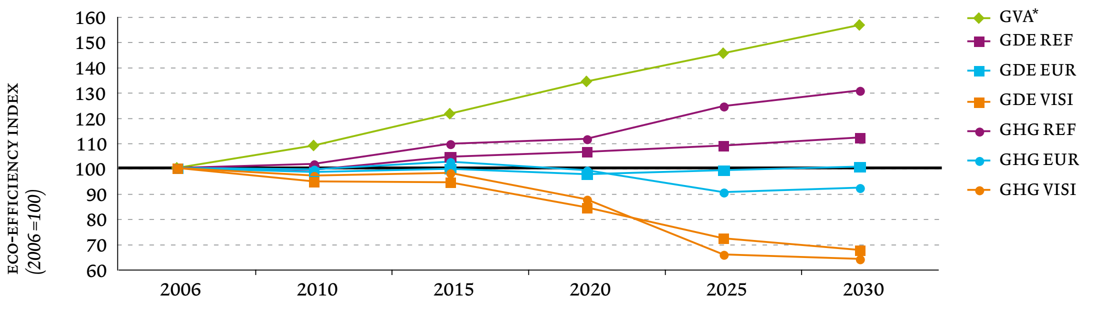
percentage share of each greenhouse gas in the total net emissions in 2006

8.4 Eco-efficiency, energy intensity and carbon intensity

Eco-efficiency

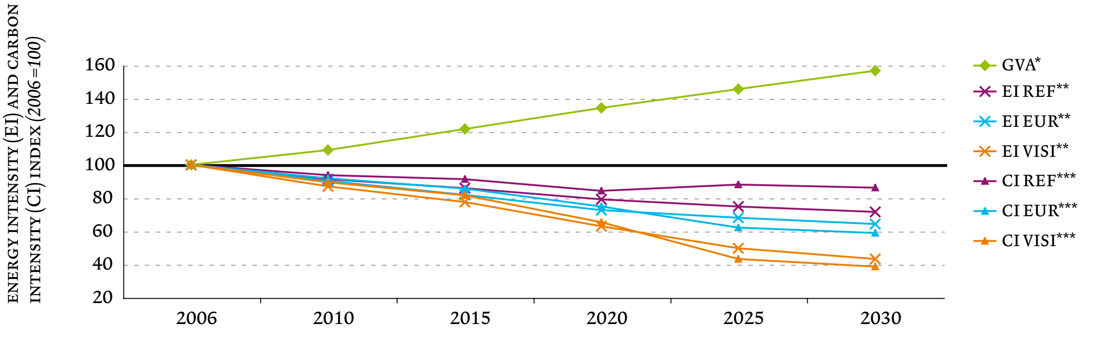
One of the targets of the Pact 2020, which the Flemish government signed together with the social partners and business organisations in early 2009 is intended to realise a further separation between economic growth and the whole of the emissions and waste products by 2020 through a gradual increase in material and energy efficiency. In short, it comes down to increasing the *eco-efficiency* of the Flemish economy.

FIG. 8.9 *Comparison between economic growth on one hand and the gross domestic energy use and greenhouse gas emissions on the other in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



* gross added value from all business sectors in Flanders[14] (at constant prices from 2000) (million euro)

FIG. 8.10 *Energy intensity and carbon intensity of the economy in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



* gross added values from all business sectors in Flanders (at constant prices from 2000) (million euro)

** energy intensity = amount of gross domestic energy use (GDE) per unit of gross value added (GVA) (in 1 000 euro at constant prices from 2000)

*** carbon intensity = amount of CO_2 emitted as a result of energetic and non-energetic processes (process emissions amongst others in chemistry (cannot be distinguished in the modelling) (in tonnes) per unit of gross value added (GVA) (in 1 000 euro at constant prices from 2000)

FIGURE 8.9 tests the economic growth forecasts against energy use and greenhouse gas emissions in the three scenarios. This makes it possible to deduce that there is a separation for all scenarios both for the gross domestic energy use (GDE) and the total greenhouse gas emissions (GHG) in the Flemish economy. Absolute separation in relation to economic growth for all forecast years is only applicable to the VISI scenario.

Energy intensity and carbon intensity

The *energy intensity* of the economy is the ratio between the gross domestic energy use (GDE) and the gross domestic product (GDP), approached here by the sum of the gross values added of the various sectors). The energy intensity outlines the energy dependency of the Flemish economy.

The energy intensity of the Flemish economy decreases sharply in all scenarios (FIGURE 8.10). In the REF scenario the energy intensity in 2030 is 28 % lower than in 2006. For the EUR scenario this is 36 % and in the VISI scenario this intensity halves in the period between 2006 and 2030.

The *carbon intensity* is calculated as the ratio between the CO_2 emissions from combustion (including process emissions) and the GDP (approached here by the gross value added). This indicator provides an image of the extent by which an economy is based especially on the use of fossil energy sources.

The carbon intensity of the Flemish economy decreases in all scenarios. Unlike the other scenarios this decrease is not continuous in the REF scenario. Unlike the EUR and VISI scenarios the carbon intensity of the economy is lower than the energy intensity. They are respectively 41 and 61 % lower than the level in 2006. This means that important steps are not only taken towards a more rational use of energy in the EUR and VISI scenarios but that the remaining use of energy is also lower in carbon. The use of renewable energy and CCS in electricity production (not available in REF but available and used in EUR and VISI) plays a role in this.

8.5 Conclusions for policy

This chapter brings together the results from the sector chapters on energy use and greenhouse gas emissions. In addition to a REF scenario, with a continuation of the current policy, these chapters also developed a EUR and VISI scenario. Additional measures were implemented per sector for the latter scenarios which respectively aim at the European 2020 targets or at halving greenhouse gas emissions by 2030.

Thanks to the measures in the VISI scenario, the *energy use* in 2020 is 20.6 % lower than the energy use with an unchanged policy. This scenario allows Flanders to meet the European target to increase energy efficiency by 20 % compared to the development with an unchanged policy. Decreased use of energy is a lever for achieving the renewable energy target. The percentage of renewable energy is measured in comparison to the final energy use. If this decreases the absolute amount of renewable energy to be produced also falls with an equivalent target.

The share of *renewable energy use* in Flanders in 2020 is respectively 8.7 and 9.2 % in the EUR and VISI scenarios. If the renewable energy target for Belgium (13 %) remains applicable to Flanders unchanged, then the use of flexibility mechanisms will even be required in the VISI scenario to achieve the target in time. Europe anticipates a certain level of flexibility for member states that cannot achieve their renewable energy targets through national measures. If the end use of renewable energy is too low, then the country may fall back on a flexible system of trading in guarantees of origin (these are documentary evidence of the production of electricity from renewable energy sources), the static transfer of an amount of renewable energy between member states and the development of communal projects between member states, possibly also with countries outside the EU27. However there is great uncertainty on whether and how this system will operate exactly, the extent of the market supply and the market prices for these instruments. Further research into the potential of green heat, and in particular in industry, could further increase the results from the scenarios slightly. All the scenarios experience a further strong growth of renewable energy after 2020. This is especially the case for the VISI scenario, where the share of renewable energy in the gross final energy consumption comes to 26.4 % in 2030.

When testing the European target to decrease *greenhouse gas emissions* by 20 % compared to 1990, a distinction must be made between sectors subject to emissions trading (ETS sectors) and those not eligible for this (non-ETS sectors).

It is apparent for *sectors that fall under the European Emissions Trading Directive,* that there are insufficient cost effective national measures available with the anticipated CO_2 prices to bring the communal greenhouse gas emissions below the 2006 level. However these sectors may fall back on the option to acquire additional emission rights.They can comply with the European stipulations in this way. The exact extent of this task for the Flemish industry and energy sectors will take shape when the allocation method is formulated at a European level.

There is currently no Flemish target for the *sectors that do not fall under the emissions trading system*. Europe anticipates a reduction target of 15 % for all these sectors in Belgium by 2020 compared to 2005. If this target should remain applicable unchanged for Flanders, then both the EUR and VISI scenarios succeed in a decrease of 23 % and 32 % respectively. It is clear from this that Flanders is independently able to realise the European commitments to *reduce* CO_2 *emission* for non-ETS sectors in both the EUR and the VISI scenarios. Consequently the task is not impossible but requires major efforts. As is apparent from the scenarios, it is crucial that these efforts are started quickly to realise results in time.

Investing in energy saving and the own production of renewable energy cannot be an aim in itself. It also decreases the dependence on international energy sources and protects the national economy from the volatile prices on international energy markets. In addition there are other environmental benefits than purely reducing greenhouse gases, for instance a better local air quality due to a reduction in the emissions of various pollutants. However perhaps the growth and employment opportunities Flanders could take advantage of in its transition to a sustainable and low carbon region are perhaps more important still (see Chapter 14 Flanders in transition?).

ENDNOTES

1 The Flemish GDE is estimated at 1 611 PJ for 2006 in MIRA-T 2008. The difference in the starting value for the three scenarios may, for instance, be explained by the use of generic key energy figures (instead of sector specific key figures).

2 European Commission Communication COM(2006)545 of 19 October 2006, relating to the European Energy Efficiency action plan.

3 The non-energetic consumption of energy carriers increases from 234 PJ in 2006 to 330 PJ in the REF and EUR and 257 PJ in the VISI scenario in 2030.

4 Like other energy production and heat production, renewable power and renewable heat not originating from biomass are included in the categories 'import/export electricity & hydrogen' and 'heat consumption and export'. To make this share of renewable energy excluding biomass visible in the total energy mix, the graph had to be increased by this renewable fraction. The 'net extracted renewable energy (excl. Biomass)' was added for this and simultaneously decreased by its homologous 'renewable energy use' (excl. biomass).

5 Directive 2009/28/EC of 23 April 2009 for the promotion of the use of energy from renewable sources and including the amendment and withdrawal of Directive 2001/77/EC and Directive 2003/30/EC.

6 The 10 % target in the transport sector is considered in the Transport sector chapter.

7 The gross final consumption of energy from renewable sources relates to the energetic values on final use, i.e. after conversion.

8 This calculation is based on the assumption that the biofuels used comply with the sustainability criteria set.

9 The authors of the scientific report on the transport sector based their research on EUCAR, JRC & CONCAWE (2006) and CE Netherlands (2006).

10 It is apparent from the MIRA 2008 Indicator report that Flemish GHG emissions in 2006 were 3.6 % lower than those from 2005 and 3.3 % below those from 1990.

11 Regulation 406/2009/EC of 23 April 2009 relating to the efforts by member states to decrease their greenhouse gas emissions in order to meet the commitments of the Community with regard to the reduction of greenhouse gases until 2020.

12 This underground storage does not necessarily have to be within Belgium.

13 Directive 2009/29/EC of 23 April 2009 as an amendment to directive 2003/87/EC to improve and expand the directive for the emissions trading system for greenhouse gases in the Community.

14 The introduction of price elasticity in the energy and industry sectors in the VISI scenario ensures a deviating gross value added in this scenario, the modelled zero growth of refineries and the iron and steel sector in all scenarios has not been factored into this gross value added figure.

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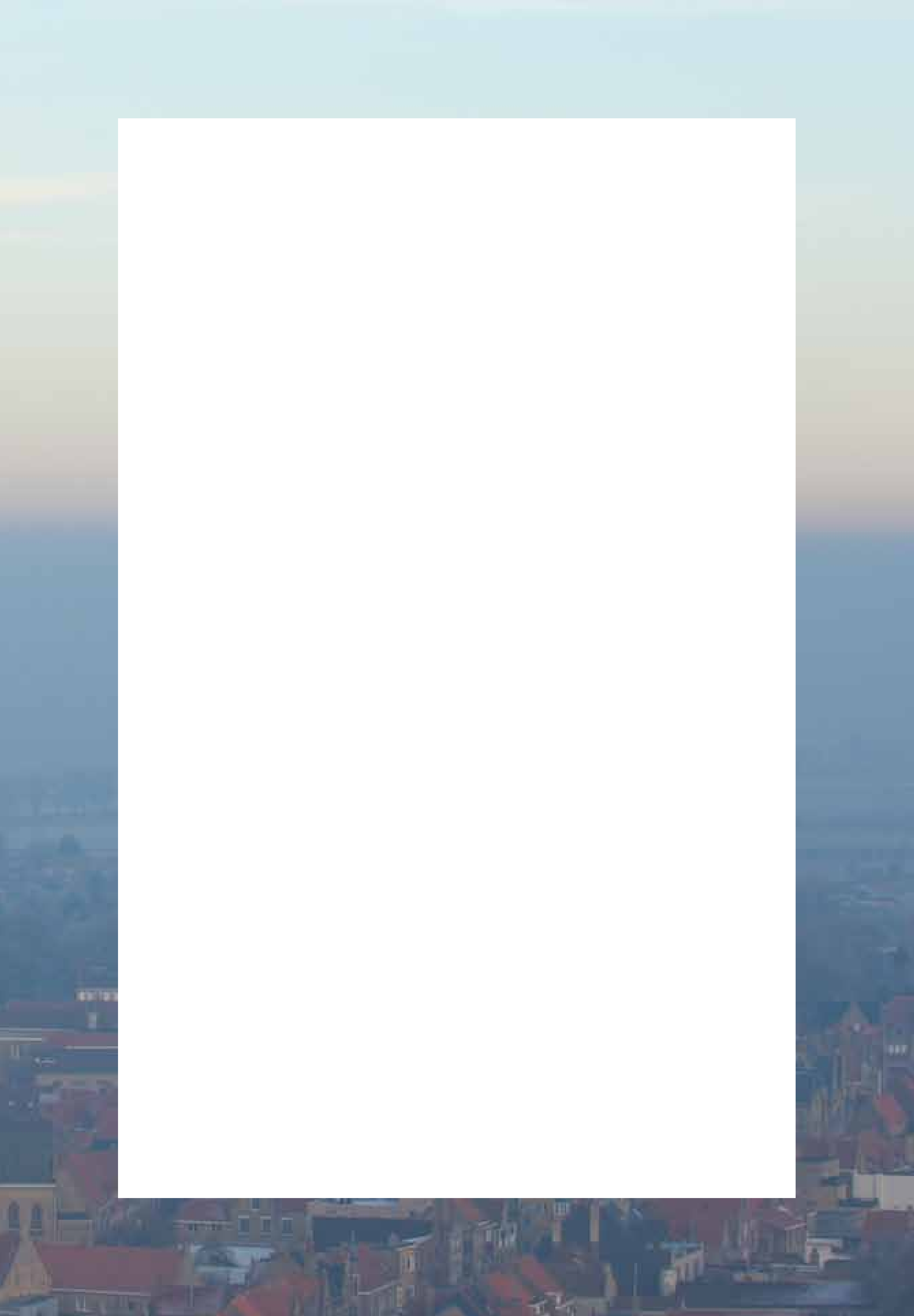

9 Air quality

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OUTLINES

- As a result of the reductions in emissions, the PM10 and PM2.5 concentrations decrease significantly by 2020. A number of targets are then within reach but achieving the European daily limit for PM10 remains problematic without any additional measures, even in the Europe scenario (EUR).

- As a result of the reductions in emissions of ozone precursors in the EUR scenario, the peak ozone concentrations fall by about a third by 2030. The annual average ozone concentration still continues to rise however in both the reference (REF) and EUR scenarios.

- Climate change may predominately or completely nullify the positive effects of the expected reductions of emissions in ozone and particulate matter air pollution.

- The 2010 target for acidifying deposition is achieved in time on average across Flanders. However, even in the EUR scenario, the deposition is still too high in one fifth of Flanders. The 2030 deposition target is not realised in time in either the REF or EUR scenarios. 19 % and 6 % respectively of the area of nature receives an excessive acidifying deposition in 2030.

- The proportion of NH_x in the acidifying deposition increases and even increases to 50 % in 2030 in the EUR scenario. This confirms the importance of the eutrophying effects: in 2030 still 29 % of the area of nature receives excessive nitrogen deposition in the EUR scenario.

Introduction

Prognoses about the quality of air in Flanders over the coming years are very important. Breathing in high concentrations of particulate matter (PM10 and PM2.5) and ozone (O_3) can seriously damage health and is responsible for decreased life expectancy. The World Health Organisation (WHO) even states that there is no safe threshold. Air pollution with acidifying substances also indirectly results in a negative impact on health. High concentrations of ozone and high acidifying deposition also have negative consequences for vegetation. For those reasons the European Union has defined limit and target values for air pollutants that all member states must comply with, with the exception of the acidifying pollutant ammonia. There is a WHO guideline value for the latter pollutant.

A number of these limit and target values were exceeded in Flanders in 2006 (acidification) and 2007 (particulate matter and ozone). Additional emission-reducing measures are necessary to protect the population from the harmful consequences of air pollution in the future. However, in many cases estimating the impact of emission reductions on concentrations of air pollutants is not obvious. This is certainly the case for secondary pollutants such as ozone. These are not emitted directly but are created in the atmosphere as a result of chemical reactions of so-called precursor compounds. Particulate matter also consists of secondary components to a significant extent.

Air quality models help to make the link between emissions and resulting concentrations in the air. These models calculate the spread of pollutants in the atmosphere, the most important chemical reactions that result in secondary pollutants and, if applicable, the deposition thereof. This makes it possible to translate emission prognoses into future concentrations and possible deposition. Uncertainties in the emission prognoses, fluctuations in meteorological parameters and the limitations of the models themselves (e.g. the model resolution) naturally result in specific uncertainties concerning the concentrations of pollutants and the deposition calculated.

In their turn, deposition forecasts make it possible to test nature-oriented deposition standards or critical loads. Furthermore the development of the condition of soil and groundwater in relation to the deposition forecasts is also an indication of the development of the acidification of the soil (e.g. in forest).

All this information should allow policymakers to make an improved estimate of the locations concerned and the extent to which additional emission reduction measures are required. This is to allow Flanders to meet the (European) limits, targets and guideline values in the future and to respect the target loads on nature.

This chapter first outlines the principles of the environment outlook: the methods used, the models and the scenarios. Then an overview is given of the total emissions from the various sectors that are important for the air pollutants reported here, specifically (primary) PM10 and PM2.5, nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), sulphur dioxide (SO_2) and ammonia (NH_3). The chapter then discusses the results per air topic (particulate matter, photochemical air pollution and acidification).

9.1 Principles of the Environment Outlook

The Flemish emissions from the scenario calculations for the various sectors formed the basis for the calculation of the concentrations of PM10, PM2.5, ozone and the acidifying pollutants in the air. Non-Flemish emissions (from other regions and abroad) also contribute to the air pollution in Flanders. These emissions were derived from international emission scenarios chosen to follow the Flemish scenarios as closely as possible as regards measures (IIASA, Amann *et al.,* 2008). The total Flemish and international emission sets are read into the Emap model. This model allows the spatial distribution of the emissions and makes it possible to input data easily into air quality models.

Two air quality models calculated the concentrations of the various pollutants: the BelEUROS model to calculate ozone and particulate matter and the OPS model to calculate acidifying pollutants. The BelEUROS model uses meteorological data, emission data and geographical data (e.g. land use) to simulate complex physical-chemical processes in the atmosphere that cause air pollution. The model calculates concentrations per forecast year on the basis of the emissions for that forecast year and the meteorological data from 2007. Then the relative difference is determined for each forecast year in relation to the BelEUROS model calculation for the 2007[1] base year. These relative differences are then applied to the interpolated concentration map (RIO-corine) from 2007. The concentrations are calculated for every forecast year, thus reducing the uncertainty of the model calculations. Relative differences between modelled concentrations have a smaller level of uncertainty than absolute modelled concentrations. The RIO-corine map, made on the basis of the air quality measurements, is also assumed to give the best possible spatial representation of the air quality at this time.

The next step translates the concentrations of ozone and particulate matter obtained into the resulting health impacts. The Ex DALY model used for this determines the number of disability-adjusted life years (DALYs) and the external healthcare expenses (Ex) due to lifelong exposure to the concentrations calculated.

The OPS model calculates transport, distribution and deposition of acidifying substances (gases and aerosols). The model uses meteorological data, emission data and receptor bound data (e.g. roughness-length, land use, background concentrations) as inputs. The model generates concentration and deposition fields for primary and secondary acidifying components on the receptor grid of 1x1 km chosen. Per forecast year the model calculates concentrations and depositions on the basis of emissions for that forecast year and the meteorological data from 2006. Own comparative research has specifically shown that the meteorological data from 2006 gives a close approximation of the meteorological situation over the last seven years. On the basis of the deposition values obtained, the area of nature (forest, heath and species-rich grassland) suffering from an exceedance of the critical loads for acidification and eutrophication was determined, in which the edges of forests were taken into account. The impact of acidifying depositions on forest soils was verified by simulating the chemical soil status of a number of selected forests in Flanders over time with the dynamic bio-geographical VSD model (*Very Simple Dynamic* model). The period over which a recovery from soil acidification may be expected was verified in this way.

The resolution used in the mathematical models does not allow conclusions to be drawn about places where (highly) local sources have a major impact (e.g. street canyons, the area around industrial sources, etc.). Therefore the conclusions give an indication but are not applicable to specific locations. This chapter considers three scenarios. The reference scenario (REF) comprises the current environmental policy, without any additional measures. The Europe scenario (EUR) takes additional measures into account required to achieve the medium-term targets of the European environmental policy. The visionary scenario (VISI) includes drastic measures with a view to a sustainable future (see Chapter 1 Policy scenarios).

9.2 Emissions of particulate matter (PM10 and PM2.5), ozone precursors and acidifying substances in Flanders

A general picture may be formed of the Flemish emission results by considering the emissions from the sector chapters for each relevant pollutant. An overview of each relevant air pollutant, divided according to sector, is given here based on the previous chapters. 2006 together with the forecast years 2010, 2015, 2020, 2025 and 2030 are presented according to the REF and EUR scenarios and the forecast year 2030 according to the VISI scenario. The principles and content of the various scenarios are described in the sector chapters.

Only emissions according to the REF and EUR scenarios are calculated for air quality. Due to the timing followed the emission set here is not entirely identical to the set used for the concentration calculations. In addition it was not possible to calculate all reduction measures for the industry and energy sectors as established or planned in the context of the National Emission Ceilings Directive or NEC (see Chapters 4 Industry and 7 Energy Production). Nevertheless a sensitivity analysis shows that neither has an impact on the conclusions concerning the air quality to be expected.

The emission totals per pollutant were tested against indicative targets for 2020, based on the IIASA emission scenarios described in the NEC Scenario Analysis report no. 6 (Amann *et al.*, 2008).

Emissions of primary PM10 and PM2.5

Both the REF and EUR scenarios initially forecast a decrease in emissions of primary PM2.5 and PM10 in Flanders in the 2006-2015 period. This is followed by an increase over the period until 2030 (FIGURE 9.1 and 9.2). This increase is particularly due to developments in the industry and energy sectors. This is primarily the result of the

FIG. 9.1 *Emissions of primary PM10 in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*

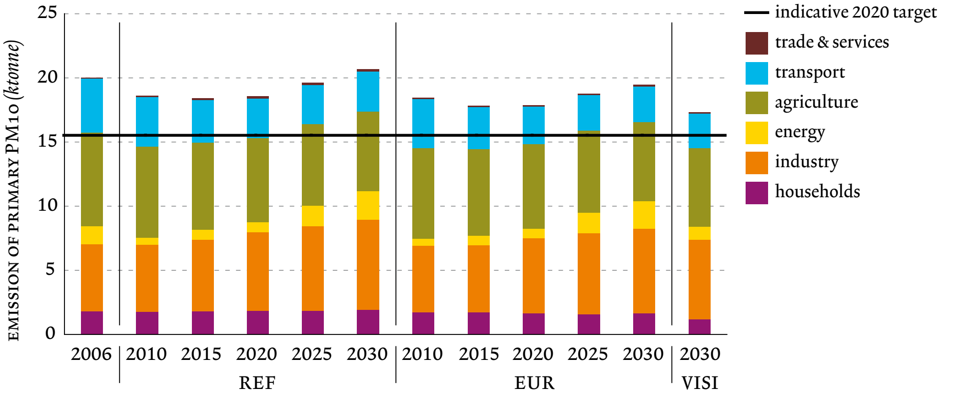
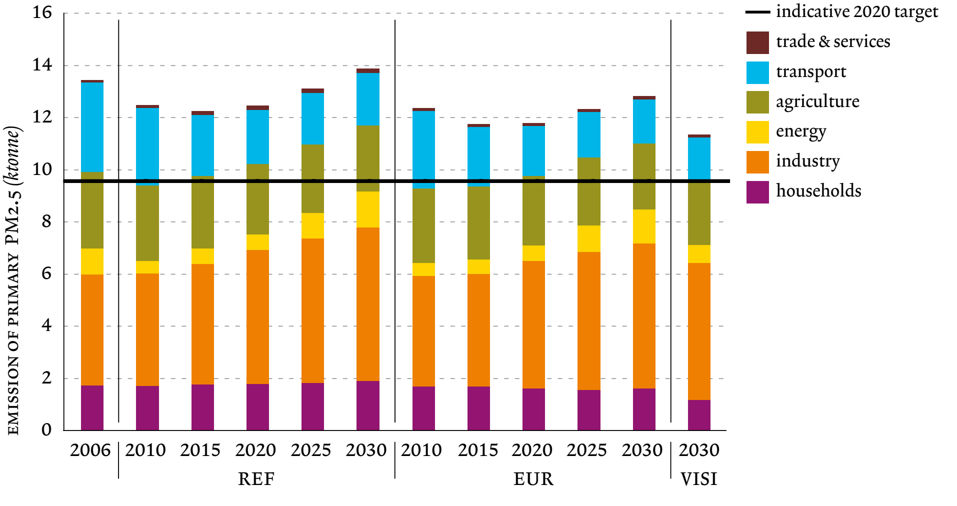


FIG. 9.2 *Emissions of primary PM2.5 in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



increased use of coal-fired power stations for the energy sector. This is due to the expected economic growth and the related increase in energy use and the use of solid and liquid fuels for the industry sector. On the other hand emissions from the transport sector decrease slightly due to stricter emission standards and the use of new technologies and alternative fuels. The emissions for 2030 are consequently higher than those for 2006 in the REF scenario. The emissions for both sizes of particulate matter in the VISI scenario are only slightly lower than those in the EUR scenario for 2030. None of the scenarios, not even the VISI scenario, reaches the indicative 2020 target.

Emissions of nitrogen oxide (NO_x)

NO_x emissions decrease gradually in the REF and EUR scenarios between 2006 and 2030 (FIGURE 9.3). The transport sector makes the largest contribution to the reduction of NO_x emissions with a decrease by approximately 45 % in the REF scenario and even by 75 % in the EUR scenario. This decrease is due, amongst other things, to the introduction of the Euro 6 standard for cars and light vans in the REF scenario and the introduction of the Euro VI standard for heavy goods vehicles in the EUR scenario. Emissions by the industry sector however increase by approximately 35 % in the same period in the REF and EUR scenarios. The NO_x emissions for 2030 are significantly lower in the VISI scenario than in the EUR scenario. This is primarily due to the additional reductions in emissions in the energy and the transport sectors. The indicative emission target for 2020 is only within reach in the VISI scenario. The emissions clearly remain above this target in both the REF and EUR scenarios.

FIG. 9.3 *Emissions of NO_x in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*

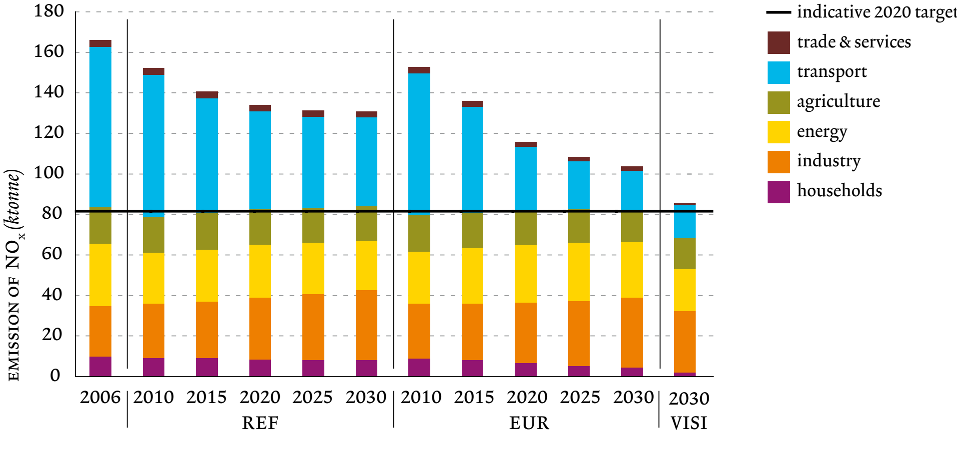
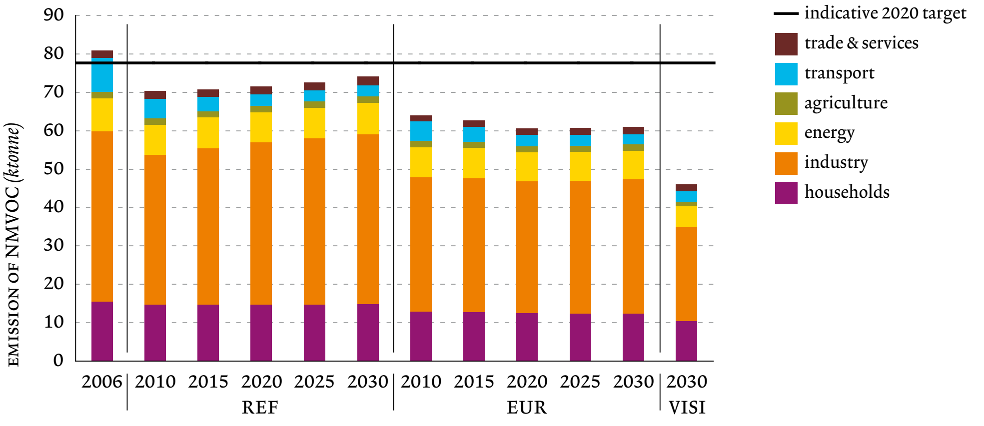


FIG. 9.4 *Emissions of NMVOC in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



The figures from the EUR scenario were transferred to the VISI scenario for the transport sector.

Emissions of non-methane volatile organic compounds (NMVOC)

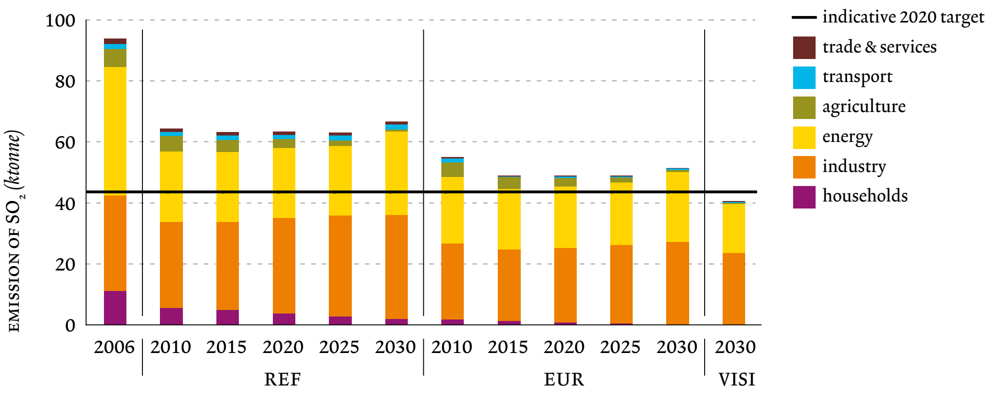
The NMVOC emissions fall in the 2006-2010 period in the REF scenario (FIGURE 9.4). However this decrease is followed by a gradual increase in emissions between 2010 and 2030. While the NMVOC emissions in the transport sector continue to drop significantly over the entire period, a gradual increase in the emissions is to be expected in the 2010-2030 period, particularly in the industry sector. The EUR scenario indicates a gradual reduction in the total emissions of NMVOC. This is due both to the decrease of emissions in the transport sector and the equivalent emissions by industry.

The NMVOC emissions in the VISI scenario 2030 are still significantly lower than emissions in the EUR scenario. This is primarily the result of the clearly lower emissions in the industry sector. From 2010 all scenarios reach the indicative 2020 target with the measures considered.

Emissions of sulphur dioxide (SO_2)

Between 2006 and 2010 both the REF and EUR scenarios anticipate a significant reduction of SO_2 emissions (FIGURE 9.5). This reduction is primarily realised in the energy and households sector, each approximately halves the emissions. The environmental policy agreements (EPA) can also explain the reduction in the energy sector. The use of CCS *(carbon capture & storage)*, the reduction of the sulphur content in fuel and the types of fuels used also play an important role.

FIG. 9.5 *Emissions of SO_2 in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



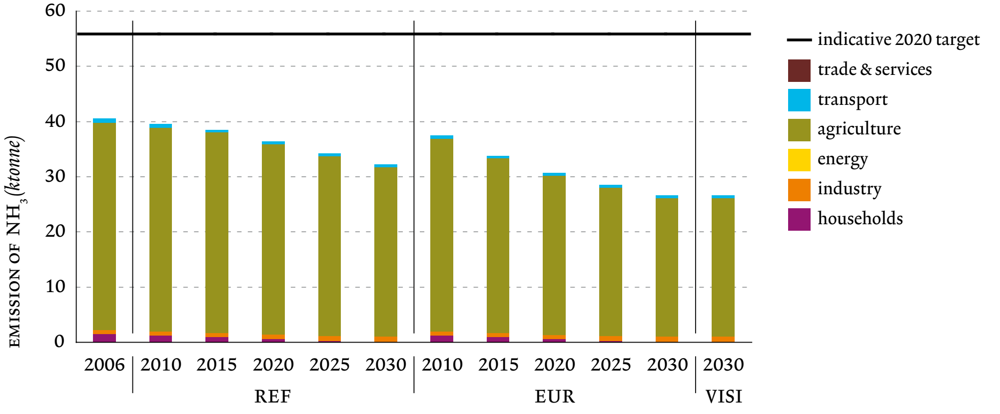
After 2010 a further reduction of emissions is only possible in the REF scenario in the households and agriculture sectors due to the switch from heating oil to natural gas with almost negligible SO_2 emissions. The reduction in the agriculture sector is due to the decrease in sulphur content, both in diesel for agricultural vehicles and in heating oil for heating the buildings (greenhouse farming and barns). The households and agriculture sectors also contribute to a further reduction of emissions in the EUR scenario until 2030. The increase of the emissions between 2025 and 2030 is primarily due to the expected increase in the use of coal for electricity production. The VISI scenario provides an additional SO_2 reduction of emissions compared to the EUR scenario particularly in the energy sector. The VISI scenario is the only one to reach the indicative 2020 target (in 2030).

Emissions of ammonia (NH_3)

The agriculture sector is responsible for more than 90 % of the total NH_3 emissions in Flanders. A reduction of emissions for agriculture is anticipated in the 2006-2030 period of over 20 % (in the REF scenario) or 35 % (in the EUR scenario) (FIGURE 9.6). In the EUR scenario the main reason is the halving of the barn emissions by 2030 as a result of the reduced cattle stock and fully low-emission housing for pigs and poultry.

The households sector, which is in Flanders the second most important sector for NH_3 emissions in Flanders, also succeeds in significantly reducing its emissions. The emissions by households originate almost entirely from wastewater treatment (septic tanks). A reduction of emissions of 94 % is expected under the assumption that 98 % of the inhabitants of Flanders will be connected to a sewage water treatment plant (SWTP) by 2027 and that there will hardly be any septic tanks remaining as a result. The indicative 2020 emission target is already achieved in 2006.

FIG 9.6 *Emissions of NH_3 in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



9.3 Particulate matter

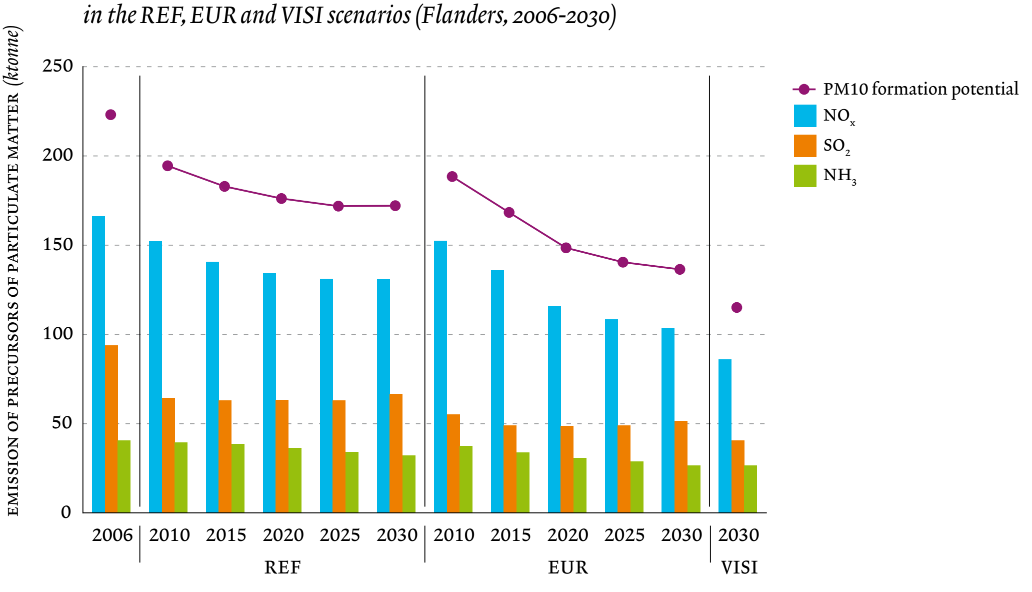
Particulate matter is a mixture of separate particles in the air. Depending on their size the particles are breathed in and deposited in the nose, throat and mouth cavity, the lungs or alveolar. The smaller particles penetrate the deepest into the lungs. There are indications that the tiniest particles can even enter the bloodstream. Amongst other things, health may be damaged as a result.

The particulate matter in the air consists on the one hand of primary particles that are emitted directly into the atmosphere and, on the other, a secondary fraction formed by gaseous compounds in the atmosphere (precursors). The main precursors are ammonia (NH_3), nitrogen oxide (NO_x) and sulphur dioxide (SO_2). Analyses of the chemical composition of particulate matter in Flanders have shown that the secondary inorganic components created from conversions of NH_3, NO_x and SO_2, make up approximately 40 % of the PM10 mass. This share may even increase during incidents of smog (VMM, 2009).

The potential for aerosol formation is used to outline the development of this secondary contribution. The extent by which the gaseous emissions of the particulate matter precursors NO_x, NH_3 and SO_2 may contribute to the formation of secondary particulate matter (de Leeuw, 2002) is thereby taken into account.

FIGURE 9.7 shows a continuous decrease of the PM10-formation potential in the REF scenario and even more strongly in the EUR scenario. The expected decrease in NO_x and NH_3 emissions particularly contribute to this. After a major reduction between 2006 and 2010 a stable or slightly increased development of SO_2 emissions is expected after 2010. The PM10 formation potential in the 2030 VISI scenario is even lower than in the 2030 EUR scenario.

FIG. 9.7 *Emissions of precursors of particulate matter and PM10 formation potential in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



The results of the model simulations of a number of important status indicators for particulate matter are discussed below, specifically the annual average PM10 concentration, the daily average PM10 concentration and the annual average PM2.5 concentration. The distribution maps are given per scenario and for a number of forecast years. The text will then consider the impact of meteorological variation (the weather) and climate change on the concentrations and subsequently the health effects and external health costs in more detail. Finally this chapter will make a number of policy recommendations.

Annual average PM10 concentration

The annual average PM10 concentration is a measure of a long-term exposure to this fraction. This section begins with the annual average for Flanders, then discusses the geographic spread of the annual averages and finally tests the concentrations against the targets. On average the annual average PM10 concentrations for Flanders show a gradual but clear decrease in the REF and EUR scenarios. The REF scenario anticipates a decrease in the annual average PM10 concentration in Flanders from 27 µg/m³ in 2007 to 25 µg/m³ in 2030 and the EUR scenario even forecasts a decrease to 21 µg/m³ in 2030 (FIGURE 9.8).

This data is calculated on the basis of the meteorological conditions of 2007. This year may be considered a ‘normal’ year without any extreme adverse meteorological conditions that ensure high levels of particulate matter pollu-

FIG. 9.8 *Annual average PM10 concentration (spatial average) in the REF and EUR scenarios (Flanders, 2007-2030)*

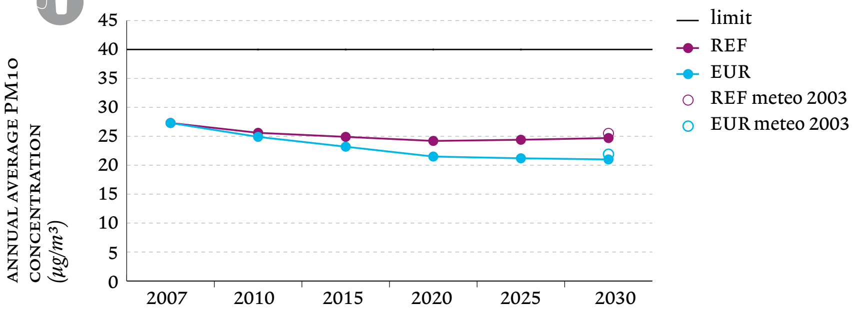
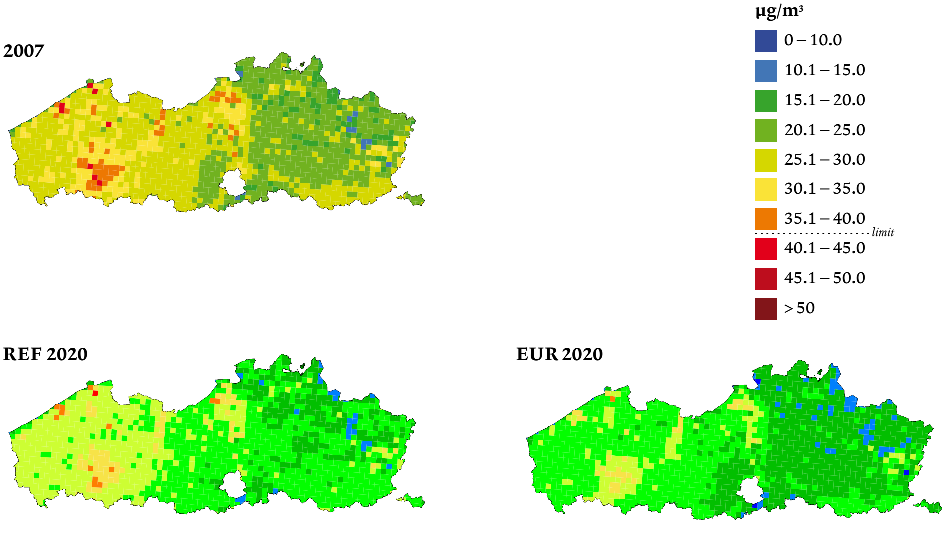


FIG. 9.9 *Annual average PM10 concentration for all 3x3 km grid cells in the REF and EUR scenarios (Flanders, 2007 and 2020)*



meteorological data from 2007

tion. The weather has a major impact on the concentration. This is discussed in more detail below.

FIGURE 9.9 illustrates the spatial distribution of the annual average PM10 concentration in Flanders in the REF (left) and EUR scenarios (right) for 2007 and 2020 on a 3x3 km grid cell. The development of the PM10 concentration on these maps is comparable to the development of the average PM10 concentration distributed spatially across Flanders (FIGURE 9.8). The province of West Flanders, which is currently the region with the highest annual average of PM10 concentrations in Flanders, is expected to have (slightly) lower PM10 concentrations. However the concentration maps for the

EUR scenario show that a larger decrease of the annual average PM10 concentrations may be expected. This is particularly the case for the main *hot spots* in Flanders, i.e. the regions of South West Flanders and the Ghent Canal Region.

Testing against the European standards shows that both scenarios continue to achieve the annual average limits for PM10 of 40 µg/m³ in the future (with meteorological conditions as in 2007), which is now also already achieved at almost all the measurement locations. A reduction of the annual average PM10 concentration of 25 % by 2020 compared to 2007 as anticipated in the Flanders action plan (ViA) will not be achieved everywhere in Flanders in the REF scenario. This may (just) be possible if the emissions fall according to the EUR scenario.

Daily average PM10 concentration

The daily average PM10 concentration shows the short-term exposure to peak levels of this fraction. FIGURE 9.10 represents the exceedance of the EU day standard through the percentage of the population exposed to PM10 concentrations higher than 50 µg/m³ for more than 35 days. FIGURE 9.10 shows a significant decrease in the REF scenario (from 35 % in 2007 to 10 % until 2020) and, to even greater extent, the EUR scenario (to 1 to 2 % in 2020). Despite the modest decrease in the annual average PM10 concentrations there is a clear impact on the number of days with a daily average of PM10 concentrations higher than 50 µg/m³. Due to the threshold for the daily average of PM10 concentrations a minor decrease of the annual average concentration may result in a significant decrease in the number of days with a daily average concentration higher than 50 µg/m³. The great uncertainty of the modelling of the daily average concentrations (compared to annual averages) must be taken into account. This also means there is considerable uncertainty as regards the percentage

FIG. 9.10 *Percentage of the population that is exposed for more than 35 days to daily average PM10 concentrations higher than 50 µg/m³ (Flanders, 2007-2030)*

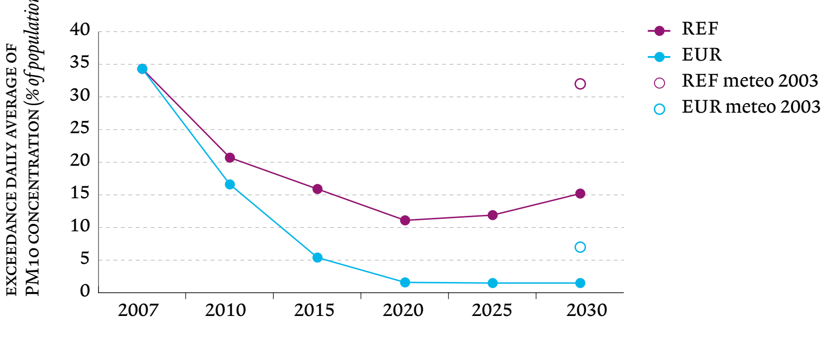
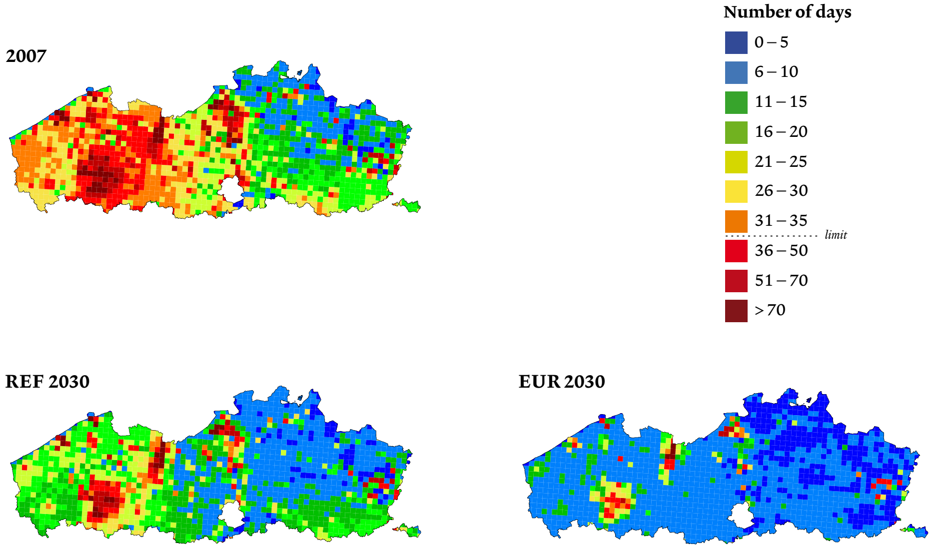


FIG. 9.11 *Number of days with daily average PM10 concentration higher than 50 µg/m³ for all 3x3 km grid cells in the REF and EUR scenarios (Flanders, 2007 and 2030)*



meteorological data from 2007

of the exposed population. However, the level of uncertainty cannot currently be estimated. An increase in the daily average concentration may again be seen in the period after 2020 in the REF scenario. This is mainly due to the predicted increase in primary PM10 emissions.

The impact of the weather is also significant in the daily average PM10 concentration. This is discussed in more detail later.

FIGURE 9.11 shows the number of days with a daily average PM10 concentration higher than 50 µg/m³ for all 3x3 km grid cells in Belgium in the REF and EUR scenarios between 2007 and 2030. The number of exceedances of the European PM10 daily standard of 50 µg/m³ decreases significantly. Despite the significant improvement in the REF scenario and even better in the EUR scenario, the EU daily limit is still exceeded until 2030 in the *hot spot* (including in the EUR scenario). According to the BelEUROS prognosis the European daily standard will not be achieved for the entire territory of Belgium in 2030 with the reductions in emissions as anticipated in the EUR scenario.

Annual average PM2.5 concentration

The annual average PM2.5 concentration is a measurement for longer-term exposure to these particles. FIGURE 9.12 illustrates the annual average PM2.5 concentrations for Flanders for the REF scenario and the EUR scenario. The evolution of the PM2.5 concentrations is very similar to the evolution of PM10 concentrations. The REF scenario forecasts a decrease in PM2.5 concentrations until 2020 followed by a slight increase thereafter. The EUR scenario also calculates a decrease over the entire period under consideration for PM2.5. The PM2.5 concentration is 18 µg/m³ (spatial) average for Flanders in the 2007 base year. The PM2.5 concentration would decrease to 16 µg/m³ in the REF scenario, a decrease slightly greater than 2 µg/m³ (or 12 %). However in the EUR scenario a decrease by 6 µg/m³ to 12 µg/m³ (or 32 %) may be realised. The decrease in concentration is consequently also significant for PM2.5 in the EUR scenario (2.5 times) larger than in the REF scenario.

The annual average PM2.5 concentration also decreases significantly as a result of the additional Flemish and European emission reductions in the EUR scenario.

FIGURE 9.13 shows the annual average PM2.5 concentrations for all 3x3 km grid cells in Belgium in the REF and EUR scenarios in the years 2007, 2010, 2015 and 2020. The maps give a comparative picture to that for the annual average PM10 concentrations. The REF scenario anticipates a fairly limited decrease in PM2.5 concentrations. An additional fall in PM2.5 concentrations can be seen on the EUR scenario maps compared to those for the REF scenario. The situation in the *hot spot* regions of West Flanders, the Ghent Canal region and Antwerp will be significantly better with emission reductions as anticipated in the EUR scenario.

Achieving the annual average PM2.5 concentration of 25 µg/m³ in 2010 (EU target) at all places in Flanders is unlikely in the REF scenario. According to the EUR scenario the target may also possibly be exceeded in a (limited) number of places in 2010. When this target becomes a limit in 2015 then this is achievable in the EUR scenario. Whether this is also true for the REF scenario is uncertain. Finally the concentration does not remain under the indicative limit of 20 µg/m³ everywhere in Flanders in the REF scenario. This may be possible in the EUR scenario.

FIG. 9.12 *Annual average PM2.5 concentrations (spatial average) in the REF and EUR scenarios (Flanders, 2007-2030)*

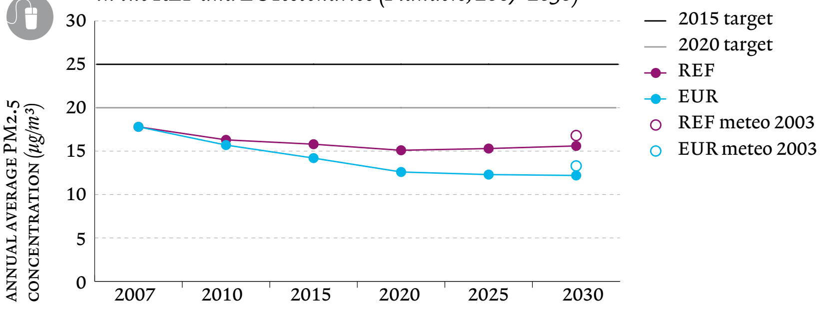
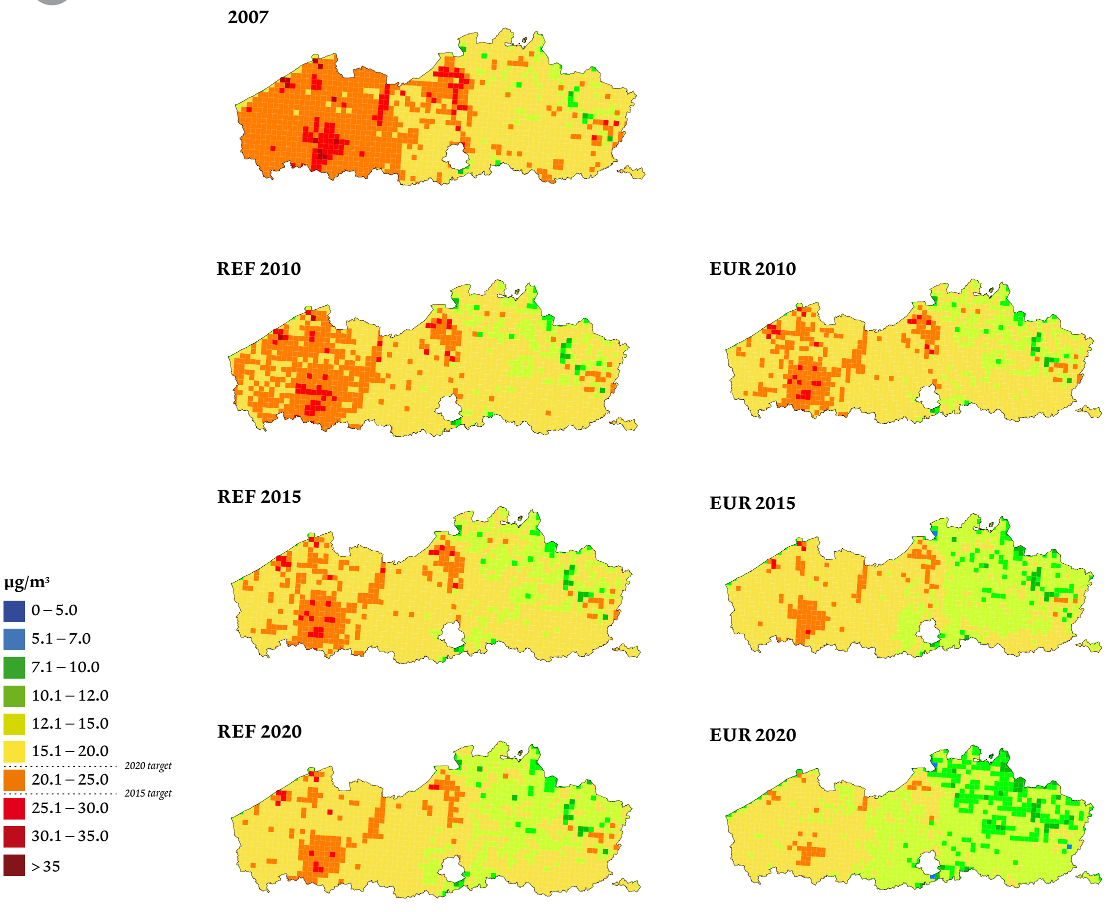


FIG. 9.13 *Annual average PM2.5 concentrations for all 3x3 km grid cells in the REF and EUR scenarios (Flanders, 2007, 2010, 2015 and 2020)*



Impact of the weather and climate change

These concentrations were calculated using the meteorological conditions of a 'normal' year for particulate matter, i.e. 2007. However the weather influences the concentrations of particulate matter. For instance it may rain more in one year than in another, which means more particulate matter is washed out of the atmosphere and the concentrations are lower as a result. In addition to these annual fluctuations this mainly becomes noticeable when using meteorological data for an extreme year. Using an extreme year also serves as an approach to a weather type that may become more common according to the current climate projections and consequently gives an illustration of the impact of climate change. Meteorological data from 2003 was used for the calculation of this type of extreme year due to the dry summer and the periods of temperature inversion in the winter. The 2030 REF scenario and the 2030 EUR scenario were used as emissions scenarios because the impact of climate change is particularly noticeable in the future.

The impact on the annual average PM10 and PM2.5 concentrations in the scenario in which the 2003 meteorological data is used is fairly limited. There is always an increase of PM10 and PM2.5 concentrations in the REF and EUR scenarios by approximately 1 µg/m³ compared to the results of the scenario with the 2007 meteorological data (FIGURE 9.8 and FIGURE 9.12). The REF scenario calculates a PM10 concentration of 26 µg/m³ for 2030 using the 2003 meteorological data compared to 25 µg/m³ using the 2007 meteorological data. In the EUR scenario this is 22 µg/m³ PM10 using the 2003 meteorological data compared to 21 µg/m³ using the 2007 meteorological data.

The scenario in which the 2003 meteorological data is used does have a significant impact on the number of exceedances of the European daily average PM10 standard (FIGURE 9.10). The percentage of the Flemish population exposed to daily average concentrations exceeding 50 µg/m³ for more than 35 days is approximately double in 2030 in the REF scenario using the 2003 meteorological data than when using the 2007 data. In the EUR scenario there is even a difference at a factor of 4.5. The REF scenario anticipates that almost the same number of people will be exposed to excessive daily average PM10 concentrations for more than 35 days in Flanders in 2030 (using 2003 meteorological data) as in the 2007 base year (using 2007 meteorological data). In other words: climate change could completely nullify the impact of the predicted reduction in emissions between 2007 and 2030. If the meteorological conditions are the same in 2030 as in 2003 the number of exceedances of the daily average PM10 standard are expected to be the same level as in 2007, even with significantly lower emissions (REF scenario).

Health impact and external health costs of particulate matter

Particulate matter can penetrate deep into the respiratory tract. PM10 can disrupt the discharge of mucous in the airways, cause respiratory disorders and increase the sensitivity to respiratory infections. Polycyclic aromatic hydrocarbons (PAHs) and heavy metals in or on particulate matter can encourage the development of lung cancer. After depositing in the lungs the toxic components on the particulate matter can spread even further in the (human) body via the bloodstream and the lymph system. PM10, PM2.5 and the finer PM0.1 particles can cause inflammation mechanisms in the lungs. This section considers the impact on health and the corresponding external health costs.

DALYS stands for *disability adjusted life years*. This indicator estimates the number of health adjusted years of life a population loses as a result of diseases caused by environmental factors. It is the sum of the years of life lost due to death to a sickness involved (lost life years) and the years of life lived with the disease, taking its severity *(disability weight)* into account. The World Bank and the WHO developed this indicator to compare the global burden of disease in eight regions in the world (Murray & Lopez, 1996). More and more the DALY indicator is used to calculate the burden of disease due to exposure to environmental factors such as particulate matter and ozone (de Hollander *et al.*, 1999), using epidemiological and toxicological evidence of the impact of air pollution on man.

Both PM10 and PM2.5 have long and short-term effects on health. The long-term effects due to chronic exposure to particulate matter considered in the calculation of the burden of disease are:

- new cases of chronic bronchitis due to PM10;
- premature death due to PM2.5.

The short-term health impacts due to exposure to PM10 investigated include:

- infant mortality;
- hospitalisation due to respiratory and heart problems in the general population;
- use of broncho-dilators by astmathic children and adults;
- lower respiratory tract problems in children and adults.

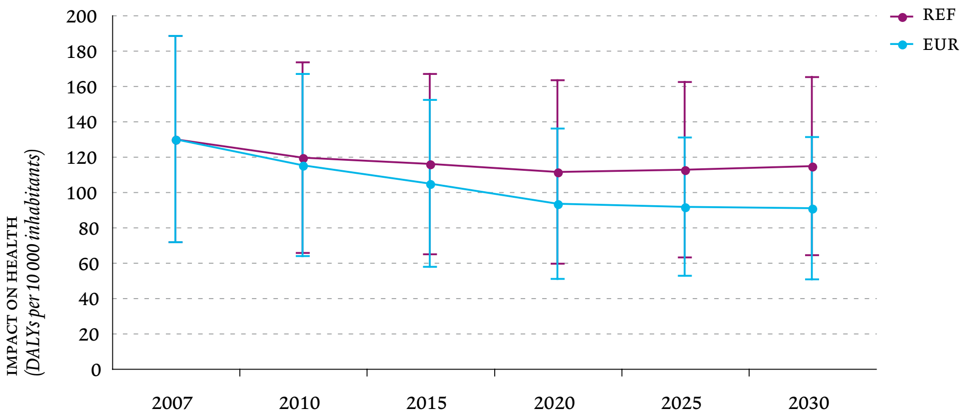
The short-term effects studied due to exposure to PM2.5 are:

- Restricted Activity Days;
- Minor Restricted Activity Days *(Minor RADs)*;
- and Work Loss Days.

The number of cases of a specific disease due to exposure to particulate matter is calculated on the basis of the concentration, the number of new cases or the incidence of the disease in the population, the size of the population group at risk for the disease and the relative risk of falling ill. The number of DALYS can be calculated by multiplying the number of cases by a disability weight and the duration of a disease. The external health costs are calculated by multiplying the number of cases by a cost per case. These two indicators can outline trends or make it possible to compare different health impacts to each other. They are suitable for making relative policy assessments regarding the environment in Flanders. Health effects and corresponding costs are only correlated here with exposure to particulate matter whereas in reality numerous factors (including smoking, genetic predisposition, diet, etc.) may contribute. For that reason no absolute interpretation can be given to the figures. They are included however in a relative comparison between two different scenarios, in this way the contribution of factors other than exposure to particulate matter may be neutralised.

FIGURE 9.14 gives an overview of the total number of DALYS per year and per 10 000 inhabitants calculated for the two scenarios. On average an inhabitant in Flanders loses one healthy life year over an entire life. This is primarily due to the chronic health effects of PM10 and PM2.5.There is a relatively faster decrease in the number of DALYS in the EUR scenario than in the REF scenario. However there is no significant decrease in the number of DALYS from a statistical standpoint ($P < 0.05$). These statistical differences are hard to realise with this indicator due to the relatively large confidence intervals defined particularly by the relative risk error. A Monte Carlo simulation could express the differences between the scenarios in probability

FIG. 9.14 *Total number of DALYs due to exposure to particulate matter per 10 000 inhabitants in the REF and EUR scenarios (Flanders, 2007-2030)*



The error bars give the standard deviation (1s).

however. In this way the probability that the REF scenario results in relatively more DALYS than the EUR scenario is approximately 52 % in 2010 and approximately 64 % in 2030.

Health effects may also be expressed in costs of environmental damage or external costs caused by environmental pollution. TABLE 9.1 gives an overview of the external health costs linked to the long-term effects of particulate matter. It is clear that the health costs follow the same trend over time as the DALYS. On average the external health cost due to long-term effects of PM10 and PM2.5 decreases between 2007 and 2030 from 546 euro per inhabitant per year to 483 euro per inhabitant per year according to the REF scenario. There is also a considerable spread of the results here.

TAB. 9.1 *Average cost of the long-term effects due to exposure to PM10 and PM2.5 in the REF scenario (Flanders, 2007-2030)*

(Euro per inhabitant per year)	LONG-TERM EFFECT PM2.5			LONG-TERM EFFECT PM10		
	Average	95 % LL	95 % UL	Average	95 % LL	95 % UL
2007	463	90	848	83	0	146
2010	424	83	777	79	0	139
2015	410	80	752	77	0	137
2020	394	77	723	75	0	134
2025	398	78	730	76	0	134
2030	406	79	746	77	0	136

LL: lower limit; UL: upper limit

Conclusions for policy

Table 9.2 gives an overview of the testing of the results obtained in this study against existing or planned European standards for particulate matter as described above. The allocation of the *smileys* is the interpretation of the authors. A ☹ means that there is a very high probability that the standards will not be met. A 😐 means that meeting the standard is possible but rather borderline. If a ☺ is allocated there is a relatively high probability that the standard will be met.

TAB. 9.2 *Overview of testing of concentrations to the corresponding standards*

Standard	**limit**	**source of norm**	**REF scenario**	**EUR scenario**
Annual average PM10 concentration	40 $\mu g/m^3$ (EU)	EU	☺	☺
	-25 % in 2020 compared to 2007 (ViA-plan)	ViA*	☹	😐
Daily average PM10 concentration	maximum 35 days >50 $\mu g/m^3$	EU	☹	😐
Annual average PM2.5 concentration	25 $\mu g/m^3$ in 2010 (target value)	EU	☹	😐
	25 $\mu g/m^3$ in 2015 (limit)	EU	😐	☺
	20 $\mu g/m^3$ in 2020 (indicative limit)	EU	☹	😐

* ViA: Flanders in Action; no statistical probability calculation was applied.

Testing the European standards indicates that the annual average standard for PM10 of 40 $\mu g/m^3$, which almost all measurement locations currently achieve, will also be achieved in the future. A decrease of the annual average PM10 concentration of 25 % by 2020 compared to 2007 as anticipated in the Flanders Action Plan will not be achieved in all places in Flanders in the REF scenario. However it is (just) possible in the EUR scenario if the emissions decrease according to plan.

It is improbable that the annual average PM2.5 concentration of 25 $\mu g/m^3$ in 2010 (EU target) will be achieved in the REF scenario at all places in Flanders. The target value may still be exceeded at a (limited) number of places in the EUR scenario as well in 2010. When this target becomes a limit in 2015 this is achievable in the EUR scenario. Whether this is also the case for the REF scenario is uncertain. Finally the concentration will not remain under the indicative limit of 20 $\mu g/m^3$ throughout Flanders in the REF scenario. This may succeed under the EUR scenario.

Testing at the EU daily average PM10 limit indicates in the REF scenario that almost all the agglomerations in Flanders (Antwerp, Ghent and the region around Kortrijk) have more than 35 days with a daily average PM10 concentration greater than 50 $\mu g/m^3$.

Meeting this European standard will also remain the most difficult in the future. According to the EUR scenario there will be significantly fewer regions with more than 35 days exceeding the standard from 2015. The EUR scenario expects a number of grid cells to exceed it from 2020 but with additional specific measures the EU standard might possibly be achieved. These 'local' measures are measures that may specifically be taken in the major agglomerations and in specific industrial areas in addition to the measures in the EUR scenario. Examples of such additional measures include *low emission zones* in cities, in which polluting vehicles are kept out of the city centre or measures that ensure lower diffuse industrial particle emissions.

A crucial element is that, even by 2020, the European standard for daily average PM10 concentrations could not be achieved everywhere in Flanders purely with the measures already taken or planned and without additional local emission reduction measures in major agglomerations and specific industrial areas. Additional efforts are necessary to decrease the emissions of primary particulate matter and precursors of particulate matter. The (mainly) European measures that will be effective by 2020 will ensure that the PM10 concentrations in Flanders are 'in the vicinity' of European limits. However without additional measures this will not be adequate to reach the targets everywhere in Flanders. These model calculations have been carried out under 'normal' meteorological conditions however. If less favourable meteorological conditions for particulate matter should occur more frequently in the future due to climate change (as in 2003) then the European emission reducing measures taken and planned will very probably be inadequate to meet the EU limits in Flanders by 2020. In that case much more additional local measures would be necessary.

9.4 Photochemical air pollution

Photochemical air pollution is the pollution of the ambient air with oxidising substances, such as ozone (O_3), nitrogen oxide (NO_2) and peroxyacetyl nitrate (PAN). Ozone is the representative substance for photochemical air pollution. It has a highly oxidising character, is harmful to the respiratory function, reduces productivity and stress resistance of crops and causes some materials and artworks to deteriorate.

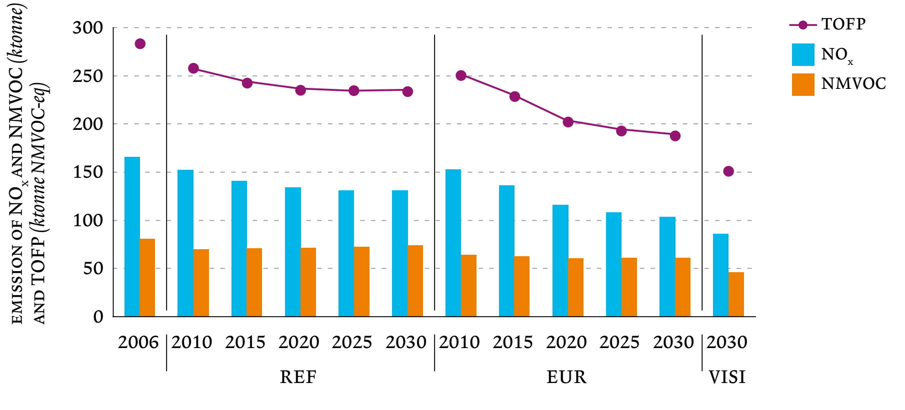
Ozone is not emitted directly but is formed in the atmosphere (troposphere) under the influence of heat and sunlight in the presence of ozone precursors like nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC) and to a lesser extent carbon monoxide (CO) and methane (CH_4). NO_x and NMVOC have a different ozone-forming capacity. The NO_x emissions are first multiplied by 1.22 before adding them to the NMVOC emissions to compensate for this. The total calculated is the tropospheric ozone forming potential (TOFP) and is expressed in NMVOC equivalents.

FIGURE 9.15 shows that the total tropospheric ozone forming potential in both the REF scenario and the EUR scenario will decrease gradually, particularly in the period until 2020. The EUR scenario clearly expects a sharper decrease than the REF scenario. Between 2020 and 2030 only the EUR scenario anticipates a further reduction of emissions. In both scenarios the total TOFP decrease is due to a drop in NO_x emissions. The TOFP in the 2030 VISI scenario is still significantly lower than in the 2030 EUR scenario. The VISI scenario assumes both lower NO_x and NMVOC emissions.

The current European emission reduction policy is aimed primarily at ozone precursors and acidifying substances. The EU directive 2001/81/EC with the *National Emission Ceilings* (NEC) per member state, linked to the European Directive on ambient air quality and cleaner air for Europe (2008/50/EC), plays an important role in this.

This section discusses the results of the model simulations for a number of important status indicators for photochemical air pollution, specifically the annual average ozone concentration, the number of exceedance days, the annual ozone excess and the seasonal excess for crops and forest. With clear developments the result at a Belgian level is shown beside the result for Flanders. The distribution maps are given per scenario and for a number of forecast years. This section will then consider the health impacts and external health costs for ozone in more detail. It ends with a number of conclusions concerning policy.

FIG. 9.15 *Emissions of the ozone precursors NO_x and NMVOC and the tropospheric ozone-forming potential (TOFP) in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



The complexity of ozone chemistry

The complexity of ozone chemistry must be taken into account with the interpretation of the results obtained. The following aspects play a role in this:

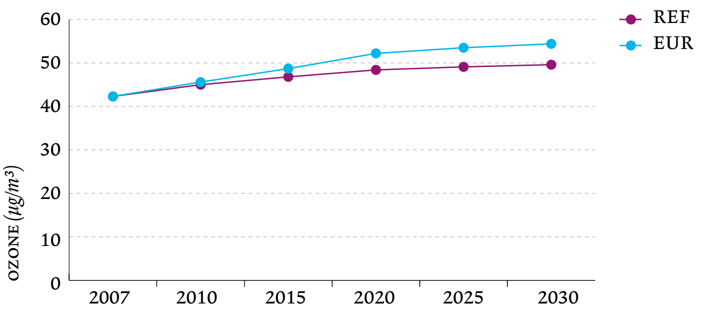
- *Ozone formation versus ozone depletion*: there is no linear parallel connection between the amount of ozone formed and the initial concentrations of NO_x and NMVOC present. A (limited) reduction of the NO_x concentrations moreover initially results in an increase in ozone concentrations in many places in Flanders. Specifically, reductions in NO_x emissions have a limited impact on ozone formation but do have a strong impact on ozone depletion. This is because the main component of NO_x, is ozone depleting NO (in addition to the ozone-forming NO_2). The ratio of NO_2 compared to NO in NO_x emissions is consequently extremely important. The model calculations therefore took account of the anticipated increase in the ratio of NO_2 compared to NO for the largest source of NO_x emissions, road traffic. This is the result of the increased number of diesel vehicles with oxidation catalyst.
- *Long distance transport and background ozone:* an important part of the ozone is not formed locally but is transported over long distances into the atmosphere and ends up in our regions. The so-called northern hemisphere background ozone gives an indication of this contribution.
- *Major impact of meteorological variation:* the model simulations are done using meteorological data for 2007. That year only had a few days of high ozone levels. Some calculations were also made on the basis of the 2003 meteorological data to verify the impact of the weather and also to make an approximation of the possible impact of climate change on ozone concentrations.
- *Testing the targets:* in order to take the impact of weather conditions into account the ozone values must be averaged over three to five years to test them to European ozone targets. This was not possible here because a maximum of two meteorological years were calculated. The long-term targets were tested, because they are applicable per year.

Annual average ozone concentration

The annual average ozone concentration is an interesting indicator of the long-term exposure of the population to ozone. The WHO specifically states that no thresholds can be established under which (chronic) health effects may be excluded. Consequently the lower, 'every day' concentrations of ozone may result in harmful health effects amongst the (most sensitive groups of the) population.

The annual average ozone concentrations in Flanders show a gradual but significant rising trend according to the model simulations in both the REF and EUR scenarios (FIGURE 9.16). According to the REF scenario the annual average ozone concentration rises from 42 µg/m³ in 2007 to almost 50 µg/m³ in 2030. In the EUR scenario there is even an increase to 54 µg/m³. This is primarily due to a decrease in the ozone depletion through NO. In the second place this is attributable to the anticipated general increase of northern hemisphere background ozone, amongst others due to the increasing emissions in countries like China and India. Both scenarios

FIG. 9.16 *Annual average ozone concentrations (spatial average) in the REF and EUR scenarios (Flanders, 2007-2030)*



calculated the contribution of the increase of background ozone to the expected increase in the annual average ozone concentrations in Flanders for 2030. Approximately one third (2.6 µg/m³) of the total increase in the REF scenario is due to the increase in background ozone. This is less than one quarter (2.8 µg/m³) in the EUR scenario. The long distance transport of ozone to Europe consequently has a major impact on the ozone concentrations in our region. However, the main reason for the increasing annual averages in Flanders is the reduction of ozone depletion due to the expected Flemish and European NO_x emission reductions.

Number of exceedance days (NET60ppb-max8h)

The indicator NET60ppb-max8h gives the number of days per year during which the highest 8 hour average ozone concentration (for that day) exceeds 60 ppb or 120 µg/m³. One of the European targets for the protection of public health is based on this exceedance indicator.

The progress of this exceedance indicator is relatively level both in the REF and EUR scenarios. The spatial average number of exceedance days in Flanders varies between eight and ten. Whereas a slight increase may be observed in the REF scenario, a falling trend is to be expected from 2015 in the EUR scenario (FIGURE 9.17). However both in the REF and EUR scenarios this relates to insignificant changes.

The impact of the emission reductions is more clearly apparent in FIGURE 9.18, which shows the development of the number of exceedance days between 2007 and 2030 at a Belgian level. Although the number of exceedance days in Flanders changes little in the REF scenario between 2007 and 2030 a significant decrease is expected for Wallonia by 2030.

According to the EUR scenario there are even significantly more exceedance days in Flanders in 2030 than in Wallonia while the opposite was the case in 2007. The explanation for this is that the expected reductions in emissions mainly have an

FIG. 9.17 *Development of the average number of exceedance days (spatial average) in the REF and EUR scenarios (Flanders, 2007-2030)*

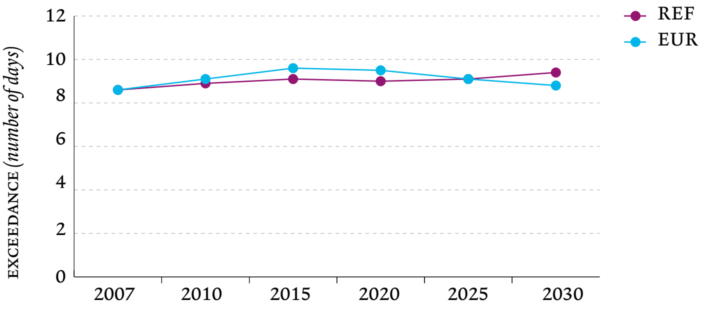
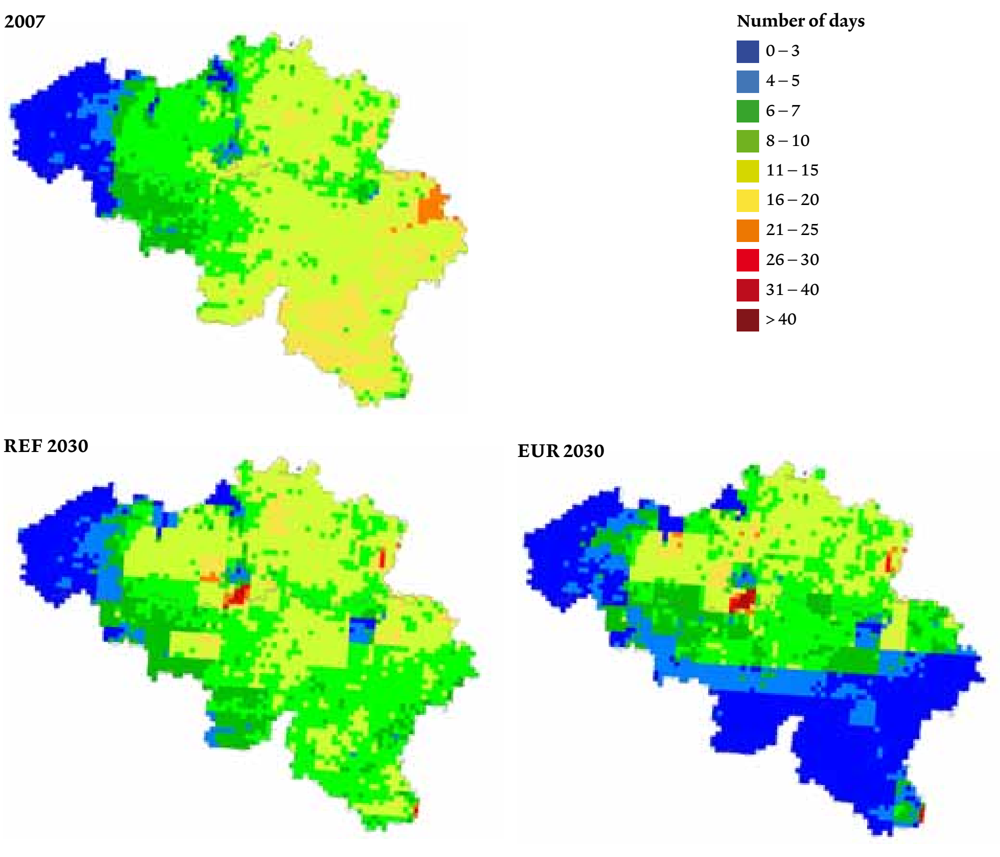


FIG. 9.18 *NET60ppb-max8hours for all 3x3 km grid cells in the REF and EUR scenarios (Belgium, 2007 and 2030)*



effect on the peak ozone concentrations. These reductions in emissions will have a smaller effect in Flanders, where fewer ozone peaks already occurred in 2007. The depletion of ozone is more important than ozone formation in Flanders due to the high NO_x emission density. This means that a reduction of NO_x emissions initially results in less ozone depletion and consequently more exceedance days.

The long-term target for the NET60ppb indicator is that the daily maximum 8 hour average concentration may not exceed 120 µg/m³ on any day. This target is not met in 2030 for Flanders either in the REF scenario or the EUR scenario, not even under the favourable meteorological conditions in 2007 which were used to make the calculations.

Annual excess (AOT60ppb-max8h)

The annual excess indicator AOT60ppb-max8h totals the daily differences from the maximum 8 hour average ozone concentration over a year with the threshold of 60 ppb (120 µg/m³). This indicator takes account of the size of the excesses and consequently gives a good measure of the progress of the peak ozone concentrations.

The annual excess indicator shows a decreasing trend in the REF scenario for the 2007-2020 period, followed by a slight increase (FIGURE 9.19). However the EUR scenario anticipates a significant decrease (37 %) in the annual excess indicator in the 2007-2030 period.

Unlike the annual average concentrations, the peak ozone concentrations consequently show a clear decreasing trend. This trend, observed in the ozone measurements in Flanders, will probably continue in the future.

FIG. 9.19 *Development of the AOT60ppb-max8hours (spatial average) in the REF and EUR scenarios (Flanders, 2007-2030)*

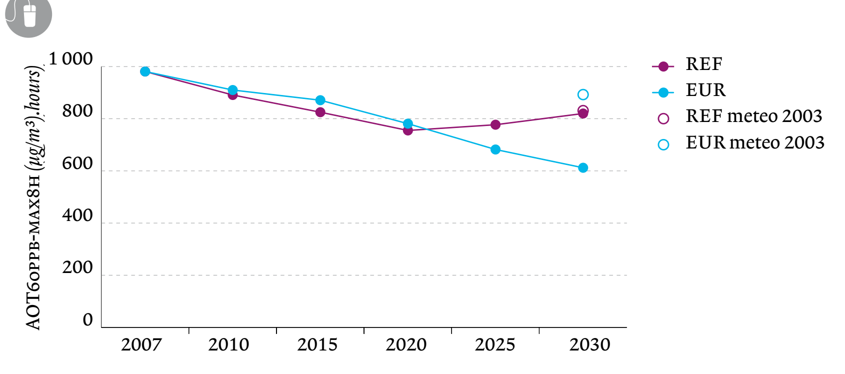


FIG. 9.20 *AOT60ppb-max8hours for all 3x3 km grid cells in the REF and EUR scenarios (Belgium, 2007, 2015 and 2030)*

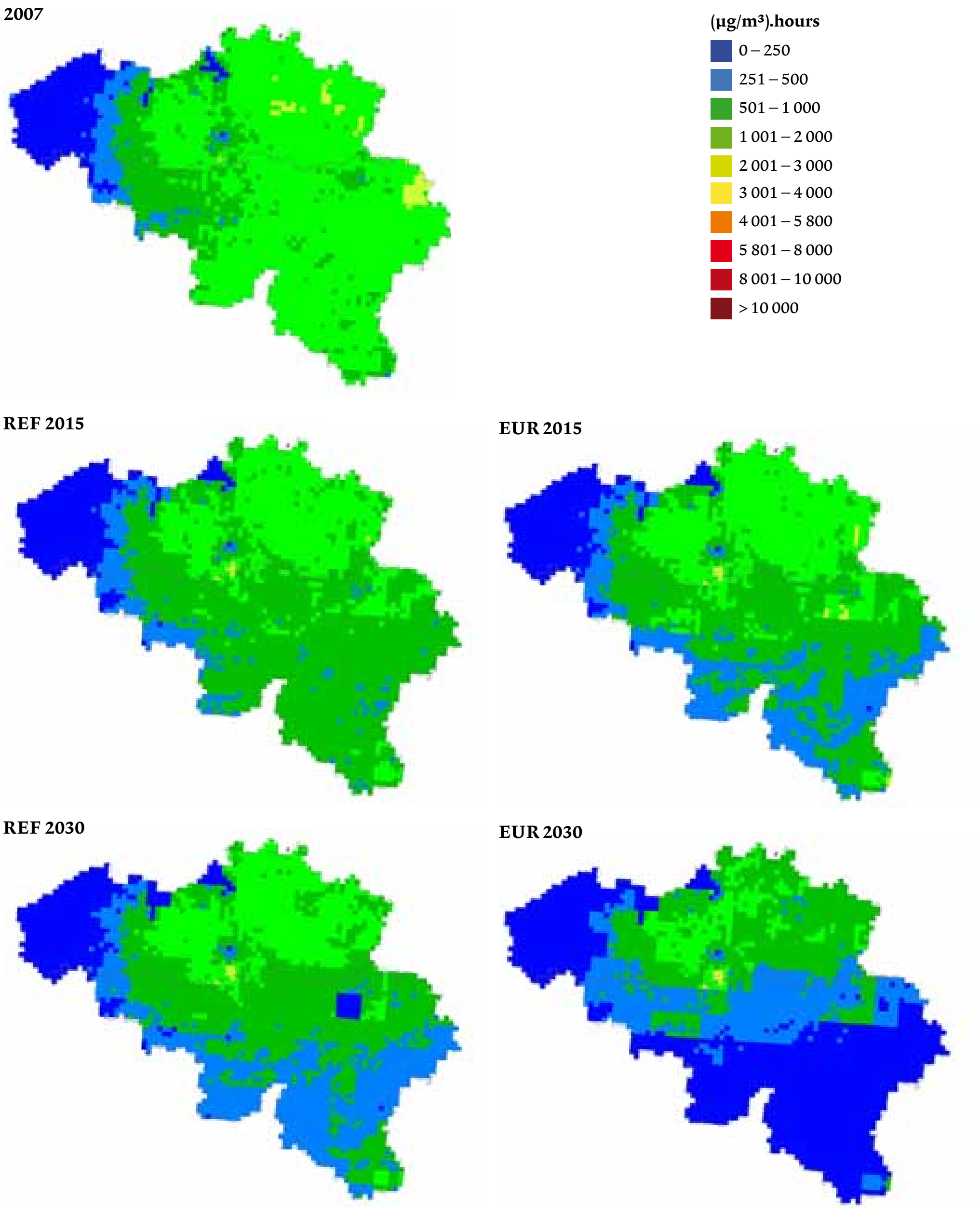


FIGURE 9.20 shows the AOT60ppb-max8h for Belgium in the REF and EUR scenarios for the years 2007, 2015 and 2030. The annual excess indicator in Flanders decreases by approximately one third between 2007 and 2030 in Flanders. This decrease is even more pronounced in both scenarios for Wallonia. Despite the less favourable situation in Wallonia in 2007 compared to Flanders, the limit indicator in 2030 will be about the same level in 2030 in the REF scenario as in Flanders. This indicator has very low values in the EUR scenario almost throughout Wallonia, significantly lower on average than in Flanders.

As no exceedance days may occur with regard to the long-term target for the exceedance indicator NET60ppb, this also means that the annual excess indicator AOT60ppb must be zero. This target is not achieved by 2030 in Flanders either in the REF scenario or the EUR scenario, not even under the very favourable meteorological conditions for ozone in 2007. There are still regions in Flanders with a value larger than 1 000 (µg/m³).hours.

Impact on vegetation: seasonal excess for vegetation (AOT40ppb-vegetation) and forest (AOT40ppb-forest)

Two status indicators monitor the impact of ozone on vegetation:

- The seasonal excess for vegetation: the surplus above 80 µg/m³ of all hourly values between 8 and 20 hours added together for the months of May, June and July (AOT40ppb-vegetation);
- the seasonal excess for forests: the surplus above 80 µg/m³ of all hourly values between 8 and 20 hours added together for the months April to September (AOT40ppb-forest).

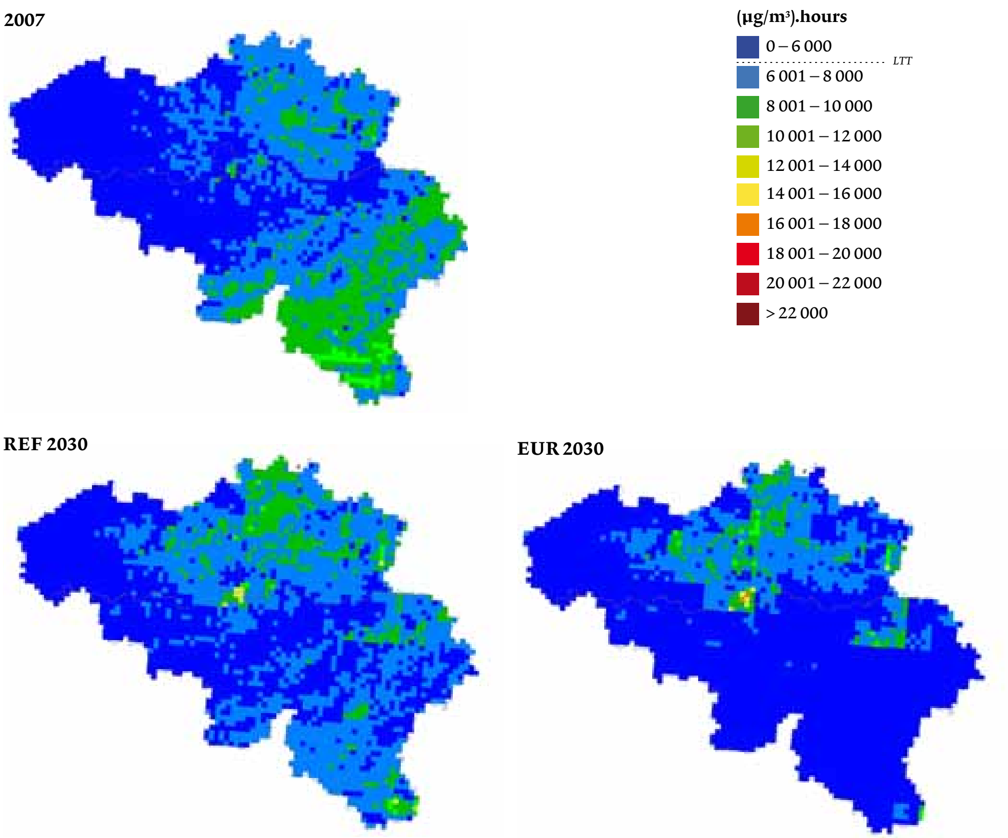
These indicators are less clearly linked to ozone peaks but also take account of the (increasing) background ozone concentrations. These 'medium' ozone concentrations are harmful to vegetation and result, for instance, in lower yields of agricultural crops.

FIGURE 9.21 shows the AOT40ppb-vegetation in Belgium. The REF scenario expects a slight increase of this indicator in Flanders and a slight decrease for Wallonia. An approximate status quo is anticipated in the EUR scenario in Flanders, however there is a significant decrease of the AOT40ppb-vegetation in Wallonia. Both the REF and EUR scenarios achieve the long-term target for the AOT40ppb-vegetation of 6 000 (µg/m³).hours in a number of regions in Flanders (particularly West Flanders).

FIGURE 9.22 shows the AOT40ppb-forest in Belgium. The REF scenario shows a slight increase in Flanders, especially in the province of Limburg and in the Kempen. Wallonia also shows the opposite trend here with decreasing values between 2007 and 2030.

The slightly faster increase in Flanders of the AOT40ppb-forest is striking in the EUR scenario compared to the REF scenario. The differences between the two scenarios remain limited however. On the other hand there is a clear difference

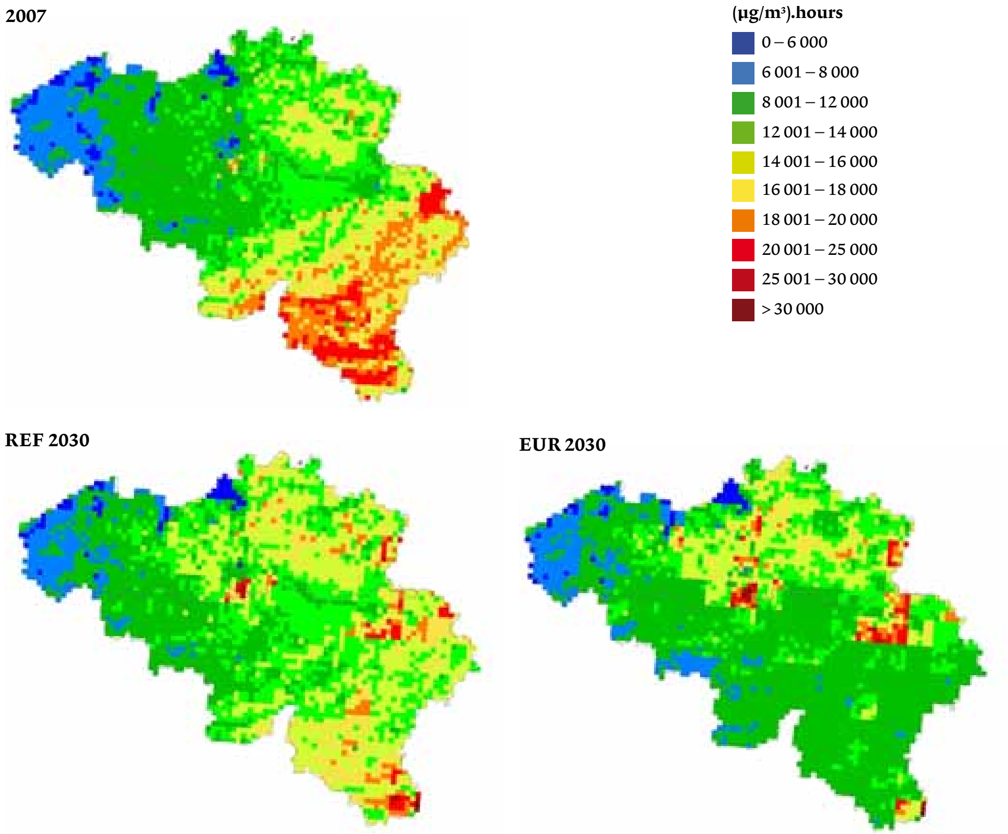
FIG. 9.21 *AOT40ppb-vegetation for all 3x3 km grid cells in the REF and EUR scenarios (Belgium, 2007 and 2030)*



in 2030 between both scenarios, due to the significant decrease in this indicator according to the EUR scenario. In summary much lower values are measured in 2007 for this indicator in Flanders than in Wallonia. The values in the REF scenario in Flanders for 2030 are still lower than in Wallonia but this situation reverses in the EUR scenario.

The reference value for the AOT40ppb-forest of 20 000 (µg/m³).hours is already achieved in 2007 in Flanders. In the future this will also remain almost the same everywhere in Flanders (despite an increase). The most recent *mapping manual* (2004) from UNECE (the United Nations Economic Commission for Europe) further formulated the critical levels for AOT40 and revised per vegetation group. 10 000 (µg/m³).hours was concluded as the critical level for forest. If the AOT40ppb-forest is tested against this updated critical level, then the ozone excess remained too high for forests (including in the future).

FIG. 9.22 *AOT40ppb-forest for all 3x3 km grid cells in the REF and EUR scenarios (Belgium, 2007 and 2030)*



Impact of the weather and climate change

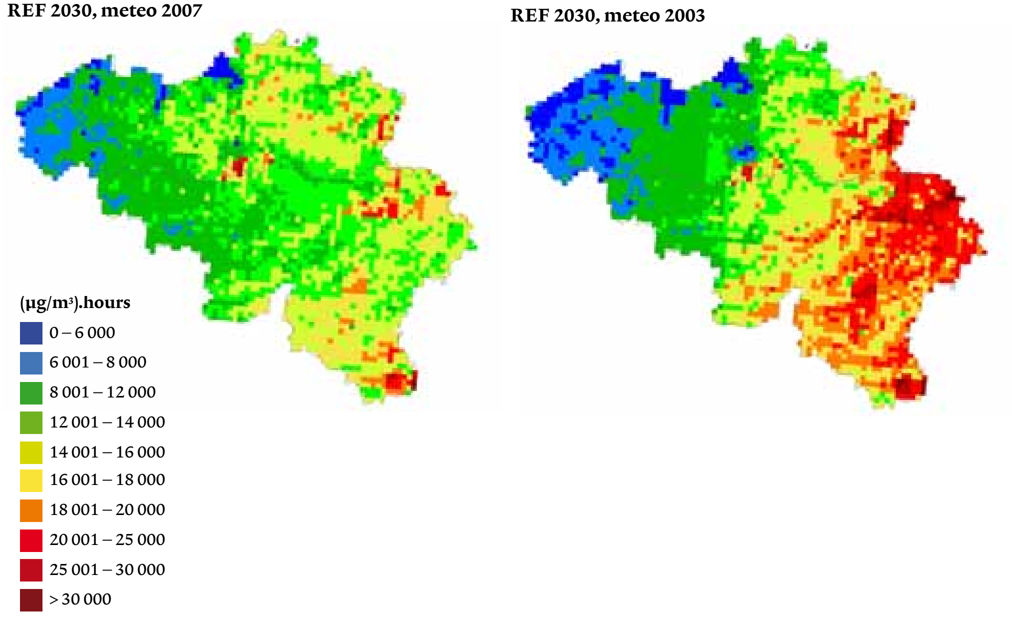
The model simulations discussed above were carried out with 2007 meteorological data, an extremely favourable year for ozone with few days with high ozone levels.

The annual excess indicator AOT60ppb-max8h was also calculated with the 2003 meteorological data to verify the possible impact of climate change on ozone concentrations (meteorological 2003 in FIGURE 9.19). The summer of 2003 was exceptional dry and warm. This study considers the weather type in that year as an approximation of the possible future weather type that might occur more frequently as a result of climate change.

Higher values were obtained for the annual excess indicator AOT60ppb-max8h with the 2003 meteorological data, particularly in the EUR scenario, than the results calculated using the 2007 meteorological data (FIGURE 9.19). The impact is limited in the REF scenario. The AOT60ppb-max8h decreases in the EUR scenario calculated with the 2007 meteorological data by approximately 37 % between 2007 and 2030. Calculations using the 2003 meteorological data only give a decrease by 9 % between 2007 and 2030. In other words: climate change may nullify the positive effect of the reductions in emissions expected between 2007 and 2030 to a great extent.

FIGURE 9.23 shows the impact of the 'climate scenario' on the values calculated for the AOT40ppb-forest. There are lower values when using the 2003 meteorological data in western Flanders. However an increase may be observed in the AOT40ppb-forest in eastern Flanders (province of Limburg) when using the 2003 meteorological data. Climate change could consequently mainly have unfavourable effects for the forest areas in eastern Flanders. There is a significant increase of the AOT40ppb-forest almost throughout Wallonia when using the 2003 meteorological data.

FIG. 9.23 *AOT40ppb-forest for all 3x3 km grid cells for the REF scenario 2030 calculated with meteorological data from 2007 (left) and meteorological data from 2003 (right) (Belgium, 2030)*



Health impact and external health costs of ozone

Photochemical air pollution is harmful to health, especially to the respiratory tract. The health impact (by means of the disability adjusted life years or DALYS) and the corresponding external health costs were calculated for photochemical air pollution in the same way as for particulate matter.

The DALYS give an estimate of the number of health adjusted life years a population loses as a result of diseases caused by environmental factors. It is the sum of the years of life lost due to death and the years of life lived with the disease, taking into account its severity. The DALY indicator is used here to calculate the number of healthy life years lost due to exposure to ozone, using epidemiological and toxicological evidence of the impact of air pollution on man (de Hollander *et al.*, 1999). This indicator serves to outline trends, make comparisons and is suitable for making policy assessments concerning the environment in Flanders. This indicator is not suitable for making absolute interpretations. More general information was given in the particulate matter section.

The short-term health impacts researched due to exposure to ozone include:

- adult mortality;
- days of slightly reduced activity;
- hospitalisations due to respiratory problems;
- use of broncho-dilators by adults;
- days of coughing;
- problems in the lower respiratory tract in children.

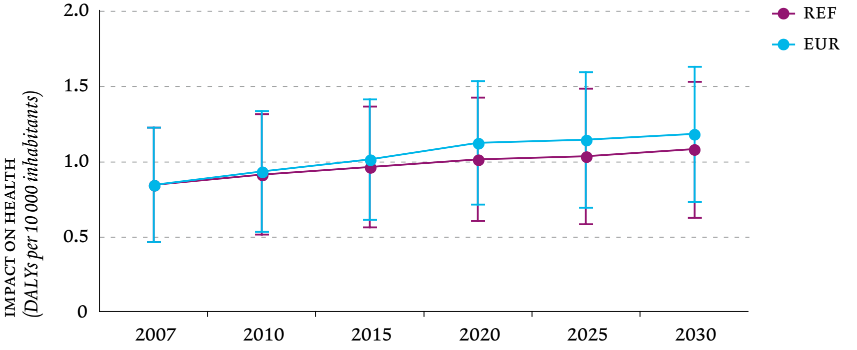
The impact of daily increased ozone concentrations may be quantified with or without the threshold. However, the calculations without the threshold and with the threshold of 35 ppb (or 70 $\mu g/m^3$) ozone do not give any significant differences in the resulting health effects. FIGURE 9.24 shows the total number of DALYS due to exposure to ozone in the two scenarios.

When comparing the two scenarios it is clear that the number of DALYS due to ozone increases in the future, both in the EUR and the REF scenarios. The EUR scenario anticipates a relatively quicker increase in the number of DALYS than the REF scenario. Considered statistically there is no significant difference ($P < 0.05$) between the REF scenario and the EUR scenario.

Finally the number of DALYS correlated with ozone is still low compared to the number correlated to long-term exposure to particulate matter. To put this in perspective: on average the number of DALYS related to mortality due to exposure to PM2.5 (chronic effect) is ± 100 DALYS per annum per 10 000 inhabitants. Whereas this is approximately 1 DALY for the effects resulting from exposure to ozone.

As for the DALYS for ozone, the external health costs correlated to the short-term effects of ozone (the sum of the various effects) increases continuously in the future (TABLE 9.3).

FIG. 9.24 *Total number of DALYs due to exposure to ozone per 10 000 inhabitants in the REF and EUR scenarios (Flanders, 2007-2030)*



The error bars give the standard deviation (1s).

TAB. 9.3 *Average cost of short-term effects due to exposure to ozone in the REF scenario (Flanders, 2007-2030)*

(Euro per inhabitant per year)	Average	95 % LL	95 % UL
2007	45	8	97
2010	48	9	104
2015	51	9	110
2020	53	10	115
2025	55	10	119
2030	57	10	123

LL: lower limit; UL: upper limit

Conclusions for policy

The peak ozone concentrations that occur on warm and sunny days will probably continue to decrease. This is due to the Flemish and European measures for reducing emissions of the ozone precursors NO_x and NMVOC, which served as the starting point for the REF and EUR scenarios in this outlook. The decrease in peak ozone concentrations is the most striking in the EUR scenario.

However, European long-term targets for the protection of public health are not achieved by 2030 either in the REF scenario or the EUR scenario on the basis of these emission forecasts. Not even if one uses the very favourable 2007 meteorological conditions. If more years occur with unfavourable meteorological conditions in the future as in the exceptional year 2003 then the positive effect of the anticipated reduction in emissions, namely the decrease in peak ozone concentrations, may be nullified to a significant extent.

These Flemish and European measures for the reduction of emissions are also inadequate to make the annual average ozone concentration (and consequently the background concentration) decrease. This reduction is necessary due to the warning from the WHO that (chronic) health effects from ozone may occur below the (peak) thresholds.

More fundamental reductions of NO_x and NMVOC emissions are not only required on a Flemish or European level to meet both the European targets for the protection of public health and sustainably to decrease background ozone concentrations but also on a world scale.

9.5 Acidification

Acidification is the result primarily of emissions into the atmosphere of sulphur dioxide (SO_2), nitrogen oxides (NO_x) and ammonia (NH_3). These primary emissions allow various nitrogen and sulphur compounds to form that end up in the environment (soil, water) via the atmosphere. This process is called acidifying deposition and takes place via a number of interim compounds: oxidised sulphuric compounds SO_x, oxidised nitrogen compounds NO_y and reduced nitrogen compounds NH_x.

Acidification is a cross-border issue because sulphur and nitrogen oxides can be transported over long distances in the atmosphere. Emissions of ammonia mainly have a local effect but ammonia is also partly converted into ammonium aerosols. They can also reach much more distant regions.

Harmful effects of acidifying deposition include:

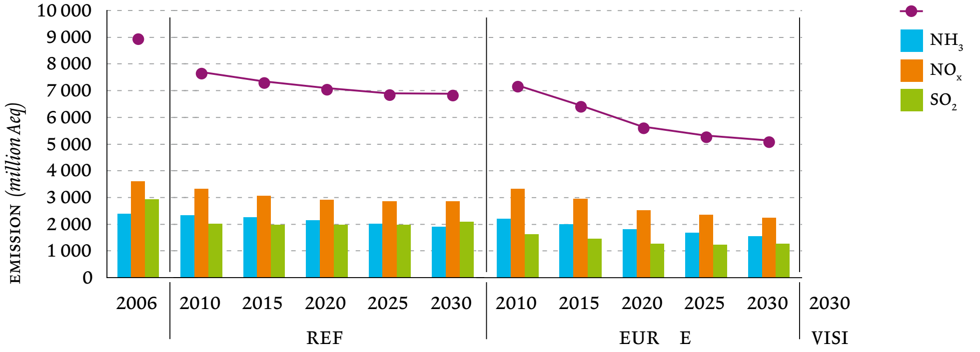
- acidification of surface water and groundwater;
- root damage to plants and trees;
- releasing excessively high concentrations of aluminium and nitrates in the groundwater due to leaching out;
- changes to biodiversity.

Nature oriented deposition standards are used to verify the impact of acidifying deposition on vegetation and soils: so-called critical loads and target loads. Acidifying deposition also causes corrosion of materials and accelerated weathering of buildings.

FIGURE 9.25 shows the total acidifying emissions of SO_2, NO_x and NH_3, converted into acid equivalents for the REF, EUR and VISI scenarios. The total acidifying emissions decrease by 24 % between 2006 and 2030 in the REF scenario, by 43 % in the EUR scenario and by 47 % in the VISI scenario. In 2006, NO_x contributed the most to acidifying emissions. Despite the significant decrease in NO_x emissions this remains the case until 2030. In 2006, SO_2 is the second main pollutant but contributes significantly less to the acidifying emissions in the EUR scenario from 2010 thanks to the clear reduction in emissions. From 2010 NH_3 contributes more to acidifying emissions than SO_2 and this remains the case in the EUR and the VISI scenarios.

The text below discusses the results from the model simulations of the 'average acidifying deposition in Flanders' (total per pollutant) and the 'distribution

FIG. 9.25 *Total acidifying emissions in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



of the acidifying deposition across Flanders'. The potential acidifying deposition is always implicitly intended by acidifying deposition because the actual acidification greatly depends on the processes that take place in the soil and (surface) water. This chapter will then consider the conversion of deposition into exceedance of critical loads and investigate how the soil acidification developed in forests. The distribution maps are given per scenario and for a number of forecast years. The chapter ends with some conclusions for policy.

Acidifying deposition

The acidifying deposition is the total annual atmospheric input of nitrogen and sulphur (NO_y, NH_x and SO_x compounds) and is expressed in acid equivalents per hectare (Aeq/ha).

In 2006, the total average acidifying deposition in Flanders was 2 854 Aeq/ha (FIGURE 9.26). In the REF scenario this decreases by 25 % by 2030 to 2 151 Aeq/ha and even by 45 % in the EUR scenario to 1 582 Aeq/ha. The difference between both scenarios increases over time, from 7 % in 2010 to 27 % in 2030.

The SO_x deposition decreases by 28 % between 2006 and 2020 in the REF scenario and even by 52 % in the EUR scenario. This figure then remains stable to all extents and purposes until 2030. In the REF scenario the SO_x deposition even increases between 2025 and 2030 to the 2010 level. The relative contribution of SO_x in the total deposition fluctuates around 30 % in both scenarios. The acidifying deposition by SO_x predominately follows the trend of SO_2 emissions.

The NO_y deposition decreases by 30 % between 2006 and 2030 in the REF scenario and even by 54 % in the EUR scenario. The relative share in the total deposition decreases especially in the EUR scenario, from 27 % in 2006 to 22 % in 2030. The emissions trend is also generally followed here.

Impact of meteorological variations on acidifying deposition modelling

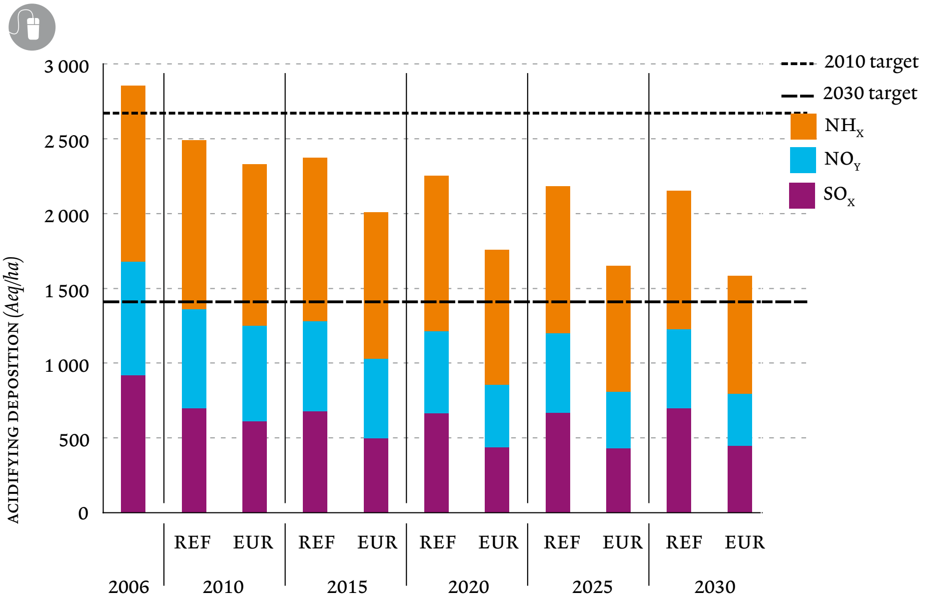
Meteorological data is extremely important when modelling air pollution. The deposition calculations used 2006 meteorological data based on measurements from three meteorological masts in Flanders. Calculating the concentrations and depositions for the 2006 emission year with meteorological data from 2000 to 2005 was necessary to verify whether this year is representative from a meteorological standpoint. The relative differences obtained in concentrations and depositions were negligible compared to the model uncertainty. The 2006 meteorological data may therefore be considered as representative meteorological data for recent years.

The NH_x deposition also decreases continuously between 2006 and 2030, with a 21 % decrease in the REF scenario and a 33 % drop in the EUR scenario. The share in the total deposition increases from 41 % in 2006 to 43 % in 2030 in the REF scenario and to 50 % in the EUR scenario. According to the EUR scenario NH_x remains the largest component in acidifying deposition in 2030, unlike acidifying emissions where NO_x is responsible for the largest contribution.

Both scenarios achieve the 2010 deposition target averaged across Flanders in time. This target is derived from the NEC directive (2 660 Aeq/ha).

The long-term target (LTT) of 1 400 Aeq/ha, to be achieved by 2030, is not met by either scenario. In 2030 the average deposition is still 54 % above the target in the REF scenario and 13 % above it in the EUR scenario. Additional measures are necessary

FIG. 9.26 *Average acidifying deposition in the REF and EUR scenarios (Flanders, 2006-2030)*



on top of the assumptions in the EUR scenario. Due to the high proportion of NH_x deposition the acidification policy in Flanders will increasingly have to become an agricultural policy and more closely follow the manure policy.

Distribution of acidifying deposition across Flanders

FIGURE 9.27 shows the geographic spread of the acidifying deposition across Flanders in 2006 and 2030 with a spatial resolution of 1 km^2.

In 2006 the deposition target for 2010 of 2 660 Aeq/ha is still exceeded across almost half the area of Flanders (46 %). According to the REF scenario the 2010 target is reached in time at 68 % of the area of Flanders, this is 77 % of the area in the EUR scenario. According to the EUR scenario it will take until 2020 before Flanders meets the 2010 target almost everywhere. The REF scenario is inadequate here. In the EUR scenario the 2030 LTT (1 400 Aeq/ha) is met for the first time at a few places in Flanders in 2020. In 2030 the LTT is only met at 39 % of the area in the EUR scenario and only at 1 % of the area in the REF scenario.

The highest deposition and the majority of exceedances occur in the vicinity of the (large) cities (primarily SO_x), major road arteries (primarily NO_y) and in agricultural areas with intensive stock-breeding as in West Flanders, the Northern Kempen and to a lesser extent in the north of East Flanders (primarily NH_x).

Contribution of the sectors in acidifying deposition

Model calculations per sector, in which the non-Flemish sources of emissions are distinguished from the Flemish sources can calculate the imports that contribute to deposition in Flanders. In 2030 the contribution of imports is smaller in the EUR scenario (47 %) than in the REF scenario (51 %) (FIGURE 9.28). These figures directly indicate that emission reduction measures must be taken both at a Flemish and a European level.

The difference between the sector contributions is rather limited in the two scenarios in general. Compared to the REF scenario, the contribution of the agriculture sector (and to a limited extent the industry sector) increases in the EUR scenario.

Exceedance of the critical load

The critical load is a nature-oriented deposition standard. It is the maximum permissible deposition of a polluting substance for a specific ecosystem, in which no harmful effects occur in the long term according to current research. The critical load depends on the soil type and vulnerability of the vegetation and consequently differs from place to place. The critical load for acidification is a deposition standard for acidifying nitrogen and sulphur deposition, the critical load for eutrophication is only for over-fertilizing nitrogen deposition.

FIG. 9.27 *Distribution of acidifying deposition in the REF and EUR scenarios (Flanders, 2006 and 2030)*

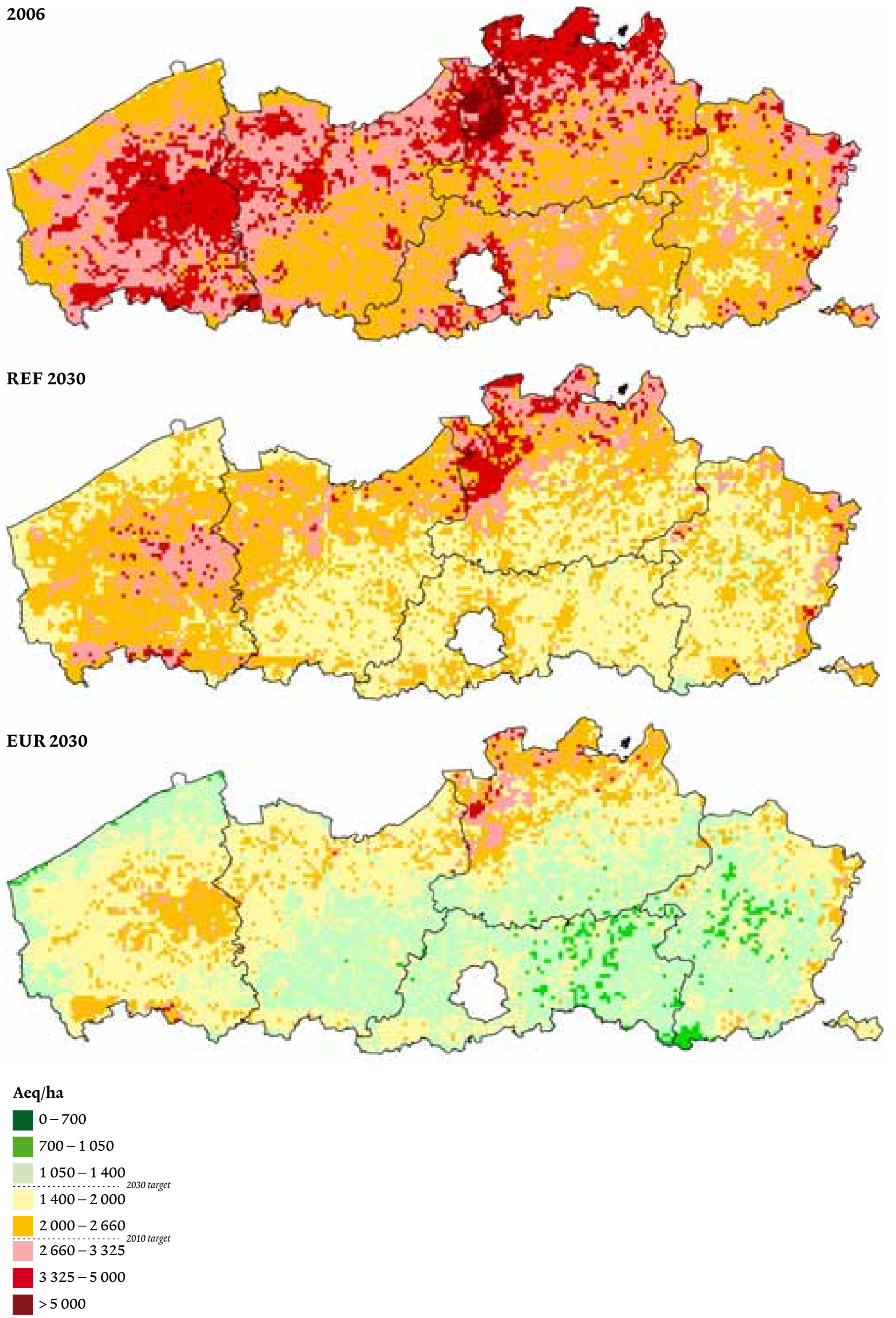
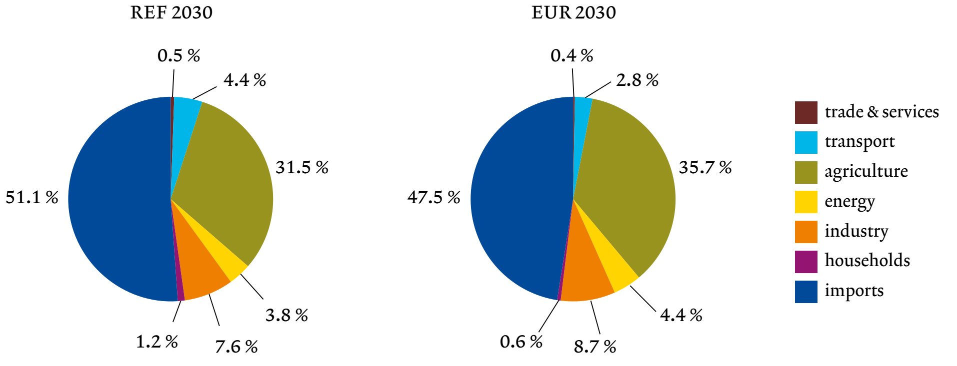


FIG. 9.28 *Contribution of the sectors in the acidifying deposition in the REF and EUR scenarios (Flanders, 2030)*



Unlike the other calculations for which meteorological data was used from 2006, the sector contributions were calculated with 10 year average meteorological data for technical reasons. This does not have any impact on the comparison between the two scenarios.

The area of nature in Flanders (forest, heath, species-rich grassland) that exceeds the critical loads for acidification and eutrophication is calculated on the basis of the anticipated deposition in the REF and EUR scenarios. An increased deposition on the wind side of forest edges was taken into account for forests, the forest edge effect. The calculations for 2006 are based on an area of nature of 182 927 ha, comprising 46 % of deciduous forest, 27 % coniferous forest, 22 % species-rich grassland and 5 % heath. A changing use of land is assumed in the 2010-2030 period as described in Chapter 10 Land Use.

The area of nature with exceedance of the critical load for acidification decreases in time in both scenarios (FIGURE 9.29). In 2006 the percentage of area with exceedance of the critical load is 33 % for heath, 39 % for forest and 46 % for biodiverse grassland. In the REF scenario this area halves by 2030 for all the types of vegetation considered. The decrease is even greater in the EUR scenario up to 5 to 7 % of the area of nature.

The strongest decrease for all types of vegetation is before 2010. This decrease in exceedance of the critical load for acidification between 2006 and 2010 is analogous to the sharp decrease in SO_2 emissions and the corresponding SO_x deposition.

The area with exceedance of the critical acidification load decreases more slowly from 2010 in the REF scenario. The area with exceedance decreases further after 2010 in the EUR scenario albeit to a lesser extent than in the 2006-2010 period.

The percentage of the area with exceedance of the critical load for eutrophication does not decrease by 2030 to the same low level of the exceedance of the critical load for acidification either in the REF or the EUR scenario (FIGURE 9.30). These

FIG. 9.29 *Percentage of the surface of nature with exceedance of the critical load for acidification in the REF and EUR scenarios (Flanders, 2006-2030)*

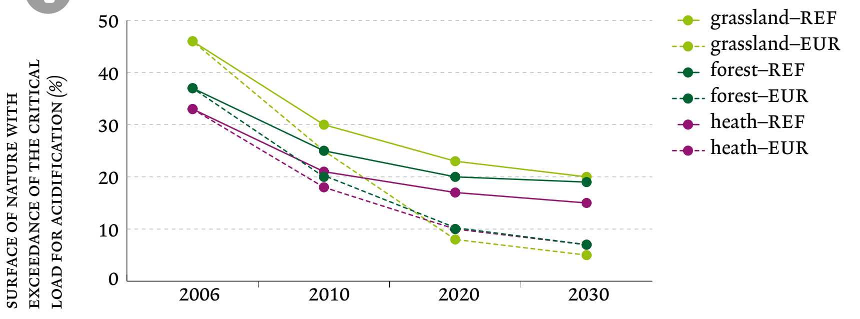
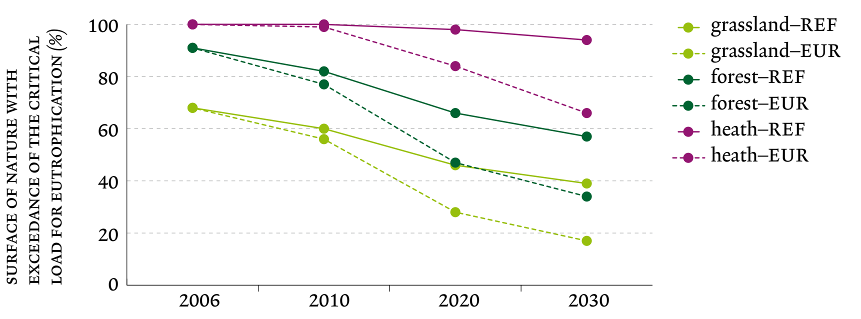


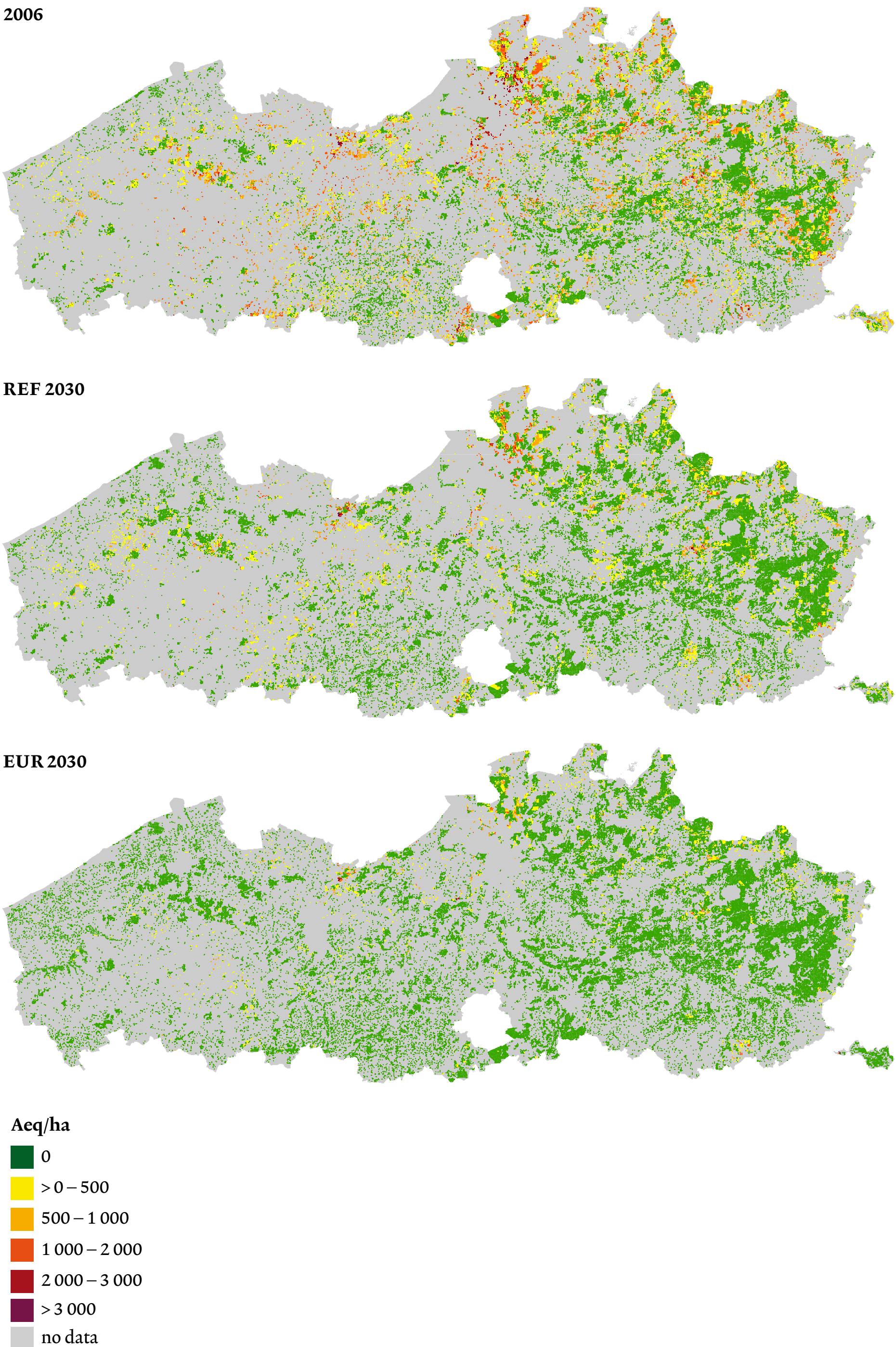
FIG. 9.30 *Percentage of the surface of nature with exceedance of the critical load for eutrophication in the REF and EUR scenarios (Flanders, 2006-2030)*



results indicate that Flemish nature suffers more from exceedance of the critical load for eutrophication than from the critical load for acidification. In 2030 the EUR scenario anticipates that exceedance of the critical load for acidification will remain very limited but that significant parts of Flemish nature will still struggle with exceedances of the critical load for eutrophication.

FIGURE 9.31 shows the distribution of the area of nature in Flanders with exceedances of the critical load for acidification. In both scenarios two thirds of the remaining area with exceedance in 2030 is made up of deciduous forest. The distribution of the exceedances partly reflects the distribution of the deposition in FIGURE 9.27. The critical load depends on the type of soil and vegetation. This explains the differences still observed between the deposition distribution maps and those for exceedance of critical loads.

FIG. 9.31 *Distribution of the surface of nature with exceedance of the critical load for acidification in the REF and EUR scenarios (Flanders, 2006 and 2030)*



Development of soil acidification in forests

Excessive acidifying deposition in forests result in accelerated soil acidification. This harms the vitality of forests and has an impact on biodiversity. A decrease in the level of soil acidification is a slow process. A reduction of acidifying deposition to below the critical load for acidification does not immediately result in a recovery to the original condition of the soil. To verify the period in which the soils in Flemish forests would change after acidification, the VSD model simulated the development of the soil condition between 1880 and 2100 for 84 Flemish forests.

The biogeochemical soil (water) condition was modelled on the basis of the following parameters, amongst others:

- pH (measure of the level of acidity) and base saturation of the soil: an increasing value indicates soil recovery.
- nitrate concentration and ratio of the concentration of aluminium to the so-called base cations (potassium, calcium, magnesium) in the soil water (Al:Bc): a decreasing value indicates soil recovery.

FIGURE 9.32 shows the relative development of these parameters as a result of the anticipated acidifying deposition between 2006 and 2030 in the REF and EUR scenarios. Both scenarios result in a limited increase of both pH and base saturation of the forest soils and a sharp decrease on the one hand of the Al:Bc ratio and on the other the nitrate concentration in the soil water. These positive developments are always more pronounced in the EUR scenario. The lower acidifying deposition in the EUR scenario results in significant improvements to the soil condition compared to the REF scenario in 2030, namely 2 % higher soil pH (or 20 % lower proton activity), a 6 % higher base saturation, a 36 % lower Al:Bc ratio and a 54 % lower nitrate concentration. The positive development of these parameters, certainly in the EUR scenario, indicates that the Flemish forest is moving towards a recovery from soil acidification.

FIG. 9.32 *Relative value compared to 2006 of the simulated soil parameters in the REF and EUR scenarios (Flanders, 84 forests, 2006-2030)*

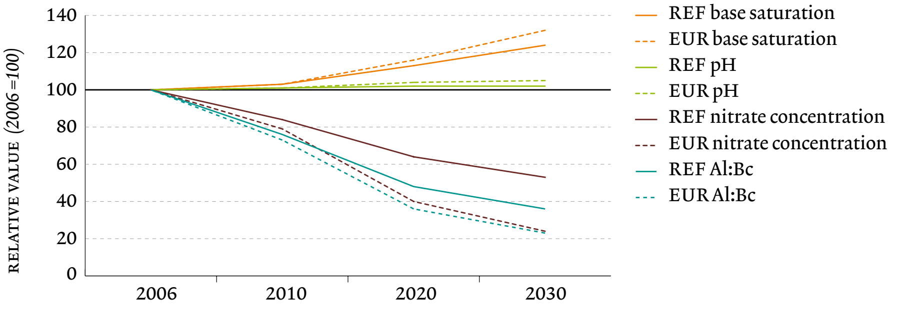
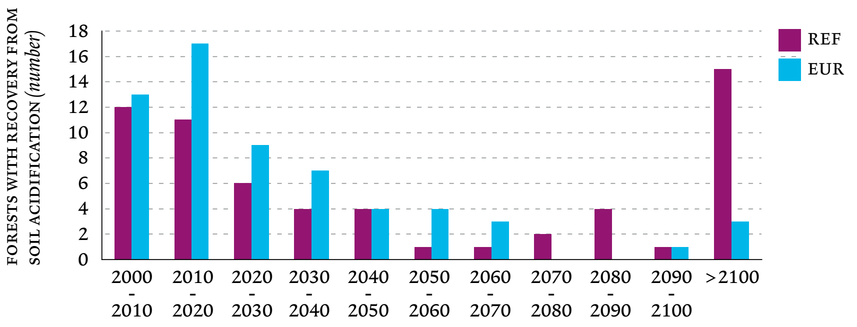


FIG. 9.33 *Number of forests with recovery from soil acidification per period of 10 years in the REF and EUR scenarios (Flanders, 61 forests, 2000-2100)*



An Al:Bc ratio below 1 is considered a recovery from soil acidification. Both scenarios investigated when this criterion would be achieved. Only those forests where soil acidification had been established in 2000 were taken into account here. In the REF scenario a recovery from soil acidification occurs in half of the forest from 2033, whereas this is already the case from 2021 in the EUR scenario (FIGURE 9.33). The soil recovery takes place more quickly in coniferous forests than in deciduous forests in both scenarios.

To achieve a recovery from soil acidification in all forests by 2050, a further reduction of deposition is required from 2030 for 29 % of the forests in the REF scenario and for 20 % in the EUR scenario.

If no further reduction of deposition is implemented and a constant acidifying deposition is assumed from 2030 – the REF scenario predicts that 18 % of the forests will still have soil acidification by 2100. Whereas this is only 4 % of the forests in the EUR scenario.

Conclusions for policy

The decreasing emissions of acidifying pollutants in Flanders result in decreasing deposition. The decrease in SO_2 and NO_x emissions is inadequate however to achieve the 2020 indicative emission targets. That emission target is already achieved in 2006 for NH_3.

Due to the insufficient decrease in SO_2 and NO_x emissions and despite the achievement of the NH_3 emission target, the short- and long-term deposition targets will not be achieved in time everywhere in Flanders. Averaged across Flanders the short-term 2010 target is achieved but the long-term 2030 target is not. This shows that there is a need for additional (environmental) policy. In the EUR scenario additional measures and instruments were assumed necessary to meet the European medium-term targets. The model calculations show that these measures are also insufficient to achieve the deposition targets in the long term throughout Flanders.

Additional sector-dependent policy measures will consequently be required to meet long-term targets. Additional emission reduction measures are required for all pollutants both at a Flemish and a European level. The impact of Flemish policy will weigh greatly on NH_3 considering the increased relative importance of the NH_x deposition and because NH_3 is predominately deposited close to its source. The measures proposed for the reduction of livestock and the modification of types of livestock housing are a step in the right direction. This may be realised by a combination of decreasing the beef stock and making completely low emission housing for pigs and poultry. This makes an 18 % reduction of emissions possible in agriculture in the REF scenario and a 23 % reduction in the EUR scenario. This goes much further than the emission ceiling for 2010.

The significant reduction of acidifying deposition in the EUR scenario may result in a potential recovery from soil acidification before 2030 in a majority of the forests studied. The REF scenario also results in the recovery from acidification, naturally not as quickly as in the EUR scenario. Additional deposition reductions will even be required in a fifth of the forests in the EUR scenario between 2030 and 2050 to allow all forests to recover from soil acidification by 2050. Without these further reductions in deposition, not all the forests will have recovered from soil acidification even by 2100. The chemical recovery of the soil is only one of the essential conditions for preserving or increasing biodiversity in Flemish forests. The response of biological organisms to improved soil conditions also plays a role. This, in turn, depends on the colonisation possibilities and expansion speed of plants and animals. Measures aimed at interrelation (town and country planning) may contribute to this.

In addition the eutrophying effects of nitrogen deposition also limit the recovery of biodiversity in forests and in nature in general. 29 % of the Flemish nature or 70 000 ha nature will still suffer from nitrogen deposition that is too high to protect biodiversity. Even with the measures given in the EUR scenario despite all measures for recovery of acidification. Acidification is only one of the disturbance factors to realise the conservation objectives. An integrated approach is required and measures against acidification and eutrophication are an integral part of this.

END NOTES

1 The BelEUROS base year was calculated from the 2006 emissions (2007 was not yet available) and meteorological data from 2007.
Meteorology is the determining factor here. The minor differences between the 2006 and 2007 emissions will not have any significant impact on the BelEUROS results. The BelEUROS base year is consequently also 2007 and the model results should therefore also be compared to the measurements from 2007.

LIKE TO KNOW MORE?

If you would like to know more, you can refer to the scientific reports which form the basis for this chapter:

Deutsch F., Buekers J., Janssen S., Torfs R., Veldeman N., Fierens F., Trimpeneers E. & Bossuyt M. (2009) Zwevend stof. Scientific report, MIRA 2009, VMM, www.milieurapport.be.

Deutsch F., Buekers J., Janssen S., Torfs R., Veldeman N., Fierens F., Trimpeneers E. & Vancraeynest L. (2009) Fotochemische luchtverontreiniging. Scientific report, MIRA 2009, VMM, www.milieurapport.be.

Van Avermaet P., Celis D., Fierens F., Deutsch F., Janssen L., Veldeman N., Viaene P., Wuyts K., Staelens J., De Schrijver A., Verheyen K., Vancraeynest L. & Overloop S. (2009) Verzuring. Scientific report, MIRA 2009, VMM, www.milieurapport.be.

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de Hollander E.M., Melse J.M., Lebret E. & Kramers P.G.N. (1999) An aggregate public health indicator to represent the impact of multiple environmental exposures. Epidemiology, 10, 606-617.

de Leeuw F.A.A.M. (2002) A set of emission indicators for long range transboundary air pollution, Environmental Science & Policy 5, 135-145.

Mapping Manual (2004) UNECE Convention on long-range transboundary air pollution, International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops, Chapter 3 - Mapping Critical Levels for Vegetation, Mapping Manual 2004, G. Mills (ed.), ICP Vegetation Coordination Centre, UK.

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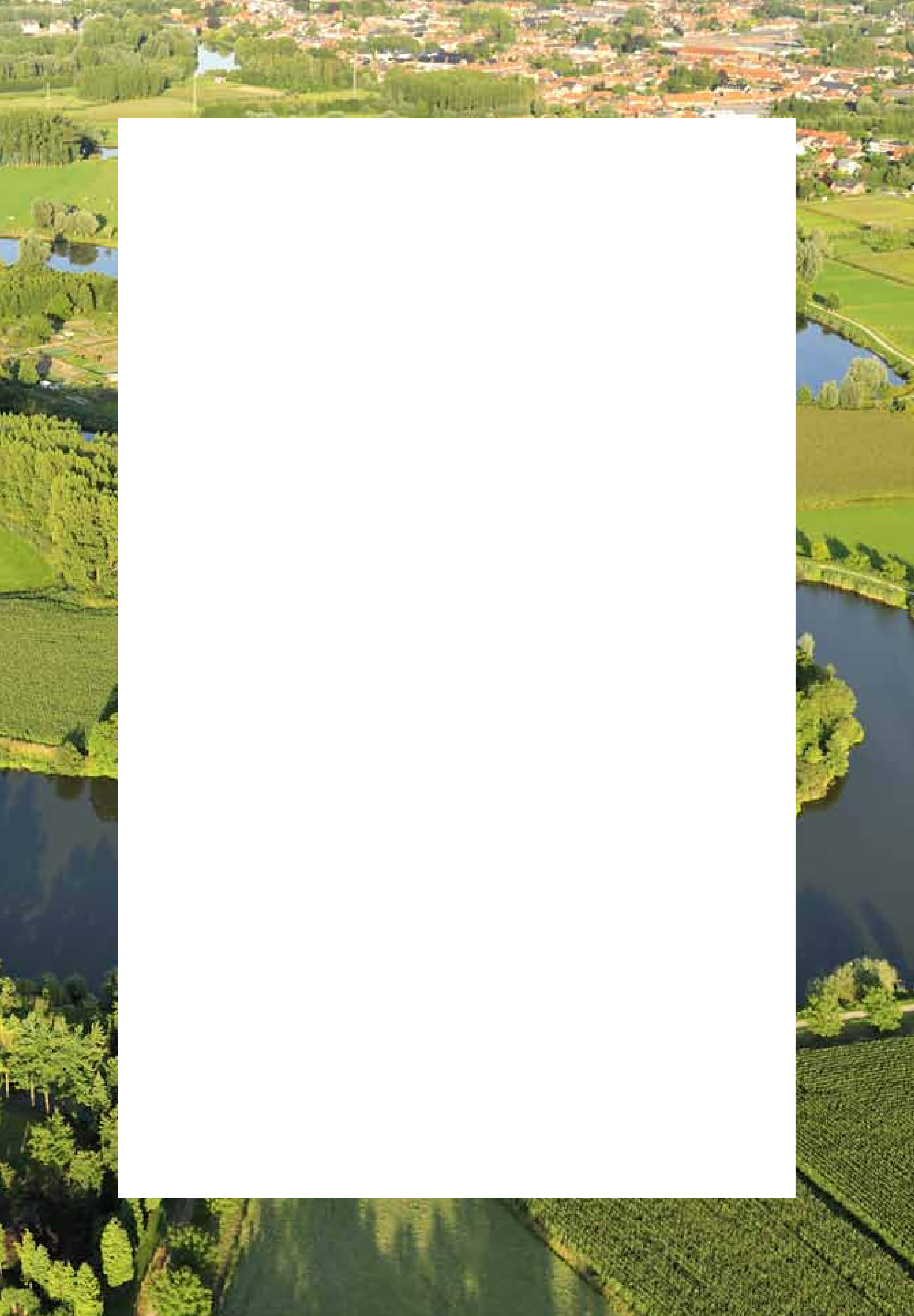

10 Land use

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OUTLINES

- There is a greater need for residential and commercial buildings due to the growth of the population and the economy. As a result the urbanized area will expand by 13 to 17 % from 2005 to 2030 respectively in the Europe (EUR) and the reference (REF) scenarios.

- The urbanized area also becomes denser due to the concentration of the building effort. This densification effect is stronger in the EUR scenario, so that the open space is preserved better in that scenario. The land use by agriculture decreases in both scenarios.

- The built area for households and trade within a distance of 450 m from major roads, increases by 21 % from 2005 to 2030 in the REF scenario and by 18 % in the EUR scenario. The negative impact of traffic on the health of the residents in the neighbourhood may increase as a result.

- According to the REF scenario 2030, 16 % of the population (or 1.1 million inhabitants) will live in an area where no collective water treatment is available. In the EUR scenario this is 14 %. By harmonising environmental and planning policy, a lot of costs may be saved in the construction of public facilities both for society and the individual.

- Farmers play a major role in a more environmentally and nature-oriented land management. In the EUR scenario the area of agriculture with environment or biodiversity targets as an additional function increases to 162 000 ha in 2030. Amongst others the green space area may increase as a result by 15 % per inhabitant in the EUR scenario.

Introduction

The organisation of the use of land affects various environmental topics such as fragmentation, air quality and the use of natural resources. Land use also plays a role in the efficient management of utilities. The space requirements of the various sectors makes us confront the finite nature of this resource.

This chapter investigates how the interaction between these space requirements and possible policy choices translates into future land use on the basis of a new land use model. This is realised for the reference scenario (REF) that continues the current policy and for the Europe scenario (EUR) that aims at the realisation of the European environmental targets by 2020. Because there are insufficient points of application for the spatial conversion of the sectoral visionary scenarios, no visionary scenario (VISI) is developed for this chapter.

The text first gives an explanation of the approach of the outlook using a dynamic land use model. The chapter then turns to the development of the land use in Flanders according to the ten land use categories formulated. The attention is subsequently focussed on indicators for urbanized space and open space. Conclusions for policy finally follow.

A web application shows the development of the land use in more detail on the basis of the maps per forecast year and scenario: www.milieuverkenning.be.

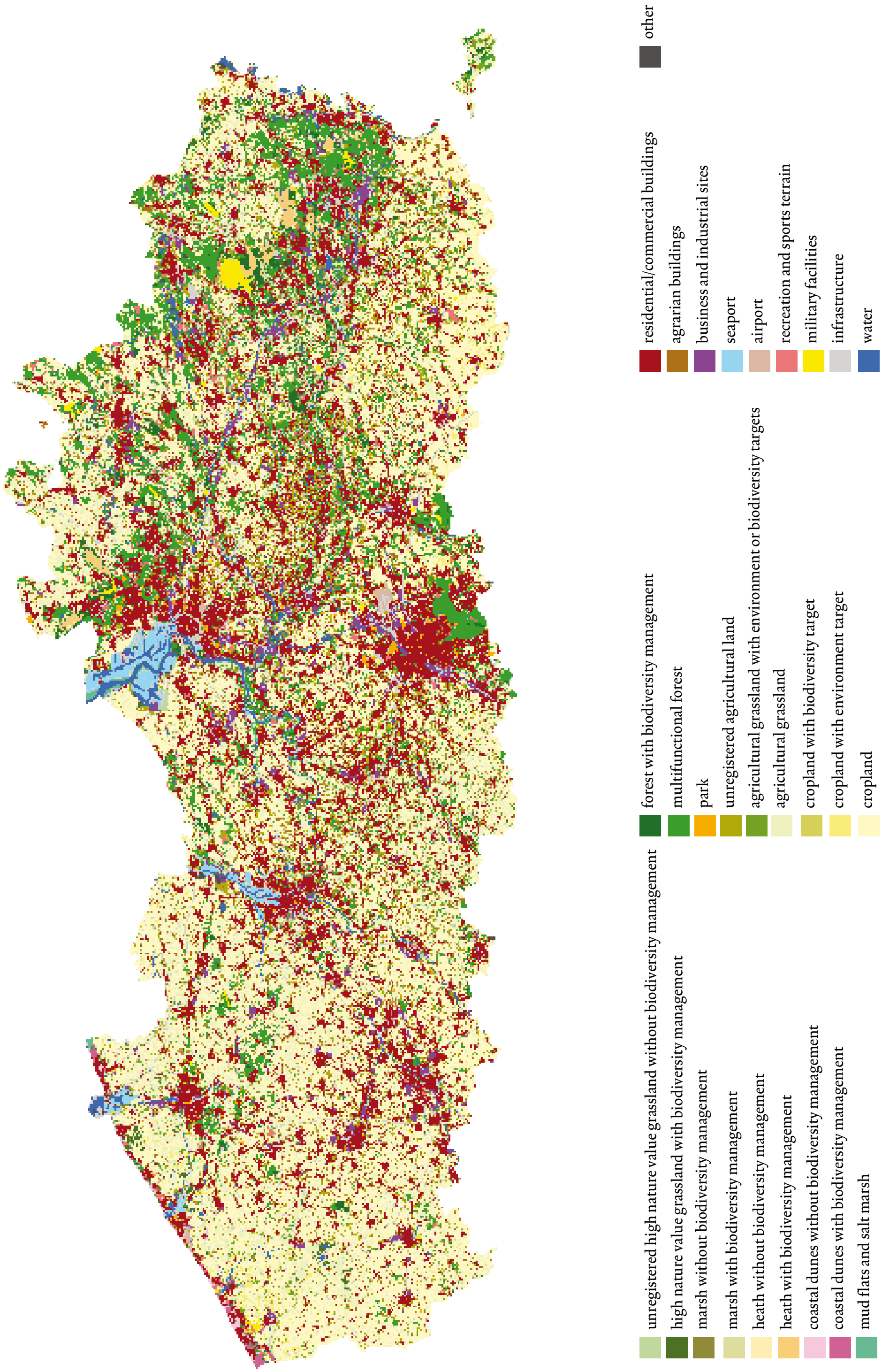
10.1 Principles of the Environment Outlook

Land use 2005

For the first time, a simulation model made it possible to investigate the consequences policy choices would have on future land use. VITO developed a new dynamic land use model for Flanders on assignment from MIRA (Flemish Environment Agency) and NARA (Research Institute for Nature and Forest).

The principle for the model calculations is the land use map that shows the status in 2005 at a resolution of 15 m. The land use was divided into 28 land use categories according to the main function. The most recent data from the Biological Valuation Map (BVM), of the agricultural parcel register (EPR) and the land parcel register are the backbone of the land use map developed. VITO rescaled the land use map for the 2005-2030 outlook to a resolution of 150 m (FIGURE 10.1). The Brussels Capital Region has a major impact on the dynamics of land use in Flanders. As a result this region has been included in full in the land use map and in the modelling.

FIG. 10.1 *Land use map at a resolution of 150 m (Flanders and Brussels Capital Region, 2005)*



Dynamic land use model with three levels

The land use model makes it possible to see, at high resolution, how the various land use categories in Flanders develop annually. The calculations are realised using data on autonomous socio-economic developments, with the current policy and the anticipated policy in the scenarios. The model output is the future land use and spatially diversified indicators. These are the spatial translation of the policy choices and autonomous developments in the scenarios. The results for each year are available in the period from 2005 to 2030 at a resolution of 150 m. When modelling land use the coherence in spatial coverage of individual sectors is monitored. In the first instance their interpretation is interesting in order to determine general trends due to the great uncertainties of the results obtained at this high resolution.

Socio-economic developments are given in the model from the global, via the regional to the local level to allocate the land use at a higher resolution (FIGURE 10.2). Information about the quality of the space (availability, suitability, policy status and transport connections) are reported in the opposite direction. The changing land use and quality and quantity of the space still available affect the dynamics at each level of the model and thereby define the relative attraction of the regions. In this way they influence the extent to which people and activities move or settle in a specific region.

The model posits that an activity will grow in regions that are attractive, relatively speaking, for that activity. If the activity increases, the pressure on the space will also increase. This results in densification. This in turn has an impact on the attractiveness of the regions: in this way the regions may mutually lose activities to or win them from each other.

The global model level deals with socio-economic activities the country needs to function. Each scenario imposes integrated growth figures at the regional level for economic and demographic developments as described in Chapter 2 Socio-economic outlook. The economic activities are categorised into agriculture, industry, services, port activities on the basis of their typical spatial behaviour and land use. The population gives shape to the residential land use. The number of active persons for the economic sectors, the number of inhabitants in the residential sector and the area taken by agriculture, forest and nature express the activity. For the agriculture sector each scenario formulates a surface target for the various agricultural categories (grassland and fields), according to Chapter 5 Agriculture. The same is true for the nature categories swamp, heath, coastal dunes, grassland with nature conservation and forest, in accordance with the scenarios from the Nature Outlook 2030.

The regional scale distributes the global activities imposed to the districts. In addition it shifts activities and inhabitants between the districts.

FIG. 10.2 *Sub-models at three connected levels in the land use model*

global: Flanders and Brussels: 1 region

regional: districts: 23 regions

local: 1 138 567 units of 2.25 ha or 1 707 in 667 units

The allocation of this demand for space steered by growth is realised according to the supply and demand principle for economic activities and for the population. The areas imposed by policy in agriculture, forest and nature are allocated by means of priority allocation. The SELES model of the Department of Agriculture and Fisheries of the Flemish Government imposed the areas per district in accordance with the scenarios for the agriculture sector. For nature and forest this was done on the basis of the POTNAT model of the INBO (NARA 2009). In order to coordinate everything as well as possible the model has been formulated so that it generates totals for the various sectors and for the population per district which are consistent with the PLANET model of the Federal Planning Bureau (Chapter 2 Socio-economic outlook).

The regional model level calculates per unit how many people live and work there per sector. The regional model level consequently determines the number of units per land use category required for the allocation at a local scale level based on this (FIGURE 10.2).

The local model level can be seen as a regular grid of land use units that covers Flanders and the Brussels Capital Region. Each of the square units, 2.25 ha in size, is always situated in a unique land use status as shown in FIGURE 10.1. This dynamic allocation of the regional spatial demand (expressed in the number of units) is realised on the basis of the unit automat. Amongst others, the change in a unit status depends on the land use of the units in their immediate surroundings: a circular area with a radius of 1 200 m. The mutual impact of the units is the first settlement aspect that regulates the dynamic transition at a local scale. The biophysical suitability of the unit (capacity to support the land use, e.g. soil type, water quality, etc.), the policy status (institutional zoning status, e.g. spatial accounting, regional plans, Flanders Spatial Structural Plan (FSSP) and spatial execution plans, specially protected areas of nature, economic nodes, etc.) and the accessibility (road infrastructure, public transport, etc.) play a decisive role.

Principles for the scenarios

The assumptions in the REF and EUR scenarios quantitatively express the driving forces for change in land use:

- The results of the PLANET model imposed the prognoses for demographic development, economic growth and employment.
- The growth parameters for the land use for ports and recreational regions are derived from historic trends.
- For the residential land use the assumption is that the land area increases with the growing population and commercial activities. However, the plot sizes differ between the scenarios. The REF scenario derived the land area from the prognoses for the floor area per type of residence and then interrelated it with the plot size and residential land use based on land registry data. Only the EUR scenario implemented target figures for residential density of the FSSP: 25 homes/ha in urbanized areas and 15 homes/ha in the centres of the rural areas. Furthermore a 60/40 ratio was strived for between the urbanized area and the rural area as regards the additional housing supply.
- For professional agriculture (EPR) the surface cultivated land and the distribution across the various categories is determined by the status-quo of the production-equivalent area. The policy aim 'preserving permanent grassland' is taken into account in this and under the assumption of a 10 % lower production per surface unit on grounds on which environment or biodiversity targets are realised. This means for the REF scenario 594 510 ha agricultural area in 2030, of which 25 182 ha with environment or biodiversity targets (4.2 %) and 608 045 ha for the EUR scenario of which 161 788 ha (26.6 %) with environment or biodiversity targets.
- For nature and forests each scenario determined the target areas per land use category. The forest category is also subject to management in which three principles are central: quantitative forest conservancy, forest expansion and qualitative forest conservation.

- The spatial principles of the FSSP define where land use may develop and steer the allocation of the land use to a unit level. In addition numerous other policy documents were implemented to define the policy status of each unit.

  The REF and EUR scenarios correspond to the RR scenario and the ER scenario in the Nature Outlook 2030.

10.2 Land use

The results of the outlook are explained here at the scale level of Flanders. The analysis of the dynamics is further discussed at the level of districts.

MIRA grouped the 28 land use classes of the land use map into ten non-overlapping land use categories that together cover the entire area of Flanders in order to give a clear overview of the results (TABLE 10.1).

TAB. 10.1 *Categorization of the land use and correspondence to the land use model*

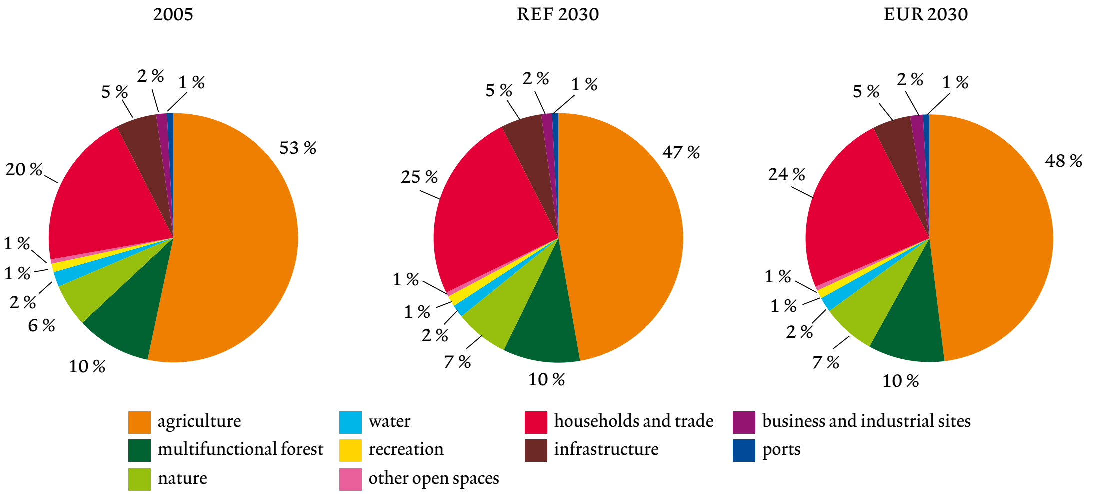
Land use category (10)	**Land use class** (28)
Nature	Sites with a primary function for nature, with or without biodiversity management
Multifunctional forest	Multifunctional forest and parks
Agriculture	Unregistered agricultural land, all grassland and cropland, excluding grassland with biodiversity management
Households and trade	Residential, commercial and agrarian buildings
Business and industrial sites[1]	Business and industrial sites
Ports	Seaports and airports
Recreation	Recreation and sports terrains
Infrastructure	Infrastructure
Water	Water
Other open spaces	Other + military facilities

FIGURE 10.3 shows that the Flemish land area (1 357 358 ha) comprised to a great extent in 2005 of the land use categories agriculture (53 %), households and trade (20 %), multifunctional forest and nature (15 %) and infrastructure (5 %).

The households and trade and agricultural land use is strikingly different in the REF and EUR scenarios in 2030:

- The land use for *households and trade* increases in both scenarios but the increase is the strongest in the REF scenario, with 23 % in 2030 compared to 2005. For Flanders this corresponds to a speed of growth of 2 502 ha/year. In the EUR scenario this is 1 955 ha/year, or an increase by 18 % in the period between 2005 and 2030. In both scenarios the majority (83 to 85 %) of the residential expansion areas defined in planning are absorbed by households and trade in 2015.

FIG. 10.3 *Land use in the REF and EUR scenarios (Flanders, 2005 and 2030)*



- Urbanization is primarily to the detriment of *agricultural land*. The decrease is 3 382 ha agricultural land/year in the REF scenario and 2 929 ha/year in the EUR scenario. Compared to 2005 this is a decrease respectively of 12 % and 10 % in 2030. In both scenarios the population grows equally strongly. The densification of the residential urbanization and the choice for more agriculture with environment or biodiversity targets in the EUR scenario determine the difference.

  The REF scenario anticipates a growth of the area of *nature and multifunctional forest* by 11 % over a period of 25 years or 924 ha/year. In the EUR scenario this is a growth of 12 % over 25 years or 1 010 ha/year. Due to the population growth by 0.74 million people to 6.78 million – which comes down to an increase by 12 % between 2005 and 2030 – the area of nature and multifunctional forest per inhabitant remains stable at about 340 m^2/inhabitant in the period between 2005 and 2030 for both scenarios. Flanders and even Belgium have the lowest levels in Europe.

  The *business and industrial sites* grow by 21 ha/year or 2 % over the period between 2005 and 2030 in the REF scenario and of 35 ha/year or 4 % over the period 2005-2030 in the European version, although the economic development is equally strong in both. The explanation for the stronger growth in the EUR scenario is the result of the smaller space taken for homes, that allows more space for business and industrial sites and for which more separate terrains are provided. The increase of the business and industrial sites remains moderate despite the anticipated growth for the industry and trade and services sectors. The gross value added increases for the industry sector by 47 % despite a decrease in employment by 16 %. For the trade and services sector both the gross value added and the employment increase respectively by 62 % and 25 %. This shows the further development towards a services based society. Employment is the driving force in the modelling for the extent of this land use category.

FIGURE 10.3 and FIGURE 10.4 show that Flanders loses 6.2 % of its area in the REF scenario in the agriculture category and 0.2 % in the other open spaces category. Households and trade (+4.6 %), nature (+1.3 %) and multifunctional forest (+0.5 %) take their place. Consequently in 2030 6.4 % of the Flemish area experiences a net change of use according to the REF scenario and this is 5.5 % in the EUR scenario.

Land use at the districts level

This section wants to study the diversity of the anticipated developments at the scale level of the districts. This is realised by the spatial information as regards the units of 2.25 ha (FIGURE 10.1) to be combined at the district level.

FIG. 10.4 *Net land uses changes between 2005 and 2030 in Flanders and the districts in the REF and EUR scenarios, expressed in the percentage of the total area of the limits taken into account in 2005*

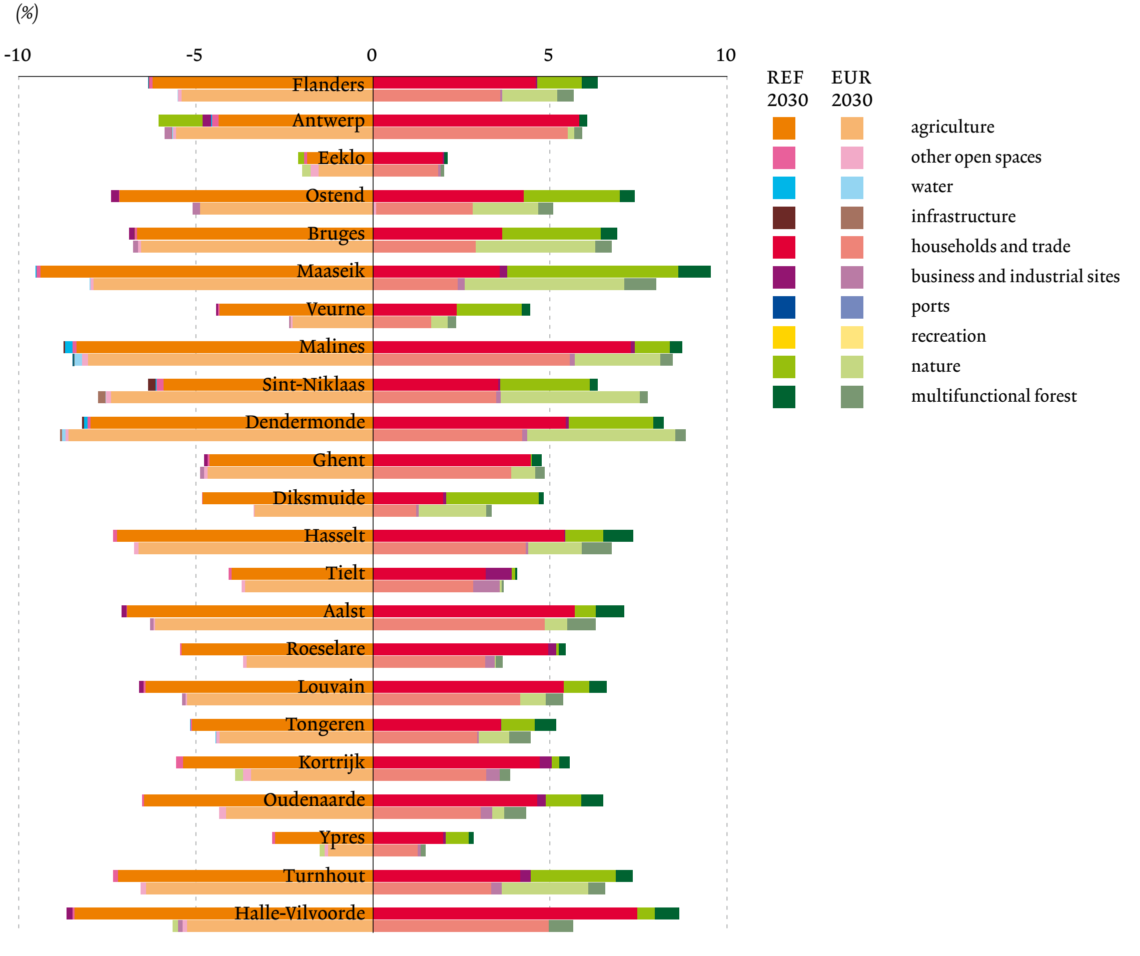


Figure 10.4 illustrates the changed land use at the Flemish level and per district for both scenarios. The percentage shows the net change in 2030 compared to the land use in 2005. This indicator is a measure of the spatial dynamics, in which the patterns on both sides of the neutral line complement each other. The total area of Flanders or the districts is actually fixed.

This dynamic is the most pronounced in the districts of Maaseik and Malines, and the least in Eeklo and Ypres. In all districts there is a lower additional land use for households and trade as a result of the smaller building plots for new building in the EUR scenario. Antwerp loses the most nature areas in percentage and Maaseik has the highest increase in nature in percentage. Tielt has the highest increase in business and industrial land.

10.3 Urbanized area

The increased urbanization and the population growth are a challenge to the quality of the environment. The impact of urbanization on soil sealing, environmental quality close to major roads and water treatment were spatially analysed on the basis of indicators.

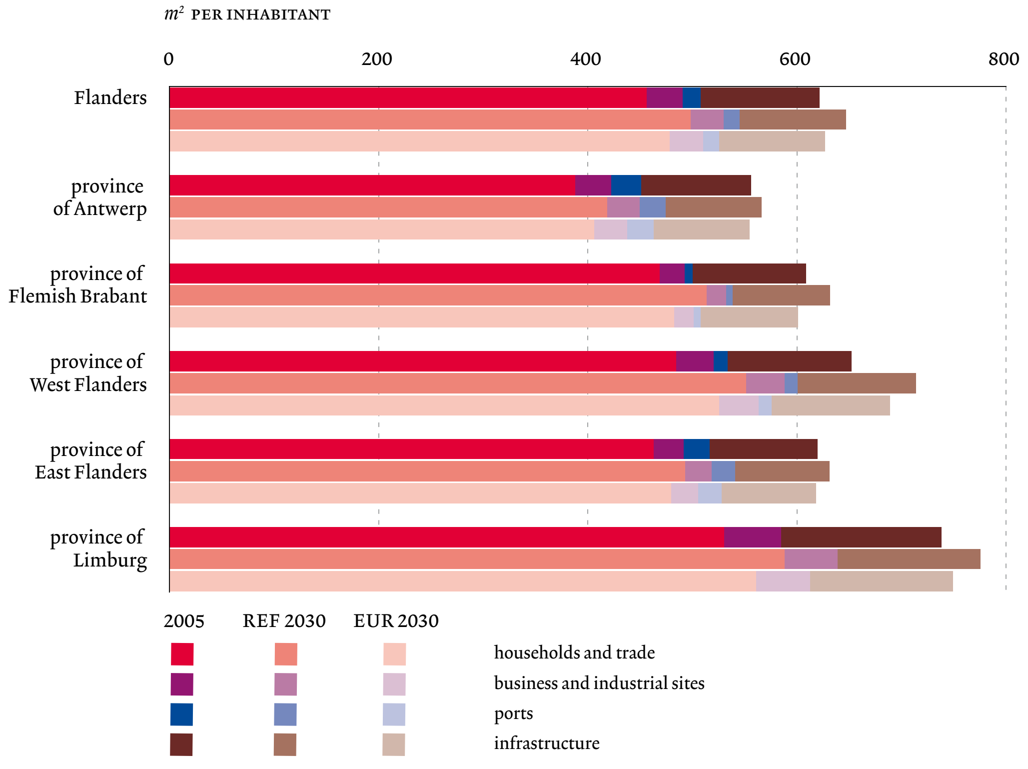
The urbanized area comprises the land use categories households and trade, business and industrial sites, ports and infrastructure. In the REF scenario the urbanized area increases by 17 % between 2005 and 2030, to 439 000 ha. In the EUR scenario growth is limited to 13 % or an increase to 426 000 ha. This means that 6.9 ha of urbanized area is added each day in the REF scenario and 5.5 ha in the EUR scenario.

Figure 10.5 shows the area of urbanized space per inhabitant in 2030 for the two scenarios and in 2005. Although the urbanized space has increased, this growth is limited to 4 % per inhabitant in the REF scenario and to 1 % in the EUR scenario in Flanders. This difference is the result of a housing concentration due to smaller building plots and extension within the limits of the towns or high-rise building in the EUR scenario. Here are differences between the provinces. In Antwerp, Flemish Brabant and East Flanders the urbanized area decreases per inhabitant in the EUR scenario because the population is increasing faster than the urbanized area there.

Level of sealing

The level of sealing is the ratio of the sealing of the area of soil to the total area of a land use category. The level of sealing varies per land use category and is the highest, for instance, for infrastructure with 75 % sealing. The level of sealing of the urbanized area decreases between 2005 and 2030 from 33 % to 31.6 and 31.8 % respectively in the REF and EUR scenarios. This is because the proportion of urbanization increases

FIG. 10.5 *Area of urbanized space per inhabitant in the REF and EUR scenarios (Flanders, 2005 and 2030)*



through households and trade in the urbanized space, which also includes gardens and residential plots.

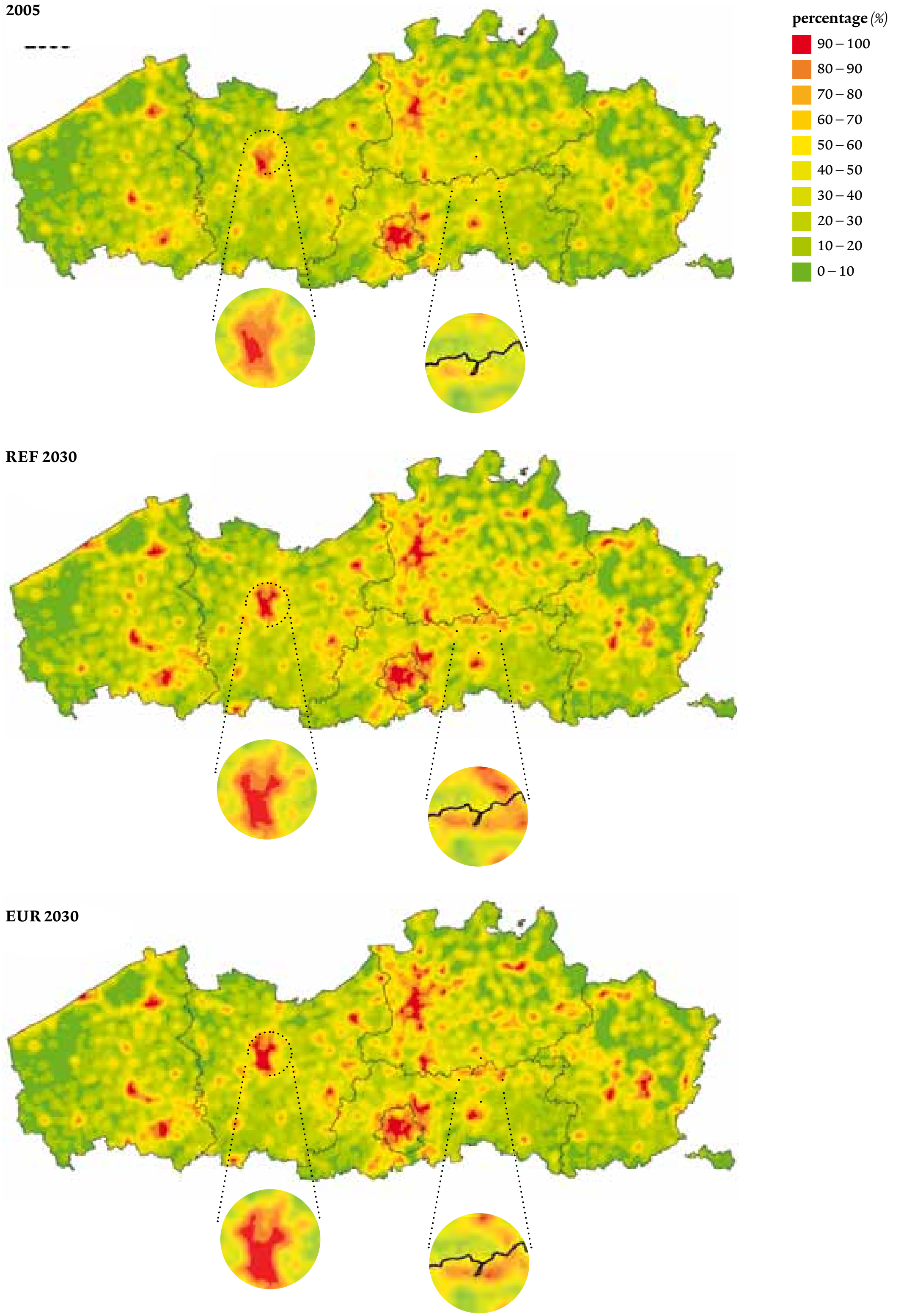
The level of sealing for the whole of Flanders increases from 9.3 % in 2005 to 10.3 and 10.1 % respectively in 2030 for the REF and EUR scenarios. This means that 1.6 ha of the land is built-up daily in the REF scenario and 1.2 ha in the EUR scenario.

The increasing sealing of the soil results in decreased water infiltration and water storage in the soil. This ensures accelerated water drainage and problematic peak flows in minor watercourses following intense summer precipitation and in large rivers following winter storms. Due to the anticipated population growth, additional measures are required to limit urbanization and to limit the negative consequences.

Densification

FIGURE 10.6 illustrates the density of the urbanized area. This indicator expresses the proportion of the urbanized land use classes within a radius of 1 500 m around a 2.25 ha unit.

FIG 10.6 *Density of the urbanized area: proportion of urbanized area within a radius of 1.5 km in the REF and EUR scenarios (Flanders and Brussels Capital Region, 2005 and 2030)*



The density of the urbanized space is increasing because both the urbanized space and its fragmentation are increasing. These effects are the highest in the urbanized areas like Brussels and Antwerp and the weakest in Diksmuide and Veurne. The density increases more strongly in the REF scenario and especially in the districts of Malines, Halle-Vilvoorde and Louvain. In Ypres and Eeklo the densification hardly changes in the EUR scenario.

The map fragments of FIGURE 10.6 show the development for an urban area (left map fragment, Ghent) and a countryside region (right map fragment: around the municipalities Keerbergen, Tremelo, Heist-op-den-Berg). By 2030 the further densification becomes clear. In the EUR scenario the densification is high in urban areas and less pronounced in rural areas. This is apparent from the strict application of the allocation of new homes according to the FFSP regulations.

Building in the vicinity of major roads

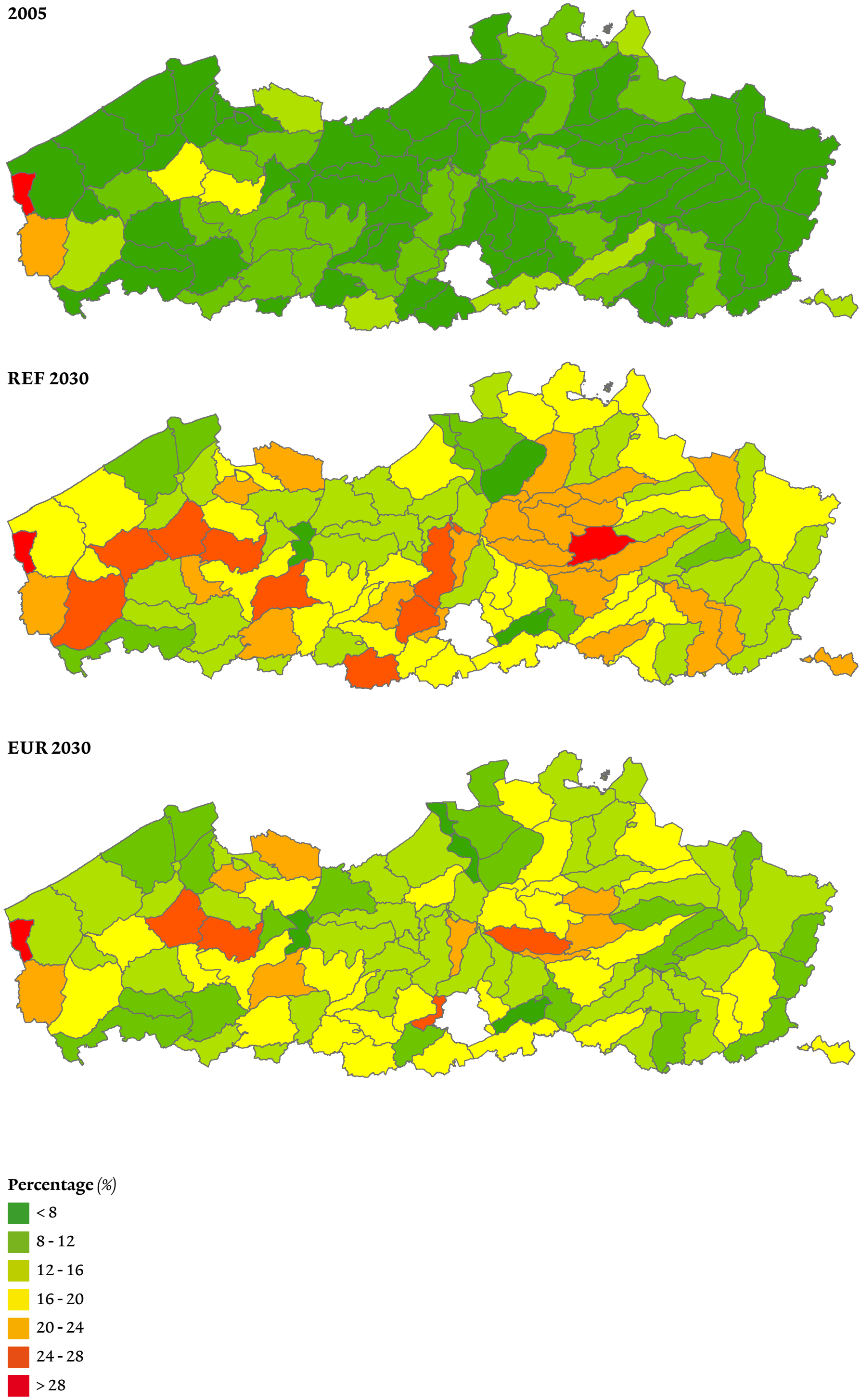
The increasing urbanization in the two scenarios primarily takes place in suburban areas and in built-up centres of the countryside: these are areas with high accessibility. This means that the urbanization in the environment of major roads[2] increases in both scenarios. In a buffer zone of 450 m around major roads, the share of land use category households and trade increases from 28 % in 2005 to 34 % in 2030 according to the REF scenario and 33 % in the EUR scenario. In narrower buffer zones the evolution is similar. This is important for exposure of the population to pollutants and the impact of traffic nuisance. Research is currently in progress to define the effects on air quality and exposure in the vicinity of roads with high levels of traffic. The further urbanization of Flanders will highlight this issue even further.

Water treatment in the urbanized area

The zoning plans for wastewater treatment divide Flanders into regions with collective water treatment (central area, rural area optimised collectively and area to be optimised collectively) and a region with individual small-scale water treatment (area to be individually optimised).

In 2030 the area to be optimised collectively must be completely provided with sewage and connected to the water treatment plants (WTP). Based on the current zoning plans this model concludes that in the REF scenario in 2030, 5.7 million Flemings will live in an area with collective water treatment. This is 84 % of the population. In 2007 5.3 million Flemings or 87 % of the population were connected to the sewage system. Consequently, the wastewater of 4.3 million Flemings was effectively treated collectively. The new urbanization will also be realised outside the current areas with collective water treatment. In the REF scenario 2030 16 % of the population or 1.1 million inhabitants will live there and 14 % in the EUR scenario. The modelling did not take the current zoning plans into account for the allocation of

FIG. 10.7 *Proportion of the population outside the area for collective wastewater treatment in the REF and EUR scenarios, per sub-basin (Flanders, 2005 and 2030)*



the new building development (FIGURE 10.7). This indicator shows that it is useful to strive for a better coordination between the environment and the spatial planning policy. This can save major costs both for society and the individual.

10.4 Open space

How open space may develop is analysed here using indicators up to a provincial level. In addition to the conversion to urbanised space (or vice versa) the open space per inhabitant and its contiguity will also be considered. The green space and its availability will also be studied. Finally this section will also analyse the possible development of the agricultural area.

Open space includes the land use categories with a limited amount of urbanization and is consequently complementary to the urbanized space. Open space comprises the land use categories nature, multifunctional forest, agriculture, recreation, water and other open spaces (TABLE 10.1).

Conversion of the open space

The sustained demand for housing results in the conversion of open space to urbanized area. There is also a transformation from urbanized area to open space. The conversion to urbanized area dominates and is 65 889 ha between 2005 and 2030 in the REF scenario and 51 809 ha in the EUR scenario. This is primarily to the detriment of agricultural land as is apparent from FIGURE 10.8. The nature and multifunctional forest categories are also built on.

FIG. 10.8 *Conversion of open space to urbanized space (large bars) and from urbanized space to open space (small bars) in the REF and EUR scenarios (Flanders and the Brussels Capital Region, 2030)*

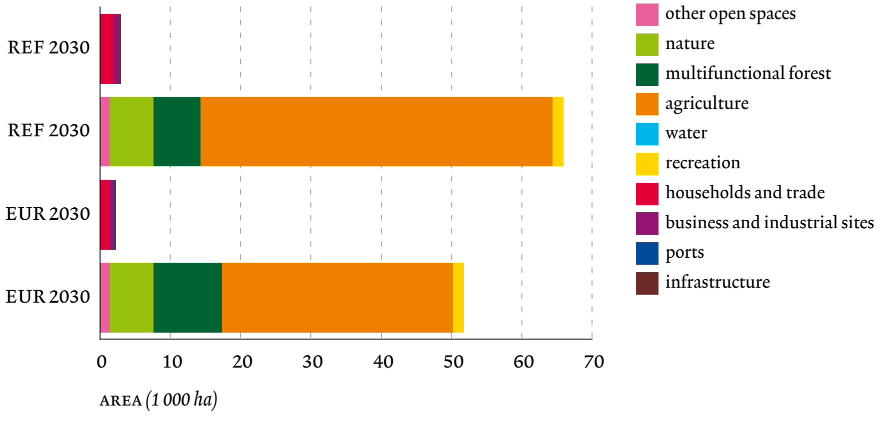
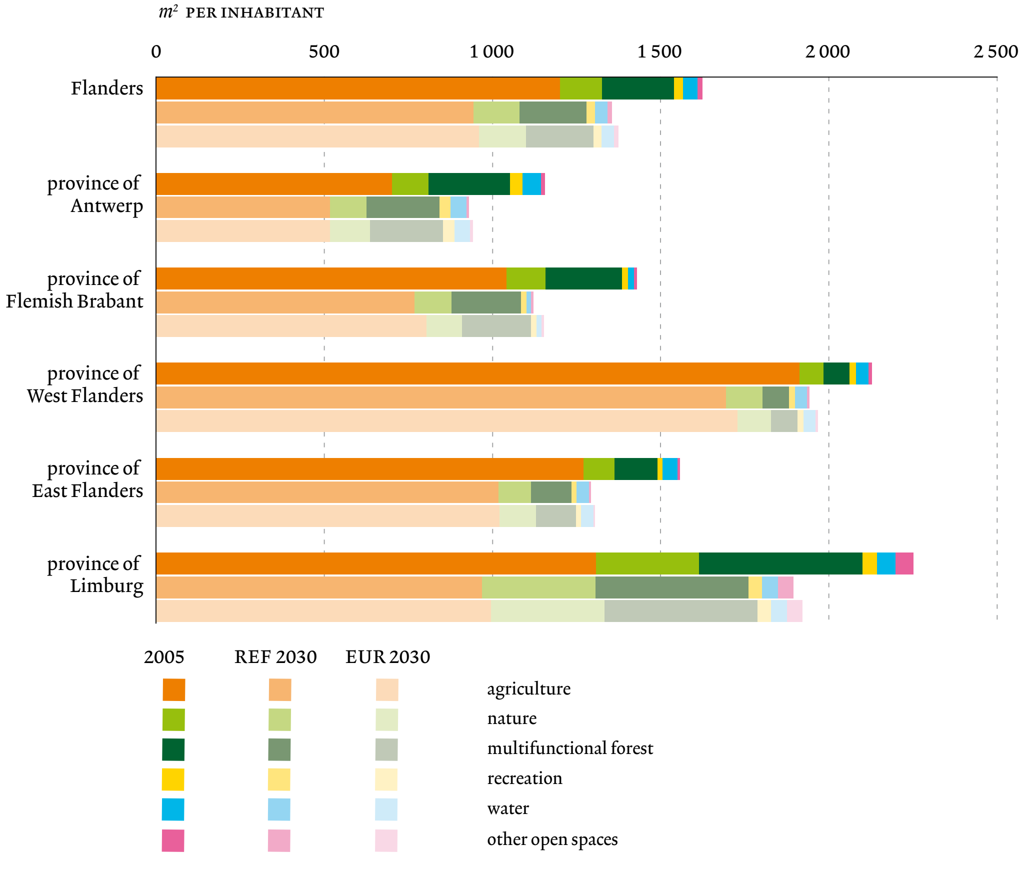


FIG. 10.9 *Area of open space per inhabitant in the REF and EUR scenarios (Flanders, 2005 and 2030)*



The limited conversion of land use primarily for housing and trade and business and industrial sites to open space is 2 968 ha in the REF scenario and 2 216 ha in the EUR scenario in 2030. It is assumed here that the urbanized space can be transformed into open space. In practice this relates to planning transformations, e.g. unused business and industrial sites or the redevelopment of an area after soil remediation.

Open space and green space per inhabitant

The decreasing open space means there is less area of open space per inhabitant. FIGURE 10.9 shows this development for Flanders and the provinces. For Flanders the area of open space decreases from 1 624 m²/inhabitant to 1 354 in the REF scenario and 1 374 in the EUR scenario in 2030. The general position here is that the developments in the urbanized space are the motor for what happens to the open space. In the provinces of Antwerp and Flemish Brabant the relative decrease in open space is the most pronounced, in West Flanders the least. Agriculture holds its own the best here: urbanization occurs at a lower pace compared to the rest of Flanders.

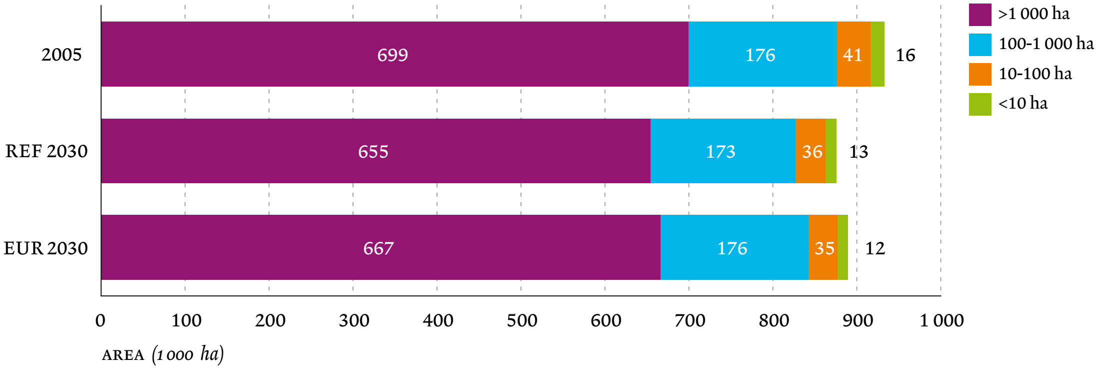
As in 2005, the availability of green space in Flanders and the Brussels Capital Region per inhabitant within a radius of 10 km in the REF scenario is 386 m² in 2030. Green space includes the land use categories nature, multifunctional forest and a limited area of agricultural land, namely agriculture with environment or biodiversity targets. Although the area of forest and nature increases in the REF scenario, the availability of green space remains constant because the population growth increases proportionately. In the EUR scenario the range increases to 444 m²/inhabitant in 2030, through the strong development of agriculture with environment or biodiversity targets.

Contiguity of open space

The experience of open space also depends on the contiguity and size of the clusters. Open space clusters are contiguous areas comprising open space land use, where major roads, watercourses and railways cut through here and there. Despite the decreasing area of open space, the open space clusters become larger on average, from 139 ha in 2005 to 163 ha in the REF scenario and to 166 ha in the EUR scenario (FIGURE 10.10). The number of clusters decreases in the scenarios in the same way. This is the result of the increasing urbanization in the suburban areas and in the built-up centres in the countryside. In both scenarios the agricultural area disappears, generally in the vicinity of the built-up centres. This ensures that small clusters of open space disappear. Large clusters of open space are more resilient but do not increase in area.

Tested against the principles of the FSSP, it is apparent that the urbanization is concentrated around existing built-up areas. This is part of deconcentrated bundling. The FSSP also posits that the undeveloped space must be maximally preserved.

FIG. 10.10 *Area of open space per cluster size class in the REF and EUR scenarios (Flanders and Brussels Capital Region, 2005 and 2030)*



Due to the high demand for housing it is only possible to preserve the larger clusters of open space by sacrificing the smaller clusters to urban development.

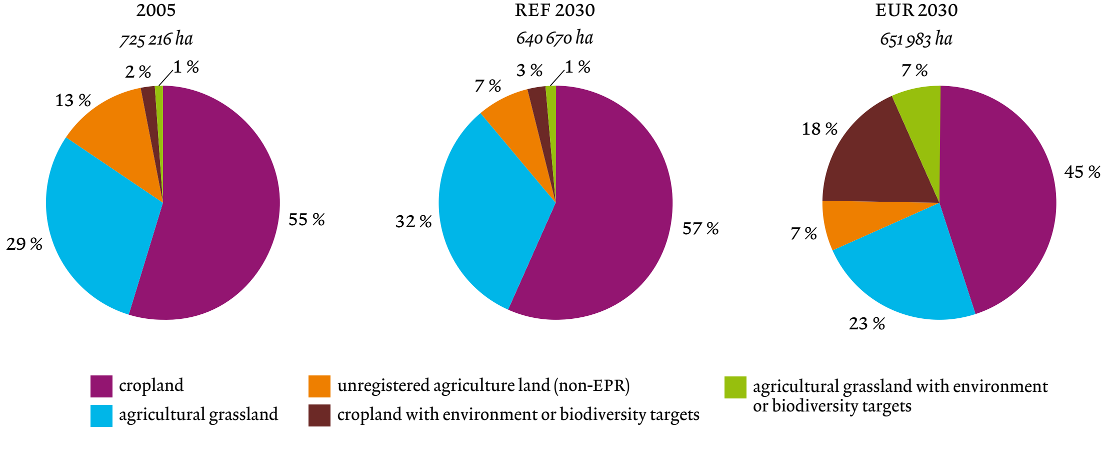
Agriculture in the open space

The land use category agriculture in the land use model comprises multiple land use classes:

- Production grassland and fields: these are registered agricultural lands with the sole function of production agriculture.
- Grassland and fields with environment or biodiversity targets: these are registered agricultural lands with the main function in production agriculture but respectively with an interwoven sub-function of environmental or nature conservation (more detail about this is given in Chapter 5 Agriculture.)
- Unregistered agricultural land: this is the collection of fields and biologically low value grasslands that are not registered with the government for subsidy, management agreements or in the context of environmental legislation such as the manure policy. In practice these plots are for hobby agriculture, horse and sheep meadows and all kinds of brushwood (undeveloped building plots ...).

FIGURE 10.11 illustrates the share of each of these land use classes in the total land use for agriculture. The agriculture described in Chapter 5 only deals with the agricultural land registered for subsidy, management agreements or in the context of environmental legislation like the manure policy.

FIG. 10.11 *Composition of the land use category of agriculture and shares in the REF and EUR scenarios (Flanders, 2005 and 2030)*



The area of unregistered agricultural land halves in the scenarios from 92 000 ha to approximately 46 000 ha in the REF scenario and 44 000 ha in the EUR scenario in 2030. The EUR scenario invests strongly in the realisation of additional environment or biodiversity targets in fields and pasture. This development requires a strengthening of the countryside policy and greatly limits the sediment flows due to erosion and drainage of nutrients into the surface water. The area of registered agricultural lands decreases slightly as is explained in Chapter 5 Agriculture.

The geographic databases available for unregistered agricultural land were unable to identify the users of this land. Because no policy options rest on unregistered agriculture, this land use is highly sensitive to change in the model simulations. Consequently no account is taken of the rights of autonomy of the owners to the sites on which unregistered agricultural activities take place. In districts where the area of registered agriculture increases, this growth is to the detriment of unregistered agricultural land. The preservation of professional agriculture and further urbanization are hard to reconcile unless other land use classes, such as unregistered agriculture, relinquish land. This is the choice made in the model.

10.5 Conclusions for policy

Population growth determines the future land use in Flanders to a considerable extent. The increasing demand for housing ensures the future urbanisation of Flanders. How and where the building is planned determines the opportunities to reduce the negative effects. The increasing demand for space for housing and business and industrial sites is primarily to the detriment of the agricultural area. A densification of the additional building development is chosen in the modelling on the basis of historic trends and a stricter application of government rules. The higher densification in the EUR scenario due to smaller building plots offers more opportunities to preserve the open space.

A second driving factor for land use is economic growth and the employment related to it. This outlook also assumed a growth scenario in the trade and services sector. Despite the strong growth this leads to a limited additional demand for business and industrial sites and to an increase in commercial building development.

According to this model simulation, agriculture will have to relinquish land in the future for residential and commercial building development. Registered agriculture remains predominately preserved and in some districts grows, unlike unregistered agriculture.

In the REF scenario the agricultural area decreases. The density of the countryside increases further. The availability of green space per inhabitant remains stable compared to 2005. In the EUR scenario the agricultural area decreases to a lesser extent. Rural densification is not as large but is all the larger in the cities. The regulations for residential building development of the FSSP are respected. The range of green space per inhabitant increases, amongst others as a result of the sharp increase in the area of agriculture with environmental or biodiversity targets.

The model results may appear rather limited at a Flemish scale but major changes may happen at a local scale. The increased building around major roads will put additional quality demands on the environment around those roads. In addition to the arrangement of the living environment, the environmental policy (including air quality, noise) and the transport policy must respond to this.

Where the many new homes will be built must be taken into consideration when providing services and laying utilities, such as wastewater treatment or fibreglass cabling elements. This modelling is based on the integration according to the principles of the FSSP in the EUR scenario, i.e. a deconcentrated bundling. A more spread out integration increases the costs for services and utilities.

The results from the model make it clear that well considered choices must be made to house people, to allow industry and trade to grow, to safeguard agriculture and protect nature. In addition win-win situations are not always possible and the policy has to take difficult but clear choices. The scenario exercise indicates that if both the agricultural area and the open and green space must be safeguarded at the current level in Flanders then it is crucial to use the urbanized space more efficiently.

The strength of this outlook with a land use model is in visibly showing the autonomous developments and policy choices at a detailed level of 2.25 ha. In addition spatially specific indicators are developed that make it possible to explore planning and environmental targets. This outlook is a first step in a process that requires further refinement. In this way a better definition of the land use classes could further extend the model. The land use model may be used as a guide when drafting town and country planning. Quantifying multi-sectoral policy scenarios and spatial dynamic model results make it possible to test developments and policy responses, such as sectoral visions, for consistency.

ENDNOTES

1 The business and industrial sites category in the land use model comprises 45 % industrial and 55 % trade & services activities. Industrial activities and trade & services are spread across the land use categories business and industrial sites, households and trade and ports.
2 Large roads comprise all regional and secondary roads, main roads, express roads and motorways. Local roads do not belong to this.

LIKE TO KNOW MORE?

If you would like to know more, you can refer to the scientific reports which form the basis for this chapter:

Gobin A., Uljee I., Van Esch L., Engelen G., de Kok J., van der Kwast H., Hens M., Van Daele T., Peymen J., Van Reeth W., Overloop S. & Maes F. (2009) Landgebruik in Vlaanderen. Scientific report, MIRA 2009 & NARA 2009, VMM, INBO.R.2009.20, www.milieurapport.be, www.nara.be.

READERS

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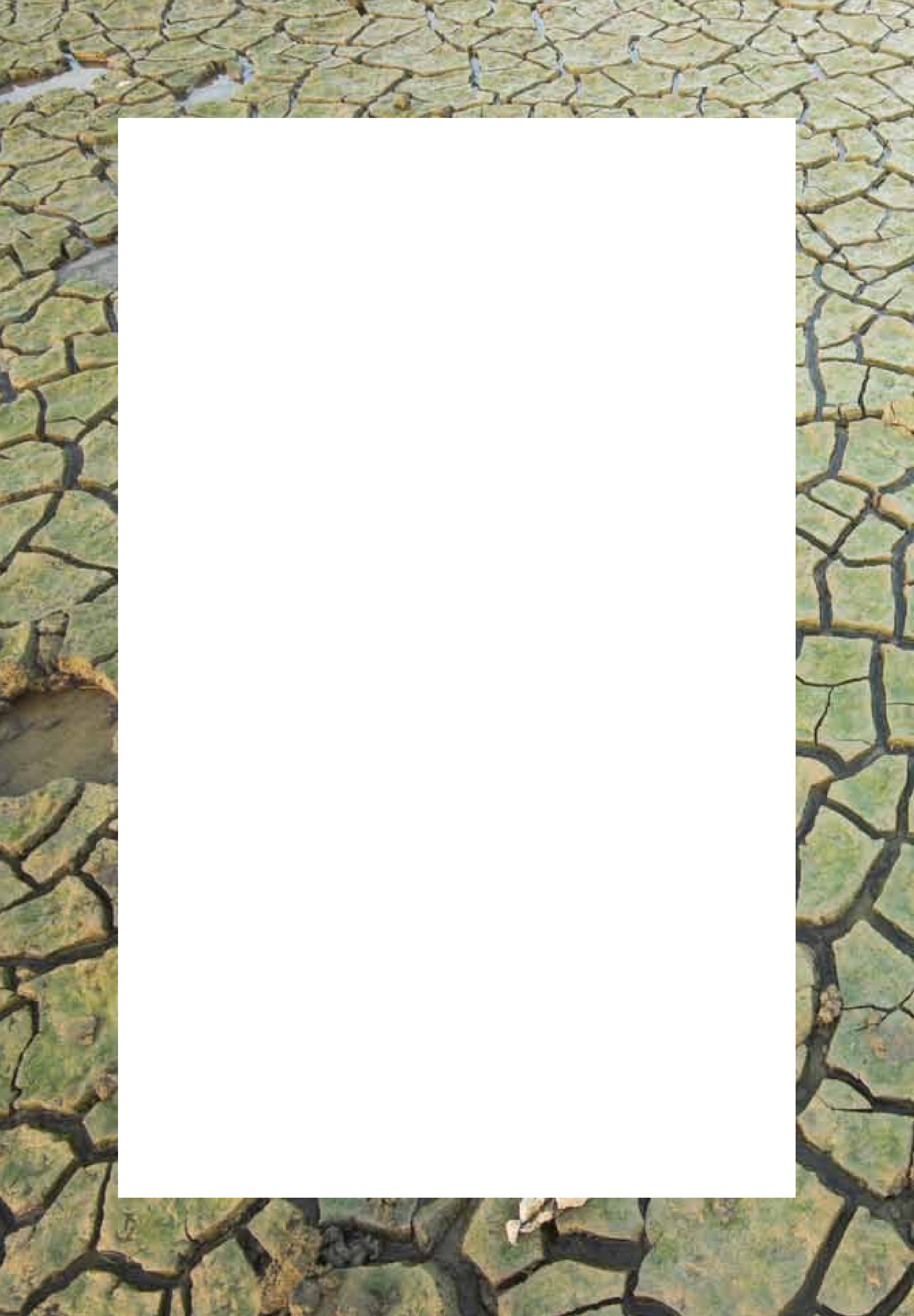
Martine Swerts, Land and Soil Protection, Subsoil and Natural Resources Division, LNE Department
Bert Van Goidsenhoven, OVAM
Axel Verachtert, Environmental, Nature and Energy Policy Division, LNE Department



11 Climate change and water systems

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OUTLINES

- All climate scenarios for Flanders clearly indicate an increase in the ambient temperature (e.g. by 1.5 °C to 4.4 °C in the winter and by 2.4 °C to 7.2 °C in the summer), a higher evaporation in the winter and summer and finally more precipitation during the winter by 2100. The sea level at the Flemish coast may rise by 20 to 200 cm this century.

- The majority of climate scenarios indicate a drop in the average summer precipitation for Flanders. Combined with higher evaporation this will decrease the lowest river flows during dry summers by over 50 % by the end of the 21st century. The chances of severe water shortages increase as a result.

- Despite a drop in summer precipitation, an increase in the number of extreme summer storms may be expected in Flanders. This increases the probability of flooding of sewers.

- The risk of financial damage due to flooding varies greatly, depending on the various climate scenarios for Flanders: from a drop by 56 % to a 33 % rise.

- Flanders is located between Northern France, where climate change strengthens the evolution towards more droughts and The Netherlands where an increase in the number of floods is expected to be more likely. In order to deal with the uncertain consequences of climate change, water managers in Flanders must therefore search for flexible adaptation strategies that are useful in any circumstances. This involves strategies that enable both flood risk limitation and the prevention of water shortages.

Introduction

The climate is the average weather condition over a period of a few decades or longer. It is described on the basis of parameters such as temperature, precipitation and wind. Apart from the annual seasonal fluctuations in weather patterns, the climate is subject to change. The current climate change is amongst other causes due to global warming and is becoming increasingly perceptible. This warming is considered one of the main problems confronting the Earth at this time. Climate change is a phenomenon that appears over a longer period. For that reason climate studies often work with a time horizon (e.g. to 2100) that is much further in the future than the target year 2030 that is considered in other chapters of this environmental outlook.

This chapter is the first to gather the results from eleven research projects recently completed or still underway which study the possible climate changes in Flanders and their consequences (see the list at the end). Achieving a more define view of the possible changes was a major focus of this chapter. New risk calculations for flood damage were carried out according to various scenarios. This information is crucial to allow the government and public authorities but also industry, agriculture, households, etc. in Flanders to adapt in time and purposefully to climate change and to be able to limit the damage due to flooding or water shortages.

This chapter will first consider the way in which climate scenarios were developed for Flanders starting from global climate scenarios. Temperature, evapotranspiration, precipitation and wind then illustrate the possible climate change for Flanders in the 21st century. The point of particular interest in this chapter will then be considered: the impact of climate change on water systems (rivers, urban drainage systems, coastal zone) in Flanders. Those consequences – for instance flooding, water shortages or exceeding water quality standards – in their turn have major socio-economic and environmental implications. Finally this chapter will conclude with recommendations to support water policy and management.

11.1 From global emission scenarios to three climate scenarios for Flanders

Climate change, which is expressed amongst other things in the global warming of the Earth, also became clearly perceptible in Flanders over recent decades. The Intergovernmental Panel for Climate Change (IPCC) is an organisation formed by the United Nations that brings together the scientific findings on climate change worldwide. According to the IPCC, humans very likely (>90 % probability) contribute to this climate change. This contribution is attributed to the increased emission of greenhouse gases[1] (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3) and chlorofluorocarbons) due to human activities into the atmosphere. Other factors also play a role in the climate change observed: for instance the variation in solar radiation, the changing presence of particles in the atmosphere as a result of volcanic eruptions or natural phenomena such as fluctuations in atmospheric circulation patterns.

Researchers use climate models to calculate future changes in the emissions of greenhouse gases to their impact on the global climate system. This modelling required significant simplification due to:

- the, as yet, still incomplete knowledge of atmospheric processes and their interactions;
- the massive computation capacity required to calculate complex interactions;
- the large spatial dimensions of the global climate system.

This simplification means that the results are still uncertain. In the first place this applies for local processes. The results for temperature are significantly more accurate than those for precipitation and wind speed, particularly because they are much less variable spatially. The average values of climate variables are also considerably more accurate than those for exceptional or extreme values. Although the uncertainty remains great, the detail of climate models is continuously improving. Increasingly more processes and interactions are integrated (e.g. interactions with the land surface, sea ice, the carbon cycle, aerosols and changing vegetation). The resolution at which the models can work – currently for sections with a height and width of 10 to 25 km – is also increasingly being refined.

In order to gain a better picture of the variation of the possible impact and due to the simplifications and remaining uncertainties, impact analyses are carried out with multiple climate models and various emission scenarios.

Greenhouse gas emissions in Flanders contribute to climate change. However the speed with which the greenhouse gases emitted mix in the atmosphere and the length of time they remain there, makes climate change a pre-eminent global concern. In order to explore the possible climate changes in Flanders, the global greenhouse gas emission scenarios are consequently taken as a basis – rather than the scenario results for greenhouse gas emissions for the various sectors in this outlook report. The scenarios for the global greenhouse gas emissions are taken from the 4th Assessment Report of the IPCC (2007). They are constructed around various world views, starting from the increase or reduction of the globalisation of the economy, differing demographic changes, various technological growth paths and the extent to which the world economy is sustainable.

These different emission scenarios were used in twelve linked global and regional climate models. The results were tested against the historical progress

(1961-1990). This made it possible to explore the range within which the climate may change in Flanders by the end of this century (2071-2100). Researchers from the Catholic University of Leuven and the Royal Meteorological Institute (KMI) defined three climate scenarios from a wide range of simulation results obtained by climate models. These climate scenarios outline a range of climate change variation in Flanders by the end of this century. They include both the differences in the possible greenhouse gas emissions and the uncertainties linked to the climate models used:

- The *wet climate scenario* (a 'high' scenario) results in the greatest increase in the level of precipitation that leads to high runoff discharges, high water levels in the rivers, flooding, high soil water and groundwater levels in winter.
- The *dry climate scenario* (a 'low' scenario) results in the greatest problems with low river flows, low soil water and groundwater levels during dry summer periods. In the spring there may be somewhat higher groundwater levels.
- The *moderate climate scenario* (a 'middle' scenario) results in moderate results, both for high and low flows and wet and dry periods.

The natural variations in climate – the coincidence by which weather phenomena may occur over time – are also taken into account in this chapter. These variations are especially important in the analysis of extreme weather phenomena and their impact.

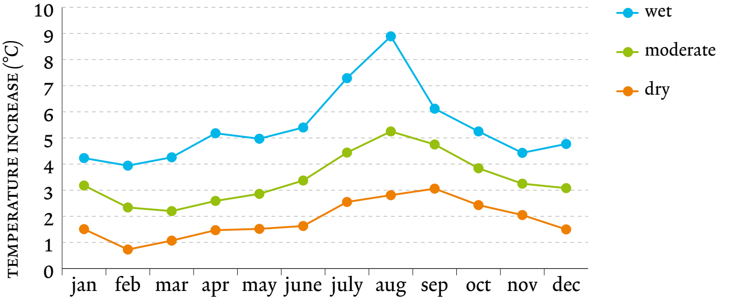
11.2 Climate scenarios for Flanders

Temperature

The three climate scenarios indicate that by the end of the 21st century Flanders will be significantly warmer over all the months of the year (FIGURE 11.1). How large the increase will be remains uncertain. For instance in January the ambient temperature rises, depending on the scenario, by 1.5 to 4.2 °C. In August the temperature may increase by 2.8 to 8.9 °C. For seasonal averages this would give an increase in the winter (December, January, February) by 1.5 to 4.4 °C and for the summer (June, July, August) an increase of as much as 2.4 to 7.2 °C.

Not only the average monthly temperature but also the temperature on the hottest and coldest days will clearly increase. The expected increase in the average day temperature for the 10 % coldest days is 1.5 to 6 °C in winter, and 2 to 5 °C in autumn (winter and autumn are the seasons in which this increase is the sharpest). For the 10 % hottest days this increase is sharpest in summer and ranges from 3.2 to 9.5 °C. This means that by the end of the 21st century there will be a lot more very hot days in the summer than during the summer in the 1961-1990 period. So far since the 1990s, the annual and seasonal temperatures

FIG. 11.1 *Increase of average monthly ambient temperature according to the three climate scenarios (Uccle, scenario period 2071-2100 compared to the reference period 1961-1990)*



and the frequency of heatwaves have also already significantly increased. The average annual temperature increased during the 20th century by about 2 °C (KMI, 2009).

Evaporation and precipitation

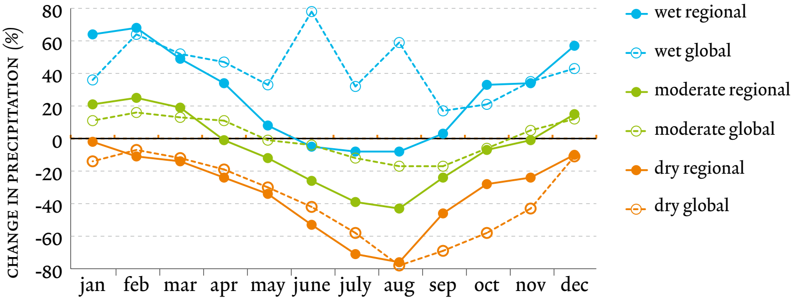
The level of evaporation increases as a result of the increase in temperature, both in the winter and the summer. For instance in February the increase of the potential evapotranspiration – an indicator of evaporation – is between -3 % and +37 % depending on the scenario and the calculation method. In August this evapotranspiration may increase by 73 %. In the spring some scenarios indicate an increase in evaporation while other scenarios indicate a decrease.

The precipitation will also increase in the winter. The changes to precipitation in the summer are more complex:

- The total amount of precipitation will probably decrease.
- There should be fewer showers.
- The heavy summer storms could be more extreme and more frequent.

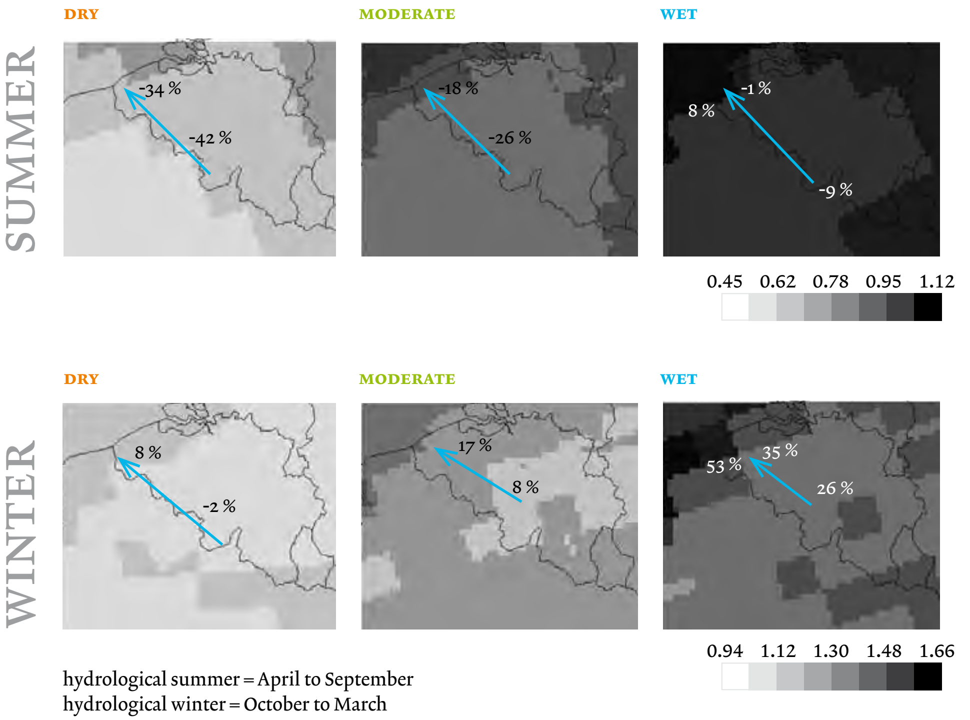
FIGURE 11.2 gives an overview of the changes to average monthly precipitation. Belgium belongs to the area where the global climate models indicate a larger spread in changes to precipitation than the regional climate models. This is the result of the larger set of emission scenarios available for global models. However, the calculations on the basis of regional climate models are geographically more precise. Simulation results from both global and regional climate models were therefore analysed. They indicate an evolution for Belgium to drier summers, although this picture is less clear in the global model results. These sometimes indicate a small increase in precipitation in the summer. The sharpest drop in summer precipitation is found in the dry climate scenario and for August. The average monthly precipita-

FIG. 11.2 *Change in the average monthly precipitation according to the three climate scenarios (Uccle, scenario period 2071-2100 compared to the 1961-1990 reference period)*



'Regional' relates to the results with regional climate models, 'global' relates to results with global climate models.

FIG. 11.3 *Regional differences for the average seasonal precipitation according to the three climate scenarios (Belgium, scenario period 2071-2100 compared to the 1961-1990 reference period)*



hydrological summer = April to September
hydrological winter = October to March
Results expressed as perturbation factors:
factor = 1 indicates no change;
factor = 1.2 indicates a 20 % increase;
factor = 0.8 indicates a 20 % decrease

tion would decrease by 76 to 78 % in relation to the current situation. Taking account of the major uncertainties this reduction may also be 17 to 43 % (moderate climate scenario), barely 8 % (wet climate scenario with regional models) or even result in an increase (wet climate scenario calculated with global climate models). The sharpest increase in precipitation is expected for January (from hardly any change to an increase by 64 %).

In addition to the average monthly precipitation the probability of occurrence of extreme precipitation events was also studied. More exceptional events may be subject to greater changes than small or average events. For instance for precipitation events that only occur once every ten years, the level of precipitation might be up to a factor of 2.5 higher than in the reference period. However, exceptional events are subject to greater uncertainty than the scenario results for the average monthly precipitation.

As mentioned above a significant increase is already noticeable in the average annual and seasonal ambient temperature and in the number of heat waves. An analysis of the measurements of the precipitation over a one hundred year period in Uccle shows that an increase is also already apparent in the number and intensity of extreme rain storms in winter (Ntegeka & Willems, 2008). Extreme rain storms are here defined as rain events that occur less frequently on average than ten times in a year. The result of the climate models is also in line with the trend already observed: the extreme daily precipitation in winter increases a few percent every ten years.

The historical data series does not yet show an increase in the number and extent of summer storms. The numerous, heavy summer storms over the last 15 years may consequently also be the result of natural fluctuations in climate over the North Atlantic and North Western Europe. Indeed, the same occurred in the decades 1910-1920 and in the 1960s (Ntegeka *et al.*, 2008).

The possible change in precipitation also shows minor regional differences within Belgium (FIGURE 11.3). In the coastal region the change is 10 % higher than inland both for the summer period and the winter period. For the summer this means that the decrease in precipitation is less strong in the coastal region (the future climate is closer to the current climate). In the winter an additional increase in precipitation of 10 % results in greater moisture in the coastal region.

Wind

The precipitation results have already shown that climate change will have an impact on the incidence of storms. However precipitation alone does not significantly define the damage that storms may cause, wind speed also plays a role. Calculations for the wet, moderate and dry climate scenarios show an increase in the average wind speed during the winter months. The wind speed would systematically be 10 to 20 % higher by the end of the 21st century compared to the 1961-1990 reference period. The results for the summer months do not give a clear picture.

11.3 Impact on high and low water in rivers in the Flemish inland: flooding and … water shortages

Rainfall run-off from river catchments

The simulation[2] of the wet, the moderate and the dry climate scenario until 2100 makes it possible to study the impact on high and low rainfall run-off discharges to rivers in Flanders. The wet scenario results in the most extreme impact for high flows and floods, the dry scenario in the most extreme impact for low flows and droughts. The conclusions for all rivers are along the same line:

- *Low flows in summer:* due to the significant decrease in summer precipitation and the increase in evaporation the flow will fall considerably. During dry summers the lowest river flows may drop by over 50 % (20 % on average in the least unfavourable scenario, 70 % on average in the most unfavourable scenario). As a result the frequency of water shortages may increase considerably, with possible detrimental consequences to industrial and household water consumption, shipping, agriculture, environmental conditions, river water quality, etc. Groundwater levels will also drop, resulting in similar problems.
- *High flows in winter:* the sharp increase in evaporation (both during the winter and the summer) compensates for the increase in winter precipitation to a great extent. As a result, the increase in the number and extent of floods (particularly along rivers in the winter) is relatively limited. Peak flows in the rivers will increase by a maximum of 35 % in the most unfavourable scenario. This increase could locally result in more frequent and more extensive flooding.
- *High flows in summer:* extreme summer showers could result in flooding of sewers and smaller watercourses. The majority of climate models predict an increase in the number (the frequency) and extent of heavy summer thunderstorms, so that an increase in the number of such floods is also to be expected. For the largest events

which currently occur once a decade, the average daily precipitation in the most unfavourable scenario increases by approximately 30 %.

The impact of climate change is not only highly seasonal but also extremely variable regionally. Climate models show a north-south variation in the precipitation and temperature change (Baguis *et al.*, 2009). In northern France, climate change will further strengthen the development towards desiccation, with a decrease in both summer and winter runoff volumes and consequently also a decrease in the number of floods. The probability of water shortage also increases in Flanders. The trend towards more floods is, however, still unclear. The increase in the number of floods is clearer to the North of Belgium, e.g. in The Netherlands.

Adaptation of sewer systems and urban retention basins[3]

In Flanders, sewers often do not only remove wastewater. Together with ditches and streams they are also often responsible for the removal of rainwater (precipitation). The peak drainage into the sewage systems, ditches and streams increases due to heavy precipitation. A precipitation intensity that in the current climate only occurs once every month and a half might occur monthly by 2100 under the wet climate scenario. A period of heavy precipitation that now only occurs once every two years would occur annually according to that wet climate scenario. The heaviest, short precipitation episodes (1 hour or less) that previously only occurred once a century might occur once a decade (Willems, 2009).

In the next decades climate change might result in a gradual increase in the number of sewer floods and overflows, resulting in a negative impact on the quality of the surface waters. To combat this, the (re)dimensioning of the sewers and ancillary structures such as urban retention basins, rainwater tanks, infiltration beds, green roofs, etc. have to take more intense periods of precipitation into account. Design values that have a return period for the overflow of the storage tank of two years according to the current approach would have a shortened return period of six months by the end of this century according to the wet climate scenario. The current design values with a five year return period will have a shortened return period of between one and one and a half years. The retention basins or storage tanks must consequently be given bigger dimensions due to climate change or additional provisions will be necessary for storing the rainwater and/or allowing it to infiltrate in the subsoil. In order to retain the same overflow return period, the storage volume must increase by 15 to 35 % according to the wet climate scenario compared to current practice. Another option is to use the existing storage capacity in a more optimal way by real-time control mechanisms.

It is still highly uncertain how future climate change will be felt. The wet climate scenario differs indeed strongly from the dry climate scenario and the actual uncertainties could be even greater. For that reason it is not advisable to design future sewer and storage systems and water management measures already now and at large scale according to the most pessimistic climate scenarios. However, new designs should best take account of the potential future climate change. This is possible through adaptive designs that allow the realisation of additional storage and pumping capacity with the lowest possible cost if it should become clear that the climate is moving in the direction of the wet climate scenario.

Moreover, the changing climate and its impact on the sewer systems must be seen in the broader context of the impact on the entire water system. If the variation in precipitation increases (more precipitation in a shorter time span, lower total precipitation volumes in summer) it is best to look for changes that combat the impact on the water balance. Additional storage and infiltration provisions for rainwater make it possible to limit both the risk of flooding during heavy showers and to decrease the expected increase in water shortages. An example of an effective and cheap measure is the careful installation of local depressions in public land (e.g. in parks), that can hold a lot of water temporarily and without much damage. This measure moreover ensures that the water stored infiltrates into the ground after the rainy period and thereby directly contributes to combating the dry-out of soils and groundwater resources. These types of measures require good coordination between urban planning and water management.

A revision of the Flemish guidelines for the design of sewer systems (current guidelines date from 1996) is necessary. Not only the precipitation statistics used to draw up the designs require updating, but the management choices for the drainage of rainwater from public roads, the separation of rainwater and wastewater and the issue of the quality of the rainwater draining away must be revised.

Flooding translated into economic risk

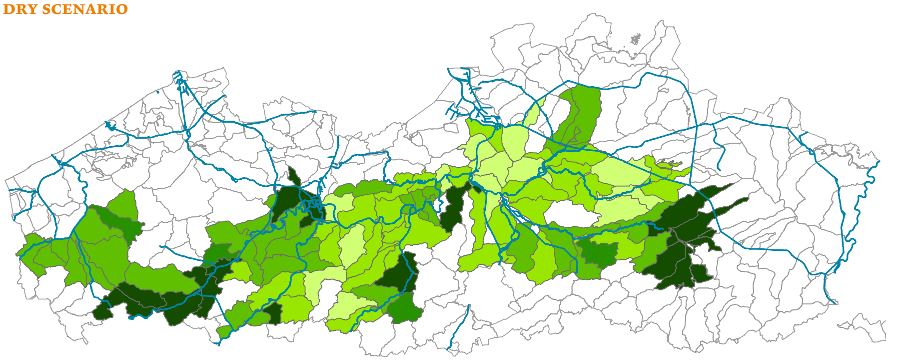
The impact of climate change on high and low river flows are further converted[4] into the possible economic risk as a result of flooding. This risk of flooding is described as the average expected damage per surface and time unit, expressed in euro per m^2 and per year. The damage at a specific location is thereby primarily defined by the land use and the local socio-economic context (housing prices in a specific municipality, yield from arable land, price of agricultural produce, vehicle prices, etc.). Densely built-up areas will suffer greater damage than pasture in the same flood; nature areas would not even suffer any financial damage from the same flood.

FIGURE 11.4 shows the ratio of the risk under a climate scenario with the current risk per zone from the Flemish Hydrographical Atlas (VHA-zone). Green indicates a drop in the risk of flooding, red indicates an increase in the risk.

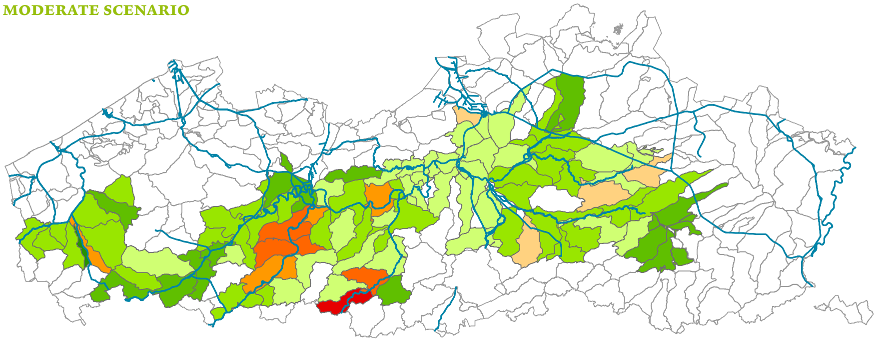
In the dry climate scenario the risk decreases strongly for all basins in Flanders. The total risk for the modelled part of Flanders has consequently also fallen

FIG. 11.4 *Evolution of the risk of flooding with the current land use as a result of the three climate change scenarios by 2100*

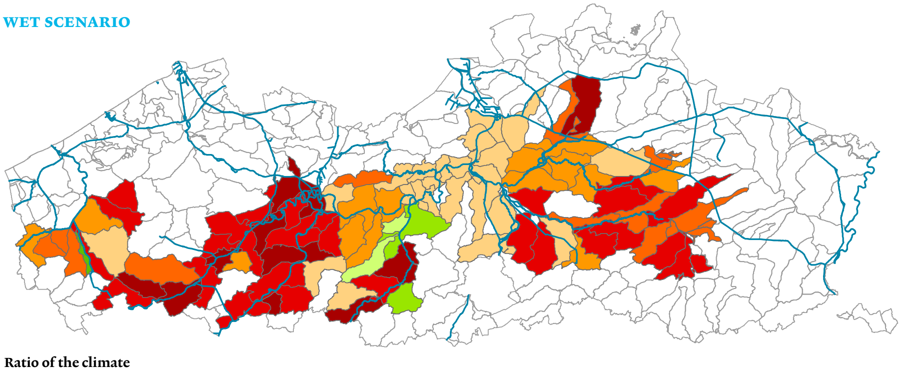
DRY SCENARIO

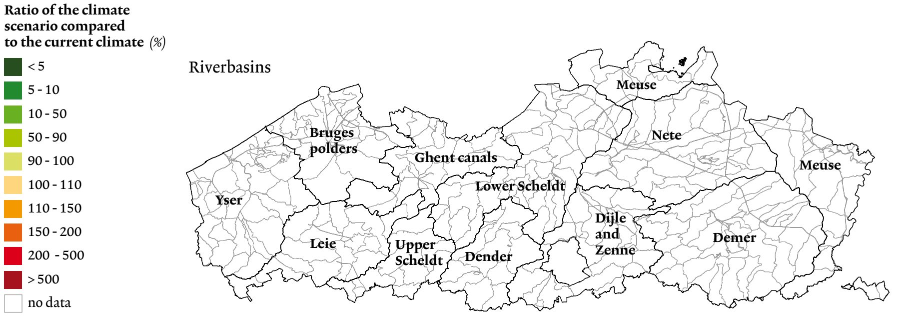


MODERATE SCENARIO



WET SCENARIO





Values expressed as a comparison of the risk in 2100 following a climate scenario with the current risk. 100 % indicates no change between 2005 and 2100.

New: flood risk management plans

The European Floods Directive of 2007 obliges member states amongst other things to draw up flood risk management plans (FRMP) by the end of 2015. Those FRMPS include measures for the reduction of potential adverse consequences of flooding for human health, the environment, cultural heritage and economic activities.

The FRMPS contain a lot of new elements in relation to the traditional approach to flood risks. For instance what flood risks the water manager must still protect will be defined. At places where flooding occurs too frequently, the risks must be managed with instruments from urban planning (e.g. by moving buildings). In the case of too extreme flooding the private insurance system and the Disaster fund must cover the risk. In the future the probability analysis of floods in the FRMPS will only be based on climate and land use scenarios for the coming decades and consequently no longer on the precipitation statistics of the previous decades.

The eleven Flemish basins will each be given a FRMP. This planning process started in the spring of 2009 and will run for four years. By September 2011 all risk analyses will have been completed and a broad range of possible sets of measures will be presented. The optimal sets will be selected from these via a broad social consultation, which will run together with the consultation on the drafting of the new basin management plans. This selection will be realised on the basis of a costs and benefits analysis. Spreading the costs and the benefits over the stakeholders involved (water managers, urban planners and insurers) will also play a role.

sharply (56 % lower than the risk in the current situation). The drop is particularly pronounced primarily in the Demer (-84 %) and Yser basins (-72 %). This is a direct result of the fact that the peak drainage into the watercourses in the dry climate scenario and consequently also the flooding areas are much smaller than in the current situation. Naturally this drop is not homogeneous everywhere in a river basin.

In the moderate climate scenario there is still a drop at the Flemish level (-8 %) when compared to the current situation, albeit of a different order of magnitude than in the dry scenario. However the risk increases both in the Upper Scheldt basin and within individual VHA-zones in other basins.

There is an increase in the risk for all basins in the wet climate scenario. At the Flemish level the increase in risk is 33 %. The Leie, Upper Scheldt and Demer basins particularly experience a very sharp increase in the risk by a factor of 2 to 3. For the Lower Scheldt and tributaries the increase is minimal: the risk would only increase strongly along the Nete and the Dijle.

Climate change clearly impacts the risk of flooding. However the frequency of flooding and furthermore the probability of damage, depends to a great extent, in densely built-up Flanders, on urban planning. To verify the extent by which the urban development within Flanders influences the possible effects of climate change, in addition to the risks of flooding with the current land use, the risk of flooding with two land use scenarios was calculated as described in Chapter 10, Land use. The built-up area increases in both scenarios, but is greatest in the reference scenario

(REF). In the European scenario (EUR) the additional built-up area is assumed to be smaller and the population density for each built-up area increases. Urbanisation primarily develops at the expense of pasture and arable land, which has lower flood damage per unit area. The nature and woodland area, for which the financial damage in the case of flooding is negligible, then progresses in both scenarios. In the land use scenarios changes in the land use were only calculated until 2030. Between 2030 and 2100 the land use is assumed to be unchanged for the calculation of the risk of flooding.

TABLE 11.1 shows the extent by which changes in the land use and climate result in a deterioration (red background) or improvement (green background) in relation to the current risk of flooding in Flanders. The following is clearly apparent from this:

- In the moderate and particularly in the dry climate scenario the risk of flooding decreases by 2100 both in the current land use and the land use under the REF scenario and the EUR scenario.
- There is hardly any difference for Flanders in the risk of flooding between the EUR scenario and the current land use. Unlike the REF land use scenario, the population increase and the corresponding housing needs in the EUR scenario are consequently absorbed without any additional increase in the risk of flooding.
- The most unfavourable combination for the risk of flooding consists of the REF land use scenario combined with the wet climate scenario.

TAB. 11.1 *Risk of flooding* with a dry, moderate and wet climate scenario compared to the current risk of flooding with different land use scenarios** (Flanders, 2100)*

*(Ratio*** in %)*	RISK IN 2100 WITH A LAND USE IDENTICAL TO THAT OF 2005			RISK IN 2100 WITH A LAND USE ACCORDING TO REF			RISK IN 2100 WITH A LAND USE ACCORDING TO EUR		
	Dry	Moderate	Wet	Dry	Moderate	Wet	Dry	Moderate	Wet
Demer	16	61	213	14	63	234	12	53	204
Dender	61	86	123	61	86	128	60	85	129
Upper Scheldt	50	134	266	50	138	279	50	136	274
Lower Scheldt and tributaries	40	93	104	41	93	104	40	92	103
Yser	28	64	134	34	81	221	30	67	140
Leie	44	79	283	88	143	377	52	95	322
Flanders	44	92	133	46	96	143	44	92	136

* solely as a result of the changing precipitation and evaporation. The changing sea level is not taken into consideration here.
** The effect of the changing land use is only taken into account in the definition of the possible economic risk. The effect of the changing land use on infiltration and drainage of rainwater could not be calculated.
*** Ratio: current situation with the land use of 2005 and 2005 climate is equal to 100 %.

With the REF land use scenario, the level of risk rises slightly under the three climate scenarios at the Flemish level compared to the scenarios with the current land use: from 44 to 46 with the dry climate scenario, from 92 to 96 with the moderate scenario and from 133 to 143 with the wet scenario. This is a direct result of the fact that there will be a larger built-up area under the REF land use scenario (both housing and industrial sites) in the flood plains. There is a high increase in the risk for all climate scenarios by 2100 especially in the Yser and Leie basins. The cause of this is an increase in urban development and industry in the flood plains to the detriment of the agricultural sector (pasture and arable land). In the Demer basin there is still a fall in the risk under the dry climate scenario. This is due to the decrease in arable land in the flood plain to the benefit of a nature area. In the moderate and especially the wet climate scenario the risk of flooding does increase here caused by the conversion of arable land into built-up land. In the other basins there is always a status quo in the three scenarios or a slight increase in the risk. The increase in the built-up area in the flood plains to the detriment of agricultural land is less strong than in the basins previously mentioned. Furthermore part of the agricultural land is then transformed into nature, which decreases the economic risk.

If the land use evolves according to the EUR scenario, it is apparent that the risk of flooding in the three climate scenarios hardly changes in relation to the current land use. The increase in built-up areas in the flood plains is limited in this land use scenario. And where there is a small increase in urban development, this is compensated by an increase in nature to the detriment of agricultural land in the flood plains. Regional differences again show higher increases in the risk for the Demer, Yser and Leie basins here. In the Demer basin a sharp fall in the risk can be noted by 2100 both in the dry and moderate scenario. The reason for this is a decrease in the arable land and the urban development in the flood plains to the benefit of nature. In the Yser basin there is again an increase in the risk in relation to the risk with the current land use in all climate scenarios but the increase is considerably less than in the REF scenario. Where a lot of grassland was transformed for urban development and industry in the REF scenario, this is not the case here. The level of industry remains constant and the level of urban development even drops slightly. A lot of grassland is transformed into arable land however which consequently means that there is still a slight increase in risk. The risk also increases in all scenarios in the Leie basin due to the conversion of the agricultural land into urban development.

Damage due to water shortages

In addition to damage due to flooding it is also important to consider damage due to water shortages. In every climate scenario for Flanders the frequency of low flow or drought periods increases and these periods become more extreme. The development towards drier and hotter summers combined with changes in the intensity of the precipitation will have a particularly negative impact on the quality and availability of the ground and surface waters and consequently also on the supply of drinking water. Climate change not only impacts the supply but also the demand for drinking water: in periods of great drought the peak consumption will increase. An analysis in Flanders shows indeed that peaks in the maximum temperature measured coincide with peaks in the daily consumption of drinking water (Peeters & Tops, 2009).

The damage in periods of drought will – as with flooding – depend on the ability of individual businesses and agriculturists to adapt. The priority the social interest places on water capture by the various parties involved (shipping, agriculture, nature, power supply, drinking water, etc.) is also important. Unlike with flooding, the spatial definition of the damage due to drought is much more difficult to assess. That damage strongly depends on the duration of the water shortage period. Furthermore systematic figures on interruptions to the water supply are currently not kept in Flanders.

11.4 Impact of climate change on the sea and the impact on the coastal region

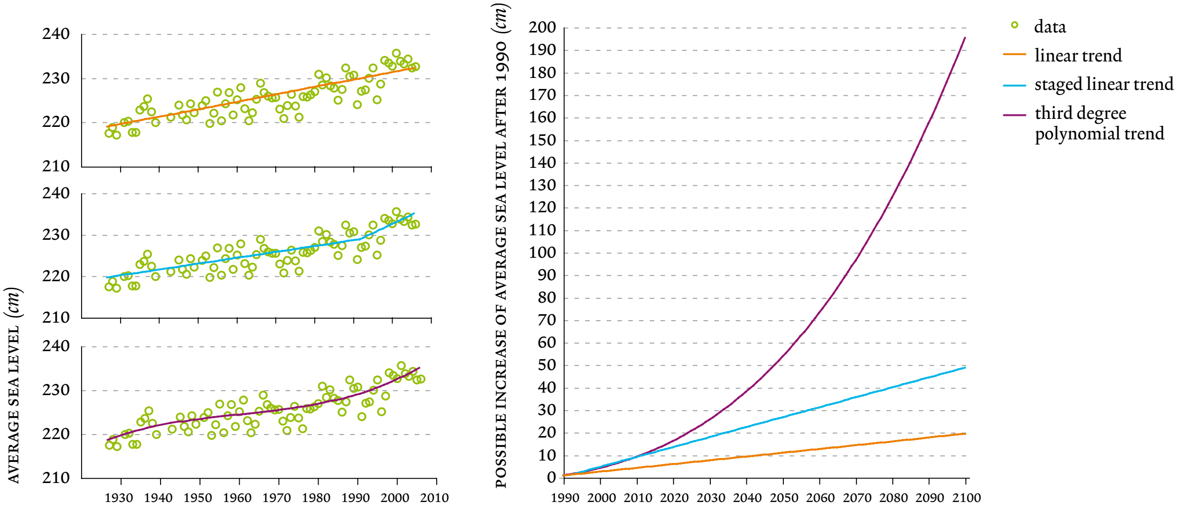
Sea level

The sea level in Ostend has risen on average by 1.69 mm/year since 1927. This rise fits closely to the global average which the IPCC derived for the 20th century (1.7 mm/year). Measurement series which started later at the Flemish coast, show even higher values. This indicates an acceleration of the rise in sea level. This is confirmed by regression analysis of the Ostend series of measurements: for instance a staged linear profile results in a kink in 1992. The increase was 1.41 mm/year on average between 1927 and 1992, but already 4.41 mm/year between 1992 and 2006. Extrapolation of the historical trend shows a further rise in the sea level for the Flemish coast, depending on the relations applied, of 20 cm to 200 cm for the period from 1990 to 2100 (FIGURE 11.5).

Temperature of the seawater

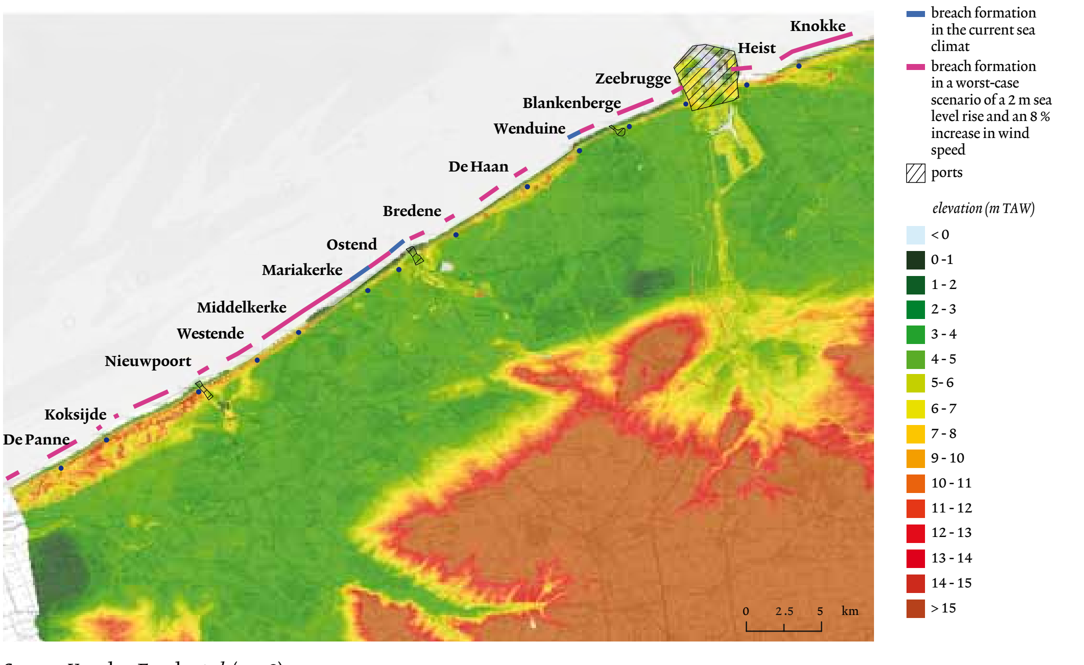
Together with the drainage of melting land ice to the sea, the thermal expansion of seawater is the main cause of the sea level rise already observed. The temperature affects the density of the water and consequently also the currents and sea level. In addition the temperature also affects the solubility of CO_2 in seawater and is thereby connected to the composition of the atmosphere. The temperature of the seawater is rising in all sub-regions of the North Sea (not only the Belgian part of it). Fur-

FIG. 11.5 *Trend analysis of the sea level measured (Ostend, 1927-2006) and extrapolation to a possible sea level rise in the period 1990-2100*



Source: Ozer *et al.* (2008), Van den Eynde *et al.* (2008)

FIG. 11.6 *Location of breaches due to erosion of beach and dunes in the event of a super-storm that occurs once every 17 000 years, both in the current sea climate and in a worst-case scenario by 2100*



Source: Van den Eynde *et al.* (2008)

thermore there appears to be a natural variability with a period of 7 to 8 years. The increase in the temperature of the seawater is between 0.023 °C/year (in the northern North Sea) and 0.053 °C/year in the central and southern North Sea. In the area closest to the Flemish coast the increase is about 0.034 °C per year or 3.4 °C per century.

Wave height and wind speed at sea

As regards wave height, the historical data series in and near the Belgian part of the North Sea shows a natural variation with a period of around seven years. There is also a seasonal cycle: there are higher waves on average in the winter and lower waves in the summer months. A clear climate trend could not yet be shown in the historical series of measurements of wave heights and wind speeds. However due to the expectations of a changing wind climate in the 21st century (see above), the frequency and size of the wind waves could change on the North Sea – and consequently also the likelihood of high water along the Flemish coast and in the Scheldt. Those wind waves may thereby result in an additional increase of coastal level maxima.

Impact on the coastal region

The flood risks are influenced along the coast by the sea level rise and the change in wind with the corresponding wave climate. The most unfavourable scenario for the Flemish coast assumes a sea level rise by two metres and 8 % increase in wind speed by 2100. This sea level rise is comparable to the upper limit scenario given by the Delta commission in the Netherlands: two to four metres sea level rise by 2200.

The wave load on the coast and sea defences increases significantly in any scenario. This relates to the increased water depth as a result of the sea level rise. Because high water rises faster and low water rises slower than the mean sea level, the semidiurnal tidal range (i.e. the difference between high and low tide) would also increase. The increase in the wave load and the semidiurnal tidal range would cause more erosion of the beaches and dunes. It would also increase the corresponding frequency of breach formation (the breaking through of a dike or natural dune belt). In the event of a super-storm that occurs on average once every 17 000 years, a breach formation is only expected in the current climate in Wenduine, Ostend and Mariakerke (excluding the coastal harbours). In the future climate, in the most unfavourable scenario and without measures, breach formations may develop over almost the entire coastline by 2100 (FIGURE 11.6).

The current coastal management designs sea defences in such a way that a storm that only occurs once every 1 000 years would not cause significant damage and has very limited likelihood that breach formation would occur. The return periods, used for a flood protection along the coast, are generally many times greater than those for watercourses not bound by tides. The coastal defence must indeed be resistant to more extreme conditions. If it goes wrong, the consequences are after all many times greater than if a river would burst its banks. Currently the Agency for Maritime Services and the Coast of the Flemish Government is developing a master plan for the coastal zone: the Integrated Coastal Safety plan 2010 (Geïntegreerd Kustveiligheidsplan 2010). Based on risk assessments of different water levels and storms, measures are being developed based on an economic analysis of costs and benefits. This plan is intended to protect the coastal region in an acceptable way until 2050. Measures will be chosen to allow them to be effective in any potential climate scenario and adapted to maintain an acceptable level of safety even after 2050.

High water levels along the coast result in a higher risk of flooding along the tidal influenced part of the Scheldt. In the current climate, flooding between Vlissingen and Ghent occurs on average every seventy years, which corresponds to a high water level in Antwerp of 7.83 m TAW. After the realisation of the controlled flood plain of Kruibeke-Bazel-Rupelmonde[5] this probability drops to once every 350 years, which corresponds to a high water level in Antwerp of 8.24 m TAW. With a middle scenario of a 60 cm rise in the sea level by 2100 and if no further measures would be taken the risk of flooding would again rise to the current probability of once every 70 years by 2050 and even once every 25 years by 2100. Furthermore there is still the combined impact of the rise in the sea level and the increased flows upstream caused by the changing precipitation, which could play a major role in the Sea Scheldt region between Ghent and Antwerp. This emphasises the importance of realising the fully updated Sigmaplan to control the risk of flooding and achieving the nature objectives in the Sea Scheldt basin. In addition to the installation of controlled flood plains that plan also includes raising the dikes in cities and industrial regions.

11.5 Conclusions for policy

General

The uncertainty concerning future changes in temperature and precipitation means that the impact of climate change on the water system cannot be established conclusively. However that is no reason to delay adaptation measures: these are initiatives by which Flanders can adapt to climate change.

Under the assumption that few measures are taken solely and exclusively to overcome the consequences of climate change, it is clear that the measures proposed must be efficient and effective, regardless of the primary reason for them being carried out and independently of the climate scenario chosen. The effects of climate change on flooding could evolve in different ways for Flanders. Even if the future would evolve more in the direction of the dry climate scenario, measures must be useful and justified. On the other hand if the climate should develop according to the wet climate scenario in the future, it must be possible to adapt, adjust, accelerate and intensify the measures en route. It is also important to stress that such focus on adaptation planning should not diminish our efforts to limit our emissions of greenhouse gases (mitigation measures).

Instead of avoiding flooding insofar as possible the management will have to increasingly focus on limiting the risk of flooding. Areas where the potential damage is great (residential areas, industrial areas) will thereby be protected to the prejudice of areas where the potential damage is small or non-existent (pasture, nature areas) or where it can even be turned into a win-win situation for functions like nature conservation and recreation. Additional efficient measures are conceivable, e.g. a warning system that tells residents how they can get themselves and their valuables to safety in time in the event of a threatening flood. In addition a policy is required that works against new homes and infrastructure being built in flood plains or makes them adapted to flooding. Water survey linked to spatial planning is a useful instrument to support that policy.

Inland adaptation

Currently adaptation measures for water management generally come down to a limitation of the likelihood of flooding by means of structural interventions. In addition the Flemish government is also developing flood predictors to allow the timely anticipation to potential floods. Considering the diverse effects of the various climate scenarios for Flanders, measures will mainly count in the future if they can offer a response both to flooding and water shortages. Whether a measure is adaptable and useful in different circumstances will determine whether that measure makes a substantial contribution in the adaptation to climate change. An example of this kind of measure is the creation of controlled flood plains along rivers. These plains can reduce the risk of flooding upstream or downstream and could possibly allow the temporary storage of water for use in agriculture in the event of a drought. Other examples include provisions for the storage and infiltration of rainwater in urban areas. These limit the rainwater draining into the sewer system and simultaneously supplement the groundwater. The stimulation of the reuse of purified wastewater is also a possible measure.

Coastal adaptation

The main adaptive measures for the coastal area are raising and broadening the beach through the supply of sand or the reinforcement of the dune bases through planting. These measures could be adjusted at the five-yearly maintenance according to the expected sea level rise. Other possible measures could include constructions to combat erosion for example (such as groynes or break-waters) or to damp waves.

Recommendations

Public authorities have an important role to play in raising awareness amongst the population and in the adequate adaptation of the infrastructure which it manages in order to overcome the consequences of climate change, regardless of the future scenario which will ultimately prove to be the closest to reality. The communication on interventions that might limit the probability of damage due to climate change and the involvement of all relevant stakeholders in drawing up the plans are necessary in this. The public authorities can also direct policies on urban planning to reduce the consequences of flooding and water shortages. The development of a long-term vision and permit policy (such as building and environmental permits) that does not mortgage the future situation desired is crucial for this. One of the supporting instruments for this would be drawing up a climate adaptation plan by 2012. The European Water Framework Directive and the directive on the assessment and management of flood risks (Floods Directive) oblige member states to draw up management plans that must show that account is taken of the possible consequences of climate change.

Other groups also play an important role in the adaptation to climate change: (re)insurers (e.g. through targeted financial incentives), drinking water companies (e.g. by encouraging rational water consumption and guaranteeing the availability of drinking water), power producers (e.g. by safeguarding energy production) ... It should not only be emphasised here that limited adaptive measures now could avoid excessive costs in the future. It should also clearly be stated what measures would be relevant in concrete cases. This includes short-term actions (e.g. knowing where current information is available on flooding or water shortage in a specific region) and long-term actions (e.g. for rebuilding/renovations).

The impact studies for Flanders clearly show that in addition to flood management, sufficient attention must also be paid to the threat of water shortages. There is currently insufficient attention to these shortages amongst others because they develop gradually and are consequently less visible and more indirect. Low water problems might become more important in this century than the problem of flooding. The government can also give direction in the limitation of the consequences of droughts. Examples include the development of regulations on water capture, standardisation and economic instruments such as water price management in relation to rational water consumption.

END NOTES

1 Water vapour (H_2O) is the main greenhouse gas but its presence in the atmosphere is mainly the result of natural phenomena. It is of little importance when considering the human role in the warming of the Earth.
2 Solely the impact of the potential future climate change was verified. Future changes in land use were not taken into consideration here – unlike in the translation to economic damage.
3 Climate change may influence the quality of the surface water in various ways (e.g. via increased sewer overflows but also due to lower flows in the rivers, higher water temperatures, etc.). The effect on water quality due to an increase in the water temperature is modelled in the 'Surface water quality' chapter.
4 This was only possible for the 67 sub-basins (VHA-zones) and corresponding watercourses in the Flemish inland for which models were available from the Hydraulics Laboratory of the Flemish Government. This primarily relates to navigable watercourses (i.e. large and more downstream watercourses) but also upstream sub-basins as these supply the navigable watercourses.
5 Tentative forecasts state that the area will be ready for commissioning in 2011 (www.gogkbr.be).

LIKE TO KNOW MORE?

If you would like to know more, please consult the scientific report on which this chapter is based:

Willems P., Deckers P., De Maeyer Ph., De Sutter R., Vanneuville W., Brouwers J. & Peeters B. (2009) Climate change and water management. Scientific report, MIRA 2009 & NARA 2009, VMM, INBO, www.milieurapport.be and www.nara.be. (in Dutch)

This chapter is based on the following research projects amongst others:

Research project ADAPT 'Towards an integrated decision tool for adaptation measures - Case study: floods', for Belgian Federal Science Policy Office, Research programme Science for a Sustainable Development, executed by ULB-CEESE, Arcadis Ecolas & UGent , UA-ECOBE, K.U.Leuven-HIVA and ULG-HACH; http://dev.ulb.ac.be/ceese/ADAPT/home.php .

Research project CCI-HYDR 'Climate change impact on hydrological extremes along rivers and urban drainage systems', for Belgian Federal Science Policy Office, Research programme Science for a Sustainable Development, executed by K.U.Leuven – Hydraulics Division and Royal Meteorological Institute of Belgium; http://www.kuleuven.be/hydr/CCI-HYDR.

Research project CLIMAR 'Evaluation of climate change impacts and adaptation responses for marine activities', for Belgian Federal Science Policy Office, Research programme Science for a Sustainable Development, executed by the Management unit of the Mathematical Model of the North Sea, Arcadis Ecolas, UGent, Flanders Hydraulics Research, the Institute for Agricultural and Fishery research and the Maritime Institute of UGent; http://www.arcadisbelgium.be/climar/.

Research project 'Actualisation and extrapolation of the design guidelines for sewer systems (in Dutch: Actualisatie en extrapolatie Code van Goede Praktijk voor ontwerp van rioleringsstelsels)', for Flemish Environment Agency, executed by K.U.Leuven – Hydraulics Division.

Research project 'Adaptation options for the Flemish agricultural sector (in Dutch: Adaptatiemogelijkheden Vlaamse Landbouw)', for the Flemish Department of Agriculture & Fisheries, Monitoring & Study department, executed by K.U.Leuven – Bioengineering faculty.

Research project 'Impact of climate change on high and low flows and on water availability along Flemish rivers (in Dutch: Effect van klimaatwijzigingen op afvoerdebieten in hoog- en laagwatersituaties en op de globale waterbeschikbaarheid)', for Flanders Hydraulics Research (WL) of the Flemish Authorities of Belgium, executed by K.U.Leuven – Hydraulics Division.

Research project 'Climate scenarios for Flanders (in Dutch: Klimaatscenario's voor Vlaanderen)', for the Flemish Institute for Nature and Forest Research (INBO), executed by the Royal Meteorological Institute of Belgium, K.U.Leuven – Hydraulics Division and the Dutch Royal Meteorological Institute (KNMI).

Research project SUDEM-CLI 'The impact of climate change on river hydrology and ecology: case study for interdisciplinary research', for Belgian Federal Science Policy Office, Research programme Science for a Sustainable Development, executed by UA, K.U.Leuven and UCL.

Research project 'Flood damage and risk calculation for MIRA (in Dutch: Risico op schade door overstromingen for MIRA)', for the Flemish Environment Agency, executed by UGent, Geography Research Group.

Project SAFECoast, for Interreg IIIB North Sea, (for Flanders) executed by Flanders Hydraulics Research and the Coast Unit; http://www.safecoast.org/.

Research Training Network SeaMocs 'Applied stochastic models for ocean engineering, climate and safe transportation', for the European Commission, (for Belgium) executed by the K.U.Leuven and KNMI; http://www.maths.lth.se/seamocs/.

Willems P., 2009. Actualisation and extrapolation of the Flemish design guidelines for sewer systems (in Dutch: Actualisatie en extrapolatie van hydrologische parameters in de nieuwe Code van Goede Praktijk voor het Ontwerp van Rioleringssystemen). Final report for the Flemish Environment Agency, Operational Water Management Division, executed by K.U.Leuven – Hydraulics Division, 79 p.

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Van den Eynde D., Ponsar S., Ozer J., Francken F., 2008b. Bepaling van de primaire impacten van globale klimaatsveranderingen. Presentation at the Workshop 'Crisis in de visserij: keert klimaat het tij?', 9 December 2008, ILVO, Oostende.

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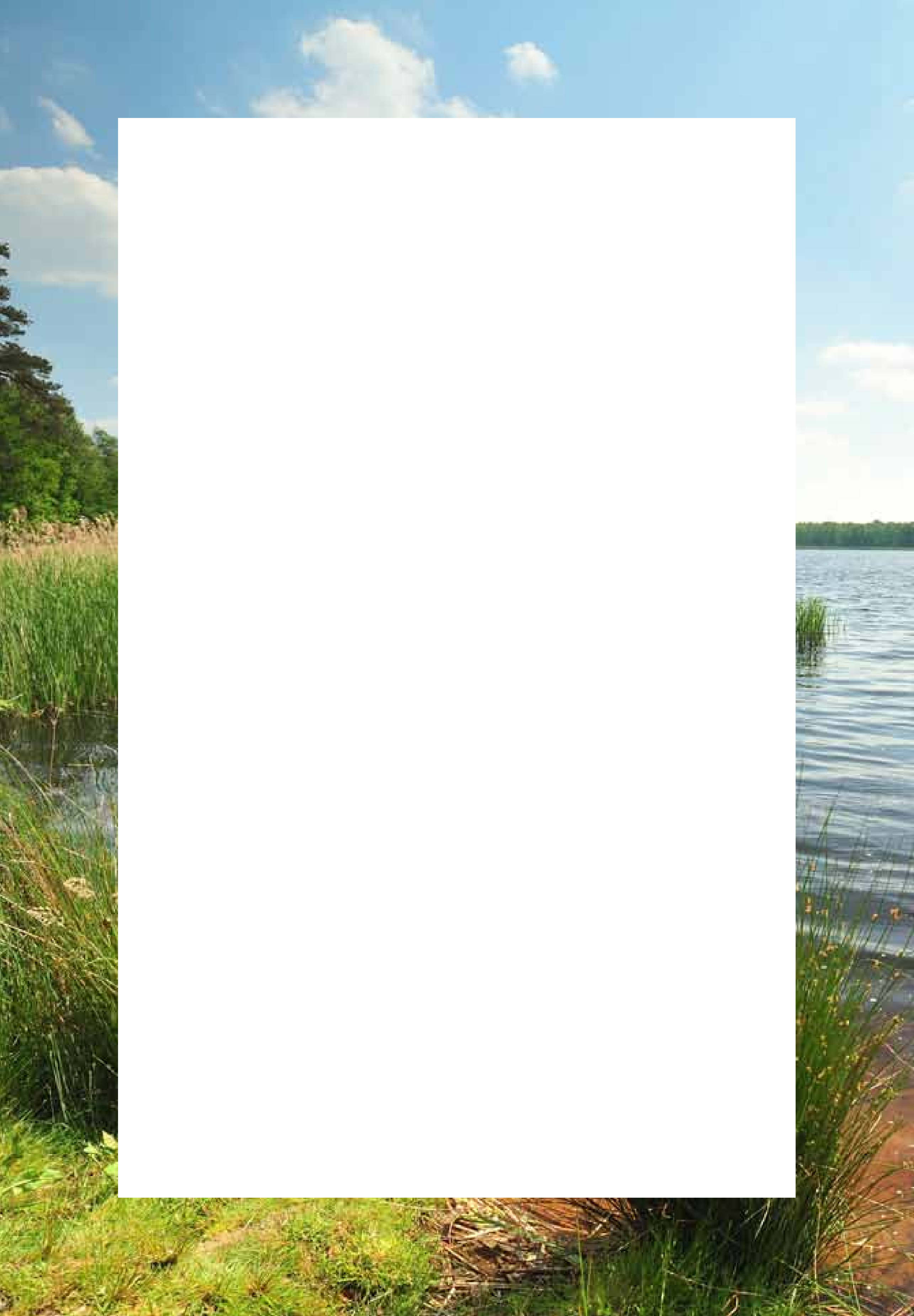

12 Surface water quality

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OUTLINES

- In the reference scenario (REF scenario), which is based on the current and fixed measures, the pollutant loads to the surface water decrease in 2015 by a maximum of 23 % compared to 2006. In the Europe scenario (EUR scenario), which takes supplementary measures into account, the maximum decrease is 49 % in 2027. The further expansion and improvement of public waste water treatment infrastructure plays the largest role in both scenarios.

- Those reductions in the pollutant loads are linked to clear improvement in the oxygen and nutrient management in the water bodies modelled. However the results of the model show that only a few of those water bodies fulfil all the standards for the modelled variables, even in the most far-reaching scenario. Especially phosphorous remains problematic.

- The improved physical-chemical water quality has a positive effect on the biological quality (macro-invertebrates). In the REF2015 scenario there are mainly shifts in the modelled water bodies of a poor to moderate quality, in the EUR2027 scenario from a moderate to good quality. However even in the most far-reaching scenario slightly less than 60 % of the water bodies achieve a good biological quality.

- In order to support the debate on how far Flanders can and must go to comply with the requirements of the European Water Framework Directive (WFD), the knowledge and modelling of the water system must be improved and expanded. This then mainly relates to other substances (e.g. hazardous substances), other biological quality elements (e.g. fish, water plants) and the impact of measures that improve the hydromorphology (e.g. re-meandering). Developing the economic foundation of the measures is also necessary.

Introduction

The improvement of the water quality has been a major component of the Flemish environmental policy for many years, not least inspired by the European directives including the Urban Waste Water Directive. The WFD was added to this in 2000, which is intended to bring the surface water (and groundwater) to a 'good status'. For the surface water this means both having a good chemical and a good ecological status. One of the obligations of the WFD is the formulation of river basin management plans, including measures to achieve those targets. A distinction is made there between the basic and supplementary measures. Basic measures include current or effectively planned measures. The additional measures required on top to achieve the targets constitute the supplementary measures. (CIW, 2009a).

A long and intensive consultation process within the Coordination Commission Integrated Water Policy (CIW) preceded the programme of measures of the draft river basin management plans (CIW, 2009b). For that reason the measures for improving the quality of the surface water have been taken from the draft for the river basin management plans. The reference scenario (REF) includes the basic measures, the Europe scenario (EUR) implements the supplementary measures. The scenario analyses have been developed further here (e.g. population forecast, calculations for biological quality), without affecting the measures themselves. The results of the scenario analyses are also analysed and discussed in more depth. As regards biological quality, this chapter focuses on macro-invertebrates. Fish are central in the Nature Outlook 2030, in which, in addition to the water quality, the approach to fish migration barriers is also taken into account.

This chapter starts with an overview of the content of the scenarios and a short discussion of the models for the scenario analysis. The DPSIR framework is followed in the discussion of the scenario results: the pollutant loads that end up in the surface water are first considered, then the effects of the physical-chemical water quality and subsequently the consequences to biological quality and the costs of the measures. Finally the main conclusions for policy are again highlighted.

12.1 Principles of the Environment Outlook

Scenarios

A scenario is a package of measures for which the possible effects are calculated and discussed. The interpretation of the scenarios is realised on the basis of the draft river basin management plans. Naturally numerous other combinations of measures are possible. The reference year for the scenario is 2006.

The REF *scenario* is calculated with the target year 2015 (REF2015). The following additional measures are modelled in the REF2015:

- The public waste water treatment infrastructure is extended and improved through the implementation of the investment programmes until 2005:
  - connection of households to the public treatment infrastructure;
  - connection of collectors to waste water treatment plants (WWTPs);
  - building additional WWTPs;
  - improvement of removal rate of WWTPs.
- Companies comply with IPPC, BAT standards and the sectoral standards through the introduction of techniques. If those techniques do not suffice to meet specific standards, an attainable concentration of the waste water was estimated.
- The Manure decree is implemented in the agriculture sector.

The EUR *scenario* is calculated for the target years 2015 and 2027 (EUR2015 and EUR2027). The measures in EUR2015 are proposed to be executed in the context of the first generation river basin management plans. The following additional measures are modelled in the EUR2015 on top of the measures from the REF2015:

- The public waste water treatment infrastructure is extended and improved through the introduction of the optimisation programmes until 2009. The Vlarem legislation for the WWTP removal rates is applied without exception.
- Industry fulfils the standards of the European Urban Waste Water Directive.
- Agriculture:
  - fertilizing according to a fertilizing recommendation;
  - sowing grass buffer strips between fields and watercourses;
  - optimising sowing of winter green cover.

The EUR2027 scenario takes the anticipated population growth into account and, in addition to the measures of the REF2015 and EUR2015, also contains the following extra measures:

- implementation of the optimisation programmes after 2009;
- connection of the remaining sewage system to WWTPs;
- connection of households where no sewage system is yet provided to a WWTP or to an individual waste water treatment system (complete execution of zoning plans);
- optimising the sewage system (lower leakage losses);
- improving the connections of households to the sewage system;
- Agriculture:
  - increasing milk production of dairy cattle per ha coarse feed;
  - improving the feed efficiency for porkers and poultry;
  - application of non rotating soil processing on potentially erosion-sensitive fields;
  - decreasing the cattle stock through government incentives .

Two other variants to the EUR2027 scenario are modelled. The EUR+2027 scenario additionally imposes that watercourses running into Flanders must fulfil the water quality standards. The EURT2027 scenario verifies the effect of an increase in water temperature by 1 °C.

This serves as a first, albeit incomplete analysis of the possible effect of climate change on water quality. TABLE 12.1 gives an overview of the scenarios modelled and the link with the scenarios from the river basin management plans.

TAB. 12.1 *The scenarios in MIRA and the river basin management plans (RBMP)*

MIRA	RBMP	forecast year	content
2006	reference year	2006	
REF2015	basic scenario	2015	fixed policy
EUR2015	additional scenario, phased	2015	REF2015 + measures proposed to be carried out in 1st RBMP
EUR2027	additional scenario	2027	EUR2015 + all additional RBMP measures
EUR+2027	maximal scenario	2027	EUR2027 + cross border water courses meet the Walloon/French standards
EURT2027		2027	EUR2027 + increase in water temperature

From pollutant loads to water quality

The measures selected take action on the pollutant loads to the surface water – in other words on the pollutant loads that effectively end up in the surface water – expressed in tonnes per year. The effect of those pollutant load reductions to the physical-chemical water quality, expressed in mg per litre, were modelled with the PEGASE model. Afterwards a statistical model made it possible to estimate the effects on the biological quality based on the physical-chemical water quality modelled.

The water quality model PEGASE models the physical-chemical water quality (oxygen and nutrient management) on the basis of the inventoried pollutant loads to the surface water. It thereby takes account of the physical-chemical and biological processes in the aquatic ecosystem. Only watercourses from the Scheldt basin have been modelled. The results of the model are available per segment of 200 m watercourse. The validation showed that the smaller watercourses clearly cannot be modelled as accurately. For that reason the results are added at a segment level to flow weighted average concentrations per water body. It also proved that PEGASE has a tendency to overestimate orthophosphate concentrations: this chapter does not consider this in more depth.

The macro-invertebrate index (MMIF) is a measure of the biological quality of watercourses. A statistical model was developed to predict the MMIF based on an extensive set of measurement points, for which both physical-chemical water quality data and the determination of the MMIF are available. In that way the expected MMIF may be estimated on the basis of the water quality modelled. This model consequently does not take any account of the impact of hydromorphological characteristics on the MMIF.

The validation shows on the one hand that the model does not systematically overestimate or underestimate the actual MMIF values. However on the other hand it is also clear that the model estimates low MMIF values rather too high and high MMIF values rather too low.

12.2 Pollutant loads to the surface water

The pollutant load to the surface water is the total load that ends up in the surface water. The loads to the surface water of chemical oxygen demand (COD), nitrogen (N) and phosphorous (P) are discussed per target group.

The fact that the pollutant loads to the surface water from households decrease greatly is primarily attributable to the increase in the number of inhabitants connected to a WWTP (FIGURE 12.1). The execution of the current water treatment policy (REF2015) allows 1.9 million more inhabitants to be connected to a WWTP than in 2006. Slightly over 1 million of these have been connected in the meantime to the Brussels North WWTP. Another 1.9 million inhabitants are connected on top of these in the EUR2027 scenario. In the EUR2027 scenario the optimisation of collection and transportation also has an important effect. In that scenario 97 % of domestic waste water is treated at a WWTP. At that time it will consequently be even more important to collect the waste water properly and to transport it with as few losses as possible to the WWTPs. The introduction of individual treatment systems for domestic waste water in the context of the zoning plans (EUR2027) has a limited impact at a Flemish level and in absolute terms. Locally it may naturally have a pronounced effect.

The pollutant loads to the surface water by industry also decrease gradually, albeit to a lesser extent than households (FIGURE 12.2). The effect of the standards imposed is always larger than that of the connection of industries that discharge into the sewer to a public WWTP.

In the REF scenario the COD, N and P losses from agriculture decrease little or not at all (FIGURE 12.3). In the EUR scenario there is a clear decrease

FIG. 12.1 *Pollutant loads to the surface water of COD, N and P by households in the REF and EUR scenarios (Flanders, 2006-2027)*

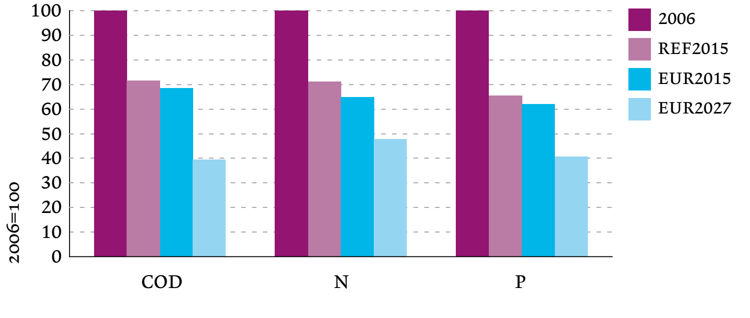
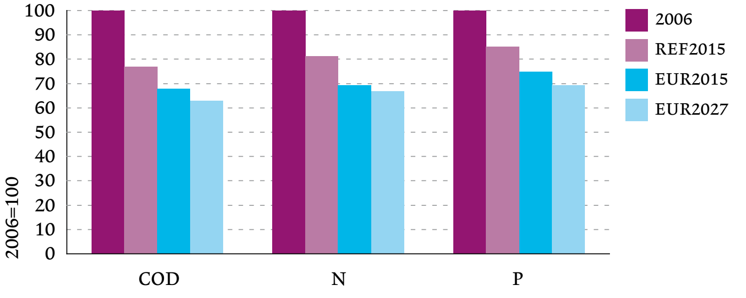


FIG. 12.2 *Pollutant loads to the surface water with COD, N and P by businesses* in the REF and EUR scenarios (Flanders, 2006-2027)*



* the MIRA sectors Industry, Energy and Trade & services

FIG. 12.3 *Pollutant loads to the surface water with COD, N and P by agriculture in the REF and EUR scenarios (Flanders, 2006-2027)*

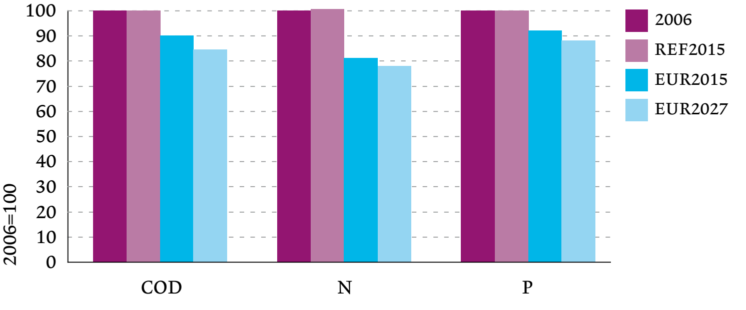
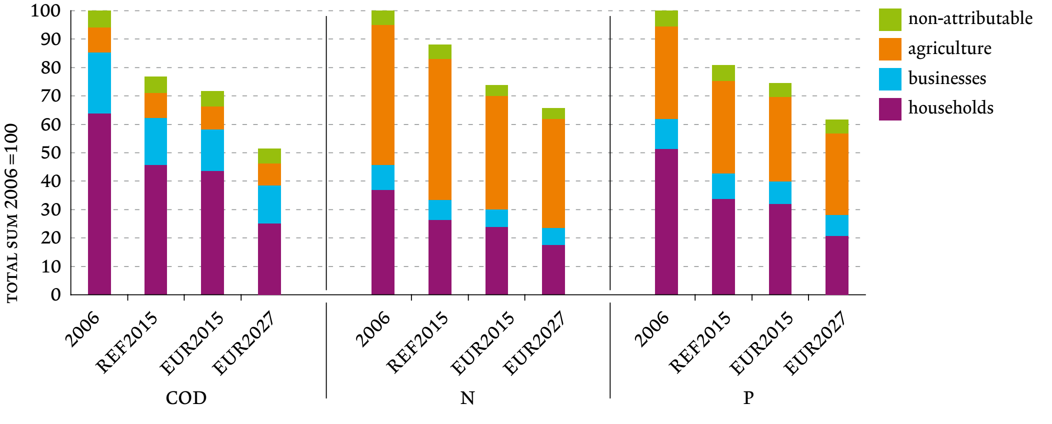


FIG. 12.4 *Total pollutant loads to the surface water with COD, N and P in the REF and EUR scenarios (Flanders, 2006-2027)*



'Non-attributable' relates to that part of the pollutant loads reaching the WWTP's but cannot be declared by known discharges of household and industrial waste water.

although this is always smaller in relative terms than the decrease in households or industry. The measures that contribute the most to this are the reduction of the cattle stock (EUR2027), the increase of feed efficiency (EUR2027), fertilizing according to recommendations (EUR2015) and sowing winter green cover (EUR2015).

The total pollutant loads to the surface water is reduced considerably in both the REF and the EUR scenarios (FIGURE 12.4). In the REF2015 scenario the pollutant loads decrease by 23 % for COD, by 12 % for N and by 19 % for P compared to 2006. In the EUR2027 scenario the reduction of the pollutant loads is 49 % for COD, 34 % for N and 38 % for P compared to 2006. The treatment of domestic waste water plays the largest role in this. In the EUR scenario (both 2015 and 2027) the reductions of the N and P loads by agriculture are also important. The discharges by industry were already much smaller in 2006 than those of households and agriculture. As a result the treatment of the industrial waste water contributes to a lesser extent to the reduction of the total pollutant loads of COD, N and P to the surface water at a Flemish level.

12.3 Physical-chemical water quality

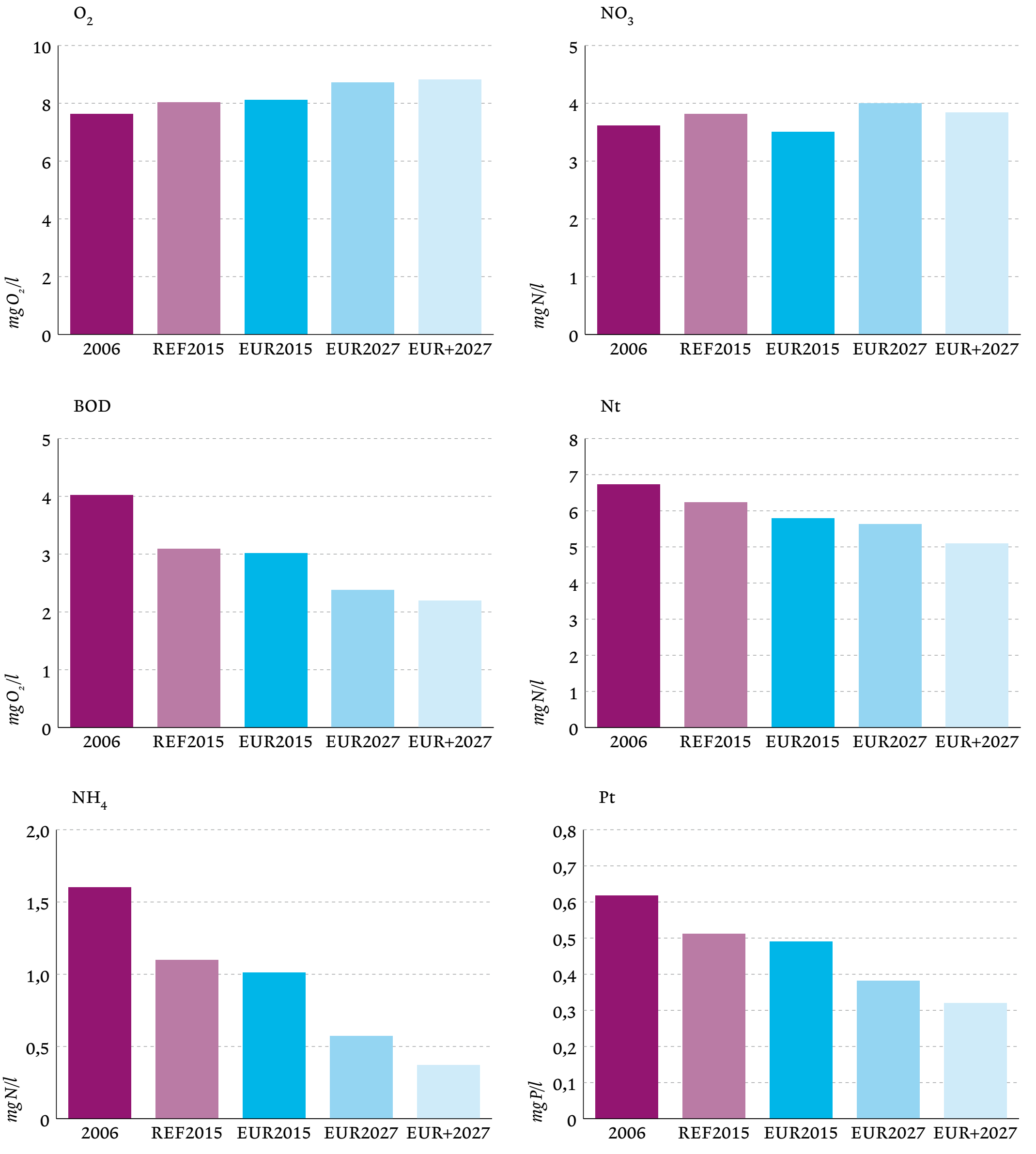
The water quality model gives a broad range of indicators to illustrate the effect of pollutant load reductions on water quality. FIGURE 12.5 shows the flow-weighted concentrations of the water bodies for dissolved oxygen (O_2), biochemical oxygen demand (BOD), ammonia (NH_4), nitrate (No_3), total nitrogen (Nt) and total phosphorous (Pt).

For the majority of variables there is a clear improvement through the execution of the policy already defined, in other words of the 2006 reference year, to REF2015. The supplementary measures, proposed to be executed in the first draft of the river basin management plan provide a minor improvement on top (from REF2015 to EUR2015). The execution of all supplementary measures again ensures a major step forwards (from EUR2015 to EUR2027). This improvement is naturally entirely due to the decrease of the pollutant loads that end up in the surface water (see 12.2 Pollutant loads to the surface water).

Nitrate is a major exception to the positive trends. Paradoxically enough the rising oxygen concentrations play an important role in this. The more oxygen in the water, the more reduced N compounds (e.g. NH_4) are converted into nitrate. However the more oxygen in the water, the less the nitrate is converted into nitrogen gas (N_2). The majority of modelled water bodies do meet the nitrate standard however (FIGURE 12.6).

By assuming that watercourses at the (regional) border meet the Walloon and French standards (EUR+2027), an improvement is particularly noticeable in the N and P variables and to a lesser extent also in the oxygen variables. This is

FIG. 12.5 *Average annual concentration of physical-chemical water quality of the modelled water bodies in the REF and EUR scenarios (2006-2027)*



because the starting point at those places are already much better for oxygenation conditions than for nutrients.

Water bodies may be further divided into quality classes (CIW, 2009a). The boundary between moderate and good quality is also the standard. Water bodies that score 'good' or 'very good' consequently meet the standard. In the EUR2027 scenario almost all water bodies fulfil the standard for O_2, BOD and Kjeldahl nitrogen (KjN) (FIGURE 12.6). However only a minority of the water bodies meet the standard for Nt. The situation for Pt is even worse: even in the EUR+2027 scenario there are only a few water bodies that meet the standard. These conclusions are only applicable to the flow weighted concentrations per water body and not for individual segments.

The WFD applies the principle of *one out all out*. This means that the variable with the lowest quality class defines the final class. According to this principle only 1.5 % of the water bodies modelled reach good status in 2006, REF2015 and EUR(+)2027.

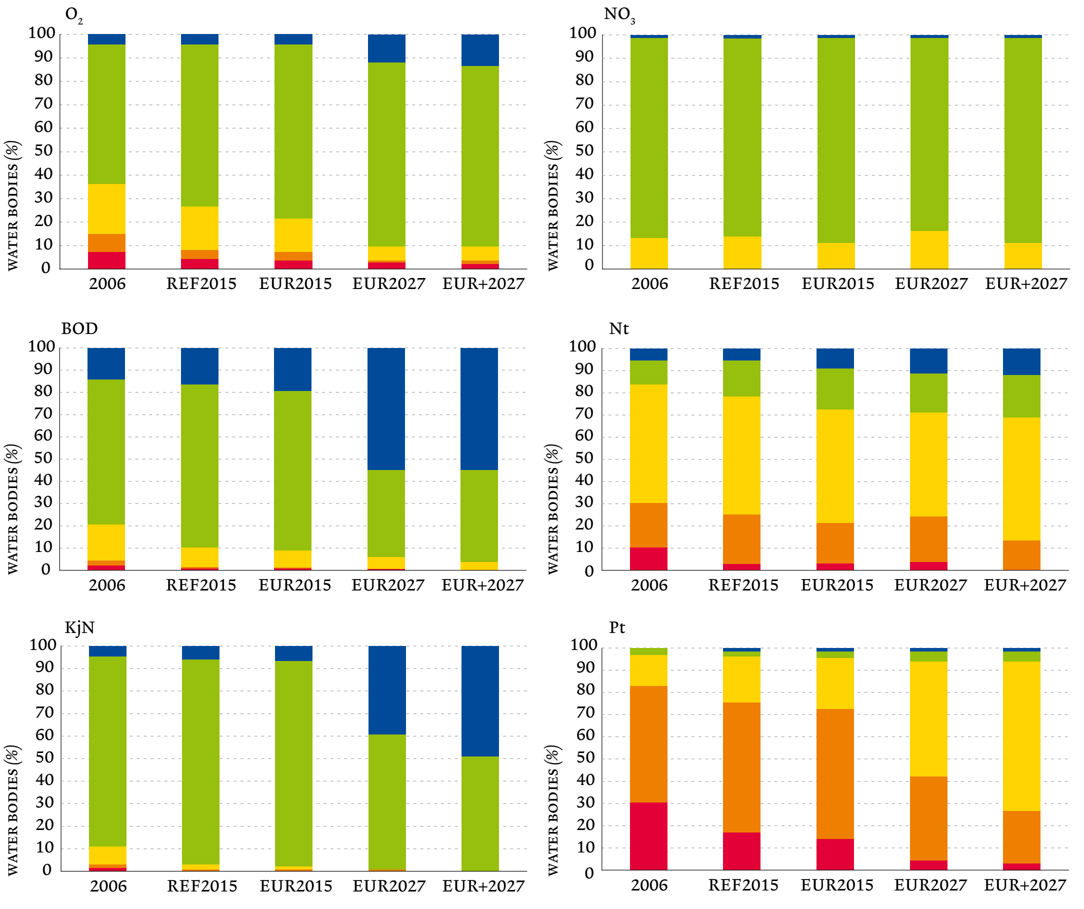
The modelling of the physical-chemical water quality could not yet take any account of improvements to hydromorphological characteristics. Re-meandering, nature friendly riverbanks, use of flood plains, etc. may increase the self-purification capacity of watercourses and thereby ensure an additional improvement to the physical-chemical water quality.

Climate change and water quality

Climate change may impact physical-chemical water quality in various ways. The dynamics of the water system may change due to a changing water temperature, which may for instance influence the solubility of oxygen but also all kinds of biological processes (e.g. algae bloom). Changing precipitation patterns may have an effect (more intense showers may result in more erosion and increased overflow or flooding problems). Increased evaporation may result in more and longer-term droughts which results in less dilution of the pollution from the sources… (Chapter 11 Climate change and water management).

It proved unfeasible to model the greatly decreased flow rates with the PEGASE model, or to quantify the effect on erosion. PEGASE may simulate the effect of an increase in water temperature however. The simulated increase in water temperature by 1 °C primarily results in a decrease in the oxygen concentrations, from 8.7 mg oxygen per litre on average to 8.5. This is logical because less oxygen is able to dissolve in warmer water. The differences are minimal for other water quality variables.

FIG. 12.6 *Classification of the modelled water bodies in physical-chemical quality classes in the REF and EUR scenarios (2006-2027)*



Kjeldahl nitrogen (KjN) is shown here because there are no class limits for NH_4 yet.

12.4 Biological quality

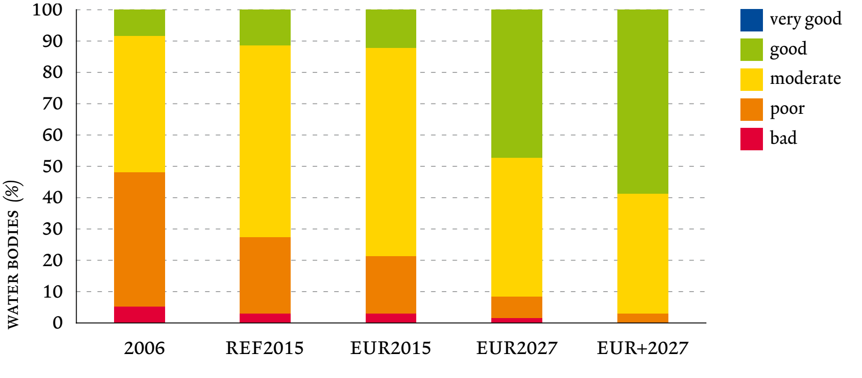
The macro-invertebrates index is a measure of the biological quality of a watercourse. Macro-invertebrates are invertebrates visible with the naked eye, such as insect larvae. A statistical model can calculate the improvements of the physical-chemical water quality to scores for the MMIF. An abstraction is made here of the effect of structural characteristics (e.g. meandering). Those effects may be either direct (due to more diversity of habitats) or indirect (due to the impact on the self-purification capacity). An important research question in the coming years will be the extent to which the improvement of structural characteristics may contribute to bridging the distance to the target.

The MMIF may have a value between 0 and 1, in which 0 corresponds to a biologically dead surface water and 1 is the maximum score. For the majority of natural water bodies the boundary between moderate and good quality is 0.7. The improvement of the physical-chemical water quality in the scenarios also clearly translates into biological quality. As more measures are taken into account (from REF2015 to EUR+2027), the percentage of water bodies with scores below 0.4 gradually decreases and the percentage with scores over 0.6 increases.

Water bodies may be categorised in quality classes on the basis of their MMIF score. There may be adjusted class boundaries for water bodies that have changed greatly due to human intervention and for artificial water bodies. All water bodies must at least meet the score 'good' in order to meet the targets of the WFD.

A clear improvement is also noticeable in the development of the distribution over the quality classes (FIGURE 12.7). The percentage of water bodies with a bad or poor quality gradually decreases and the percentage with a good quality increases strongly in the EUR2027 scenario. In the REF2015 scenario there are primarily shifts from poor to moderate quality, in the EUR2027 scenario primarily from moderate to good. Nevertheless even in the most far-reaching scenario (EUR+2027) only slightly less than 60 % of the modelled water bodies have a good biological quality.

FIG. 12.7 *Classification of the modelled water bodies in biological quality classes (MMIF) in the REF and EUR scenarios (2006-2027)*



Notes with the scenario analyses

There are a number of notes to be taken into consideration with the scenario analyses. These are still incomplete, conservative and optimistic. *Incomplete* in the sense that measures are only considered that have a direct effect on the pollutant loads to the surface water. The improvement of hydromorphological characteristics may also have a positive effect on the physical-chemical and biological quality. In addition there are also measures and phenomena (e.g. release of pollutants from polluted sediments) for which the effect is still unknown. The oxygenation conditions and nutrients have also only been considered and not, for instance, dangerous substances. As regards biological quality only macro-invertebrates were considered and no fish life, macrophytes, phytoplankton or phytobenthos. The results of the biological monitoring in 2009 already indicate that the distance to the target for fish and macrophytes is greater than for macro-invertebrates. The scenario analyses are in the sense that if the effect of a measure is very uncertain, the effect is estimated as being rather low (e.g. N removal in buffer strips and long-term effect of lower N fertilisation on losses via the groundwater). The model that calculates the N losses from agriculture is probably also not very sensitive to changes in the use of fertilizer. The scenario analyses are also because it is assumed that the measures will be carried out completely and on time as planned (e.g. realisation of the programmes and plans for public waste water treatment). There is also certainly room for improvement in the models applied. Due to these inadequacies it is difficult to say whether the distance to the target of the WFD has been overestimated or underestimated. The distance to the target will by taking account of the missing measures and if it becomes apparent that the conservative estimate of the effect of a few measures is indeed too low. The distance to the target will by taking account of missing physical-chemical and biological water quality variables and if it becomes apparent that the implementation of certain measures has indeed been estimated too optimistically.

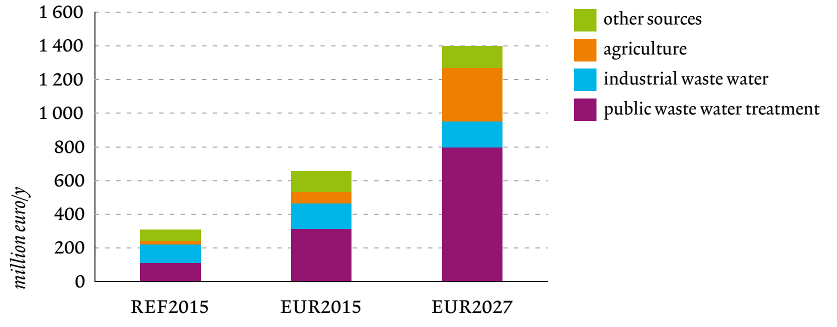
12.5 Costs

When drafting the river basin management plans an estimate was also made of the annual costs of the measures. The economic life of the measures and the maintenance costs are taken into account in this amongst other things. The costs for improving surface water quality make up the largest part of the total costs of the programme of measures in every scenario. Other important groups of measures, which also contribute to meeting the targets of the WFD, include water sediments, flooding and hydromorphology (structural characteristics).

The total annual costs for improving the surface water quality, increase sharply in the EUR2015 and the EUR2027 scenario: from 308 to 656 and 1 398 million euro per year (Figure 12.8). The increase in costs is especially large for public waste water treatment and measures in agriculture. A few remarks in this regard:

- These amounts also include the costs for measures for which it was not yet possible to model the effect (e.g. all measures for hazardous substances). The costs known of modelled measures are estimated at 119, 362 and 1 044 million euro per annum respectively for REF2015, EUR2015 and EUR2027.

FIG. 12.8 *Annual costs for the measures for improving the quality of the surface water in the REF and EUR scenarios (Flanders, 2006-2027)*



- Annual costs differ from annual expenses, for instance WWTPs are currently paid off spread over 30 years but their economic life is estimated at 50 years. That is the period that is also charged when determining the annual costs.
- The costs of the scenarios only include the costs of the measures considered. The costs for measures that had already been taken previously still continue however. For instance the historic cost for meeting the European Urban Waste Water Directive requirements, is estimated at 120 million euro per annum, excluding the investment costs for municipal sewage systems. The historic costs for measures in industry and agriculture are not known either.
- Costs for measures do not mention who will have to bear the financial burden. For instance it may very possibly be the case that government subsidies take responsibility for part of the costs for agricultural measures.
- Measures for improving the quality of surface water do not only incur costs, they also bring social benefits that may be monetised (e.g. more recreation). Numerous approaches are possible for estimating those benefits. The annual benefits linked to achieving a good status of the surface water were estimated in Flanders between roughly 65 and 500 million euro.

12.6 Conclusions for policy

The *REF2015 scenario* includes the basic measures, current and planned policy, of the first generation of river basin management plans. In this scenario the pollutant loads to the surface water decrease for instance by 12 % for N and 23 % for COD. This decrease is the largest in domestic waste water both in relative and absolute terms. This is due to the further expansion and improvement of the infrastructure for public waste water treatment. The Brussels North WWTP which has started operations in the meantime plays an important role in this. The pollutant loads to the surface water due to industrial discharges also fall, albeit to a lesser extent. This decrease is attributed to the standards imposed and the improvement of public waste water treatment. The pollutant loads from agriculture barely or do not decrease. The general drop of the pollutant loads to surface water ensures a clear improvement of the physical-chemical water quality. The nitrate concentrations do not improve however. This is related to higher oxygen concentrations. The majority of water bodies meet the standard for O_2, BOD, KjN and NO_3. Nt and particularly Pt remain problematic variables however. This general improvement of the water quality also results in an improvement of the biological quality (MMIF). A lot of shifts particularly arise here from poor to moderate biological quality. The annual cost of all the basic measures is approximately 308 million euro. The cost for the measures which are modelled for their effect on water quality in the REF2015 scenario is estimated at 119 million euro per year.

The *EUR2015 scenario* includes the supplementary measures for the first generation river basin management plans. In this scenario there is a further drop in domestic and industrial pollutant loads by 2015. It is striking that the loads from agriculture do drop now. The measures that contribute the most to this are fertilizing according to recommendations and sowing winter green cover. Overall these decreasing pollutant loads to the surface water ensure a minor additional improvement to the physical-chemical water quality. The greatest improvement is in N variables (e.g. from 6.2 in REF2015 to 5.8 mg Nt per litre in EUR2015). The biological quality also improves slightly. The total annual cost of the basic and supplementary measures for the first river basin management plans is approximately 656 million euro. The costs for the measures modelled in the EUR2015 scenario are estimated at 362 million euro per year.

When executing all the modelled supplementary measures (*EUR2027*) a significant, additional decrease of the pollutant loads to the surface water may be expected. The COD load has then almost been halved compared to 2006, N and P load fell by approximately 35 %. The decrease was again the strongest in domestic waste water and is primarily attributable to the complete realisation of the zoning plans. All the domestic waste water is then treated, either in a public WWTP, or in an individual waste water treatment system. At that time it becomes even more important to discharge the waste water that must be treated in a WWTP correctly into the sewage system and to transport it to the WWTPs with the least loss possible. The increase in feed efficiency of porkers and the reduction of cattle stock have the largest effect amongst the agricultural measures. Logically the physical-chemical (excluding nitrate) and the biological quality also develop positively. Still only a small minority of the water bodies meet the standard for Pt. The shift in biological quality is primarily from moderate to good but still less than half of the water bodies modelled meet the standard. The total extra annual cost of all basic and supplementary measures is almost 1.4 billion euro. The costs of the modelled measures in the EUR2027 scenario are estimated at slightly over 1 billion euro per year.

The improvement in water quality is even more pronounced if, on top of all the supplementary measures, it is assumed that the watercourses that run into Flanders meet the Walloon or French standards at the border (*EUR+2027*). This particularly gives a considerable extra improvement for nutrients. In that scenario almost all the water bodies modelled meet the standards of O_2, BOD and KjN. Nt and particularly Pt remain problematic variables however for which only a (small) minority meet the standards. The biological quality also improves further. Nevertheless only slightly less than 60 % of the modelled water bodies achieve good biological quality in that scenario.

The WFD states that all water bodies must meet the good status by 2015. For bodies of surface water this entails that they must be in a good ecological status (or potential) and in a good chemical status. Only a few water bodies fulfil all the standards for all modelled variables in all the scenarios. However the WFD foresees specific circumstances in which *exemptions from the target* are possible. In this way the draft river basin management plans justify an extension of the deadline because it is technically not feasible to achieve the targets by 2015 (CIW, 2009a). Less stringent objectives are also possible. In order to support the debate on how far Flanders can and must go to fulfil the requirements of the WFD, the knowledge and modelling of the water system must be improved and extended with other substances (e.g. hazardous substances), other biological quality elements (e.g. fish, water plants) and the effects of measures that improve the hydromorphological characteristics (e.g. re-meandering). Working out the economic foundation of the measures in more detail is also necessary.

LIKE TO KNOW MORE?

If you would like to know more, you can consult the scientific report, which forms the basis for this chapter:

Peeters B., D'heygere T., Huysmans T., Ronse Y. & Dieltjens I. (2009). Toekomstverkenning Stroomgebiedbeheerplan/Environment Outlook 2030: Modellering waterkwaliteitsscenario's. Scientific report, MIRA 2009, VMM, www.milieurapport.be.

REFERENCES

CIW (2009a) Ontwerp stroomgebiedbeheerplan voor de Schelde. Document of public research from 16 December to 15 June 2009, 283 p.

CIW (2009b) Ontwerp maatregelenprogramma voor Vlaanderen. Document with the design of the river basin management plans for the Scheldt and the Meuse in public research from 16 December to 15 June 2009, 271 p.

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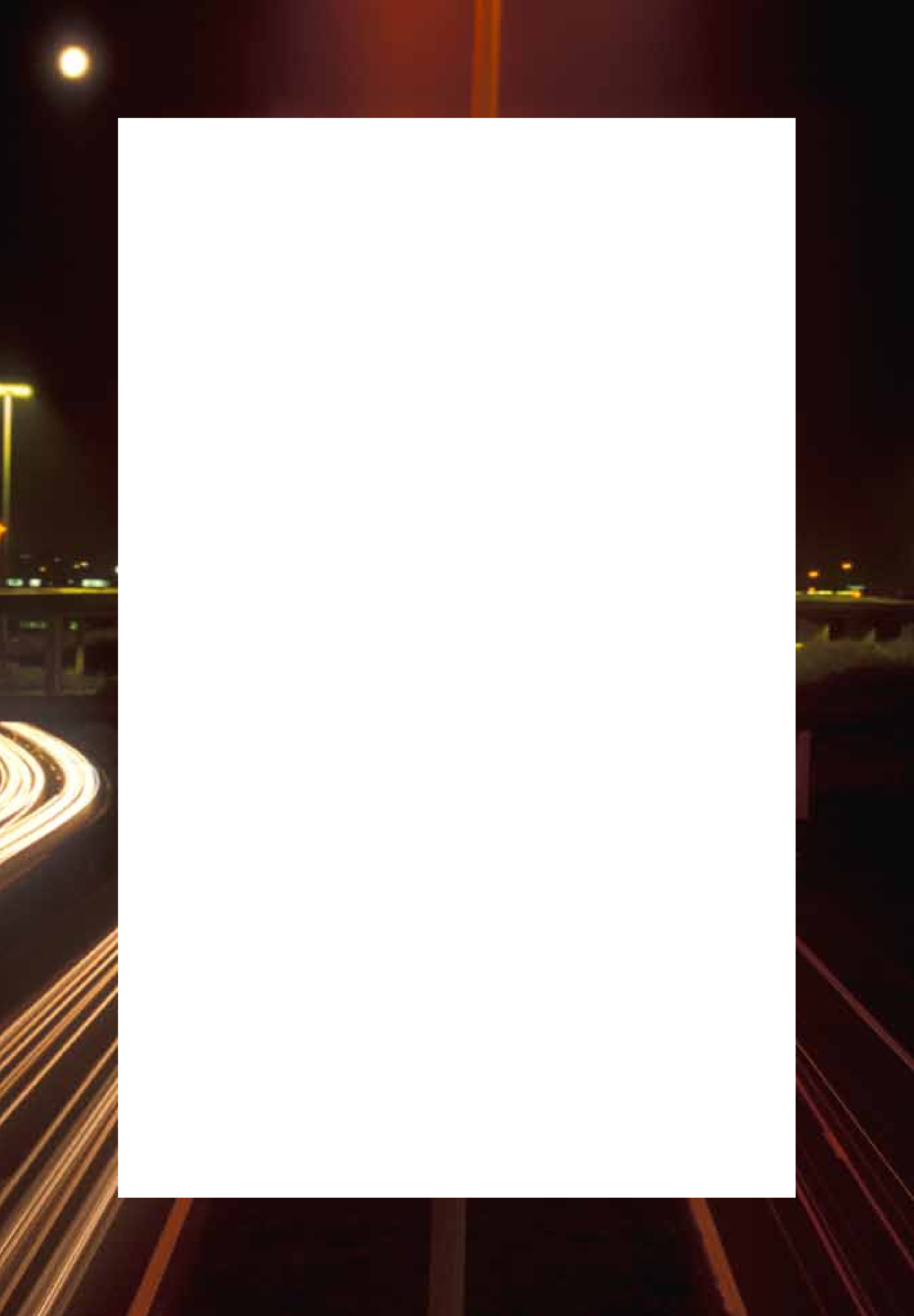

13 Noise

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OUTLINES

- Exposure to road traffic noise and the resulting potential serious noise nuisance will continue to increase in the future in the reference scenario (REF), so in the continuation of the current policy.

- Intensive measures on a Flemish scale, as described in the Europe scenario (EUR) and the visionary scenario (VISI), may reverse the trend of increasing exposure to road traffic noise (in the reference scenario). These measures include a systematic choice for noise-friendly road surfaces, a decrease of the driving speed actually driven, amongst others through the resurfacing of roads, good spatial planning ...

- Rail traffic increases. Nevertheless the accelerated use of quieter trains as anticipated in the EUR scenario succeeds in decreasing the population exposed to more than 70 dB by a quarter in 2030. Additional Flemish initiatives are required to maintain the falling trend, such as the reorganization of black points and a policy around quieter tracks.

- The calculated effect of the European Tyre Directive on general road traffic noise remains limited. Indeed the tyres on some cars already comply with the directive. The anticipated impact for trucks is small, amongst others because the engine noise is relatively more important.

- A decrease in noise impact is expected for the Brussels Airport and the airport Oostende-Brugge until 2010 and 2015. This is the result of measures already taken (REF scenario). Additional measures (e.g. a thorough renewal of the fleet) are required to limit noise pollution (which has then risen due to the increasing intensity of traffic).

Introduction

Environmental noise constitutes a major threat to the quality of life in a district and the few quite areas in Flanders. This may have a negative impact on health. The Written Environmental Investigation of the Flemish government, which regularly surveys the population, indicates that residents of Flanders primarily experience noise nuisance and sleep disruption from noise originating from traffic. In the past the government has, successfully, combated industrial noise and – albeit less systematically – recreational noise. Traffic noise (road, rail, air) however was – with the exception of the immediate surroundings of airports – tackled poorly. For that reason, with the prospect of action plans formulated in the context of the European Environmental Noise Directive (2002/49/EC), this chapter focuses exclusively on traffic noise.

This chapter first considers the method used. It will then first discuss road and rail traffic and then air traffic in more detail. These modes of transport are studied separately because the impact of both sources differs greatly geographically. As regards road and rail traffic this chapter focuses the attention on the emissions and noise maps. The impact is then estimated on the basis of the number of people potentially experiencing serious nuisance. An estimate is also made of the disturbance of the quiet region in Flanders. For air traffic this chapter discusses the noise contours and the number of people potentially experiencing serious nuisance for the Brussels Airport and the airport Oostende-Brugge. Finally this chapter formulates a few recommendations for policy.

13.1 Principles of the Environment Outlook

Modelling

The noise from individual vehicles or separate roads and railways only spreads over a limited distance. For that reason models are used for rail and road traffic that track the entire territory of Flanders at a resolution of a few dozen metres. To calculate noise levels, account is taken at each location of 1) the flows of traffic present as defined in Chapter 6 Transport and 2) the typical noise emissions depending on the road network, driving speed, road surface and the noise screens. The MIRA model also records the traffic on secondary and some local roads and on all railways. This is a major difference to the noise map drawn up by the Flemish government in order to fulfil the obligation in relation to the European Commission. For the calculation of noise emissions and noise propagation this report uses the standard models: *Harmonoise/Imagine* for emissions by road traffic, the Dutch calculation method for rail traffic emissions and ISO9613 for the propagation of road and rail traffic. To determine the exposure and potential noise nuisance, the model also takes account of the residence of the inhabitants of Flanders, as may be derived from the population maps and address databases. The impact of acoustic housing insulation is included as an approximation in the determination of the potential serious nuisance. These calculations are strategic, in the sense that they do not take any account of the screening by housing and terrain profile. Consequently they do not make it possible to predict the noise levels in the vicinity of an individual home or to determine the nuisance for a person or small group.

The noise impact from air traffic around the airports is calculated using the INM *(Integrated Noise Model)* version 7.0a. The INM is used worldwide for the calculation of the noise impact of air traffic around airports and is imposed by the Flemish environmental legislation (Vlarem) as the mandatory model. This model is based on the geographical data of the airport, the description of the flight paths (use of runways and routes), the meteorological conditions and the description of the air traffic. This environment outlook only takes the Brussels Airport and the Oostende-Brugge airport into account.

Three scenarios with specific assumptions for noise

This chapter calculates three scenarios: the reference scenario (REF scenario), the Europe scenario (EUR scenario) and the visionary scenario (VISI scenario). The various scenarios for noise use the assumptions for the transport sector, including assumptions concerning traffic intensity (see Chapter 6 Transport). The scenarios also include additional packages of measures aimed specifically at noise. These measures relate to:

- infrastructure (e.g. laying quieter road surfaces);
- materials (e.g. replacement by quieter aeroplanes (ICAO Chapter 4 limits));
- measures at the receiver (e.g. housing insulation).

The REF scenario assumes the continuation of the current policy for combating the noise pollution of road, rail and air traffic.

The EUR scenario comprises measures within the sector aimed at achieving the European targets on the one hand and on the other this scenario comprises measures that could be a part of the noise action plans currently being formulated in the context of the European END directive. In addition to the growing intensity only the anticipated market developments as regards the renewal of the fleet have been taken into account for air traffic.

The VISI scenario is primarily based on the visionary developments resulting from the transport sector (e.g. the development of the road network). A few additional measures were formulated on top of this. Compared to the EUR scenario a few additional measures have also been integrated into this scenario for air traffic. This scenario uses the same traffic intensity as in the EUR scenario.

13.2 Road and rail traffic

Noise emissions of road traffic and rail traffic

Unlike the issue of air pollution, which is regional to global, noise has a local impact. This local impact generally has a clear relationship to one or a few sources of noise. Impact is only mentioned if man or nature is exposed to the noise emissions. A good spatial planning policy is consequently also essential to tackle the noise issue. Nevertheless considering the main emission trends in more detail is relevant.

Road traffic

If the general growth percentages for road traffic are solely taken into account, the noise emissions on Flemish roads are expected to increase between 2006 and 2030 by 1.7 to 1.9 dBA in the REF scenario. In the EUR scenario the growth of road traffic is more limited but still results in an increase of emissions of 1.5 to 1.7 dBA in the same period. The additional trends and measures in the various scenarios do ensure however that the noise emissions due to road traffic increase less in the various scenarios (and especially in the EUR and VISI scenarios).

Engine noise plays an important role for heavy traffic such as trucks and busses and for cars in city traffic. However few stricter rules are expected in this field. The trend towards alternative and hybrid engines may give some relief although it is clear from simulations that the impact in typical situations on the motorway and access routes is very limited with the share of hybrid vehicles anticipated in both the EUR and REF scenarios.

The recently approved amendment to the European Tyre Directive will decrease the rolling noise of some cars on certain road surfaces by many dBA. Because some car tyres already comply with the directive, account is taken of the current distribution of the tyres used when determining this global impact. By also taking the share of freight traffic into account, the fact that the directive has less impact on noise emissions by trucks was also taken into account. This global impact was estimated for typical situations on motorways and access routes by a decrease of 0 to 1 dBA depending on the road surface in the period between 2006 and 2030. All scenarios include this trend.

As yet no specific policy has been developed in Flanders to stimulate the use of road surfaces that limit the noise emissions of road traffic. This means there is still a significant margin for improvement. The REF scenario assumes that no road surfaces will be chosen that would result in more noise emissions by road traffic. However the EUR scenario assumes that a road surface will systematically be selected that, on average across its life, produces 2 dBA less road traffic noise emissions than a standard road surface (type AB-2C). Because age and the time for replacing the road surface are so important at every place it is difficult to estimate the average effect on the noise emissions in Flanders. This is possible in the calculation of the noise level and exposure, as is shown later in this text.

Rail traffic

Wheels rolling over the rails cause the noise emissions by trains, excluding a few exceptions such as heavy diesels and high-speed trains. The roughness of the rail and the wheel are determining factors but vibration insulation, sleepers and ballast, and any bridges also play a role. The finish of the wheels and wheel boxes may help reduce the noise emissions. At a European level the noise emissions of rolling stock is regulated by the *Technical Specification for Interoperability* (TSI) which has been in force since 2006. This directive is mandatory for all new rolling stock. The introduction of this directive would be expected to have a major effect. Taking the life of rail trucks and carriages and self-propelled trains and their current noise emissions into account, the noise emissions of the average passenger train on Flemish railways in the period between 2006 and 2030 is estimated to decrease by slightly over 1 dBA and of the average freight train by 2.5 dBA. The EUR scenario expects that existing freight trucks will be adapted more quickly (so-called *retrofitting*) under the impact of diverse stimuli taken from the scenario calculations by the European Commission. The emissions will thereby already decrease in 2015 and will rise to 4 dBA by 2030.

No data is available about the condition of the rails in Flanders. The calculations consequently do not take this into account. However this does not mean that an effective policy for quieter tracks is not equally important as an effective policy for quieter road surfaces. On the contrary, the need for acoustic inventory is large.

Exposure to noise and noise maps for road traffic

The noise level caused by road traffic to which the Flemish population is exposed, is represented here on the basis of $L_{den.}$ This is the European indicator for noise that takes account of the need for quiet in the evening and at night. For the highest exposure levels of 65, 70 and 75 dBA there is a stronger than linear increase in the percentage of people exposed in the period between 2006 and 2030 in the REF scenario (Figure 13.1). The increase in road traffic, in particular the increase in heavy traffic (freight traffic and busses), explains this increase. Technical noise measures such as quieter tyres and hybrid vehicles do not succeed in reversing this trend. These measures specifically have little impact on the noise emissions for heavy traffic. This impact was ignored in the model.

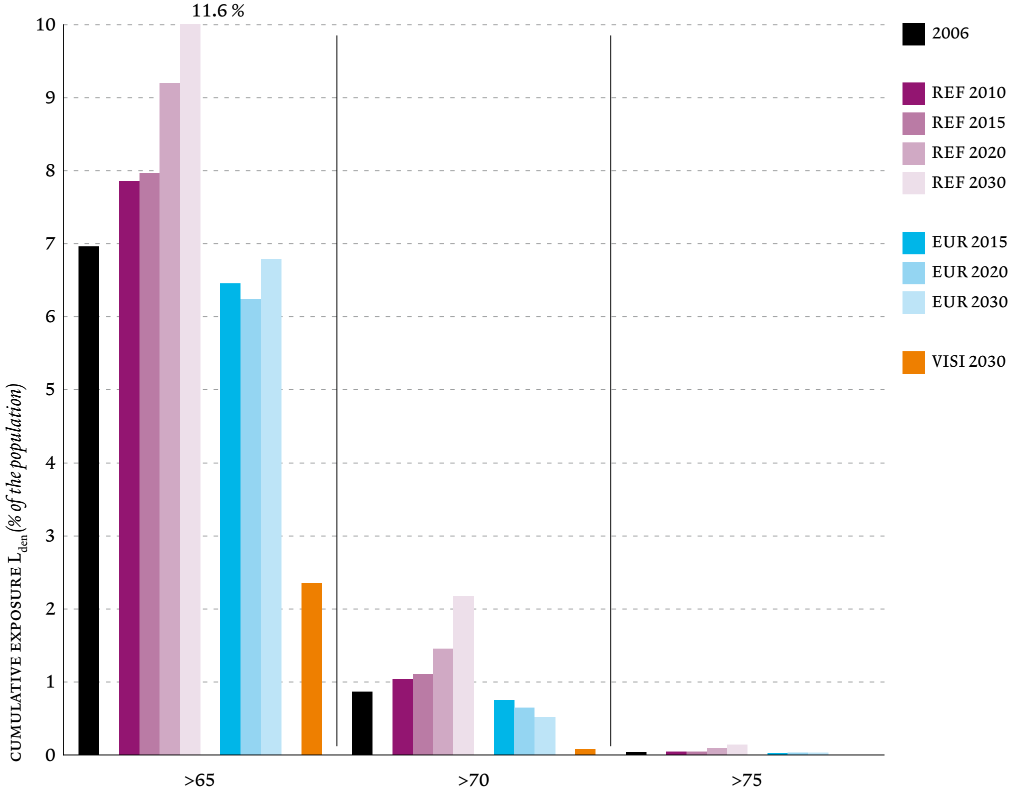
The growth of traffic is more limited in the EUR scenario and this is consequently also true for the corresponding pressure on exposure to noise. Two major measures are also added to this:

1 On replacement of road surfaces, types that limit noise emissions are consciously chosen (see below).
2 Black spots are cleaned-up at a higher rate (260 km before 2020 and 460 km before 2030). Discouraging development of critical zones should prevent new black spots being created.

Together these measures result in a reduction of the exposure to high noise levels.

The traffic pressure increases even less in the VISI scenario and there is an even more drastic choice for noise-friendly road surfaces and more black spots are cleaned-up. The result is also illustrated in FIGURE 13.1: the population is no longer exposed anywhere to noise levels in excess of 70 dBA.

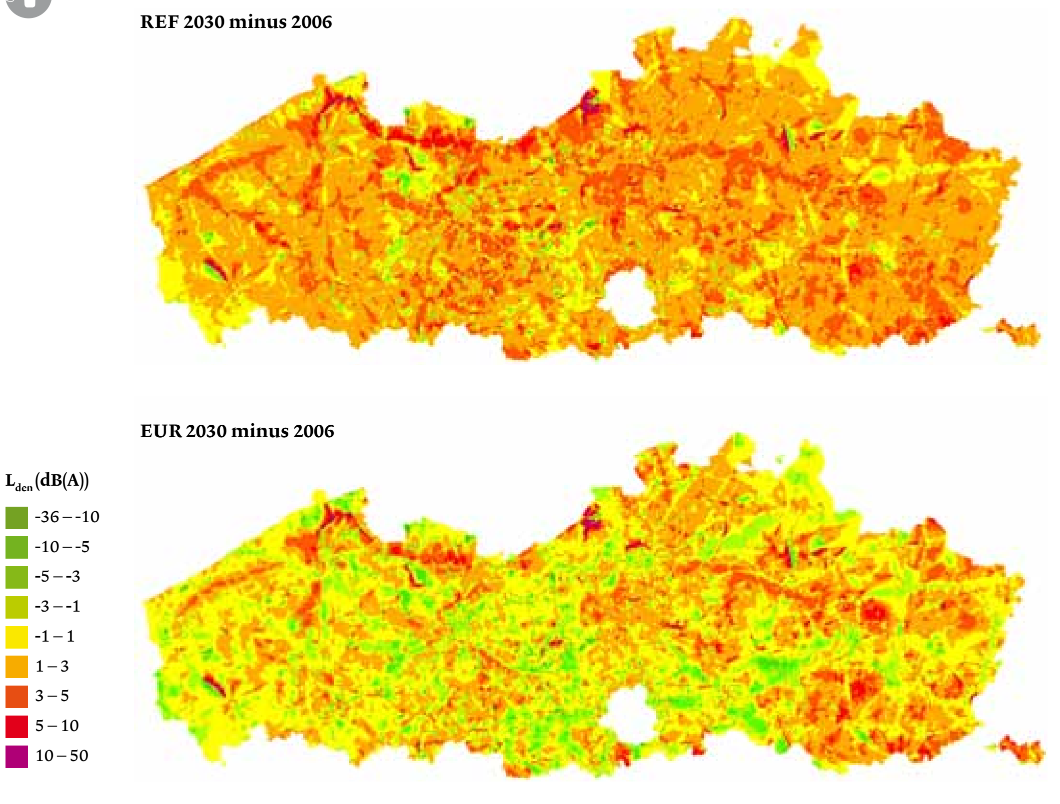
FIG. 13.1 *Cumulative exposure to road traffic noise, L_{den}, originating from traffic on the roads included in the traffic model in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



The input data for the reference year date from different years. 2006 is given as the reference year because the traffic intensity of the transport sector for 2006 was used.

An increase or reduction of the exposure to road traffic noise does not automatically imply that it becomes louder or quieter everywhere. FIGURE 13.2 illustrates that there are few places in the REF scenario where the noise level does not increase due to road traffic. The map shows that the noise levels fall in the majority of Flanders in the EUR scenario but that there are still areas where the noise level rises. The fluctuations across the territory may predominately be explained by replacing the oldest sections of the road surface. However the model selects which road surfaces are replaced in which years at random because the exact age of each piece of road surface in Flanders is not available in a central database.

FIG. 13.2 *Difference (in dBA) between L_{den} due to road traffic on modelled roads in 2030 and L_{den} in 2006, the REF scenario at the top, the EUR scenario at the bottom (Flanders, 2006-2030)*



Exposure to noise and noise maps for rail traffic

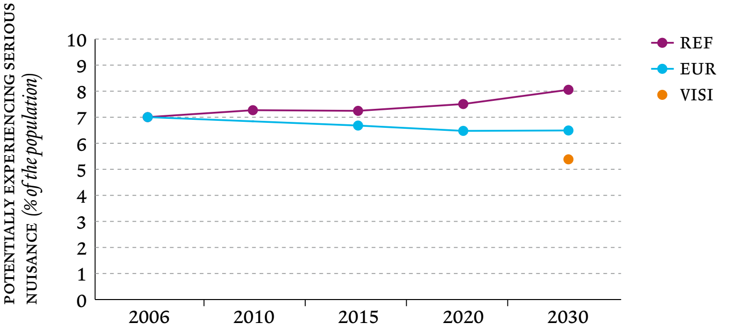
The expected growth of rail traffic (see Chapter 6 Transport) indicates a break of the trend in 2015. In its turn this ensures a reversal in the percentage of the population exposed to high noise pressure levels. In 2007, in the REF scenario 0.85 % of the population is exposed to levels higher than 70 dBA, in 2015 this percentage increases to 1.05 % and then decreases to 0.95 % of people exposed to more than 70 dBA in 2030. From 2015 the positive effect of the TSI seems to compensate for the growth. In the EUR scenario the decrease starts from 2006 and ends at 0.64 % of the Flemish population exposed to levels higher than 70 dBA in 2030. The growth in vehicle kilometres is not significantly different but the EUR scenario does base its figures on wide-scale *retrofitting,* as described above. Furthermore 5 km of black spots are cleaned up each year in this scenario.

People potentially experiencing serious nuisance due to road and rail traffic

Both the growth of the road traffic and measures that have an impact on the entire territory (such as the systematic choice for noise-friendly road surfacing), impacts the percentage of people potentially experiencing serious nuisance in the same way as the impact on exposure. Cleaning up black spots has a more limited impact on the percentage of people potentially experiencing serious nuisance. The percentage of those subject to serious nuisance also takes the improved housing insulation as described in the population sector into account. Nevertheless the general trends discussed in the section on exposure are also visible here (FIGURE 13.3). In the REF scenario the percentage of people potentially experiencing serious nuisance increases from 7 to 8 % in the period between 2006 and 2030. A more limited growth of the road traffic and the said measures ensure a decrease in the percentage of people subject to serious nuisance in the EUR scenario to 6.5 % over the same period. However this decrease is particularly realised over the first 10 years. The percentage of people potentially experiencing serious nuisance due to road traffic noise only decreases significantly however in the VISI scenario.

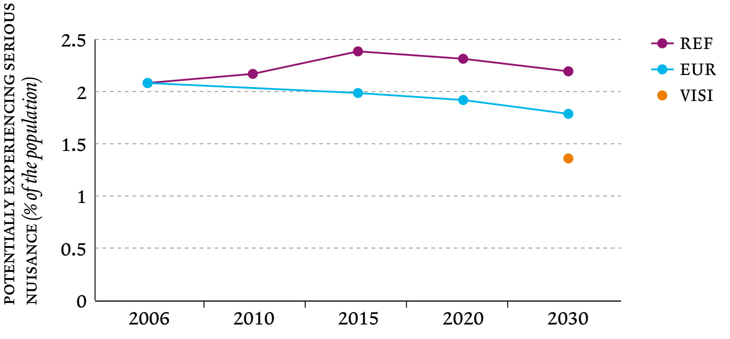
The percentage of residents of Flanders who may potentially experience serious nuisance due to rail traffic noise is lower than the percentage of people potentially experience serious nuisance due to road traffic noise. The additional measures of the EUR scenario ensure in this case that the percentage of people potentially experiencing serious nuisance starts to fall more quickly than in the REF scenario, where it initially still rises (FIGURE 13.4).

FIG. 13.3 *Percentage of the population potentially experiencing serious nuisance by road traffic noise in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*



values including the positive effect of an improved façade insulation in housing; road traffic only on the roads included in the traffic model

FIG. 13.4 *Percentage of the population potentially experiencing serious nuisance by train traffic noise in the REF, EUR and VISI scenarios (Flanders, 2006-2030)*

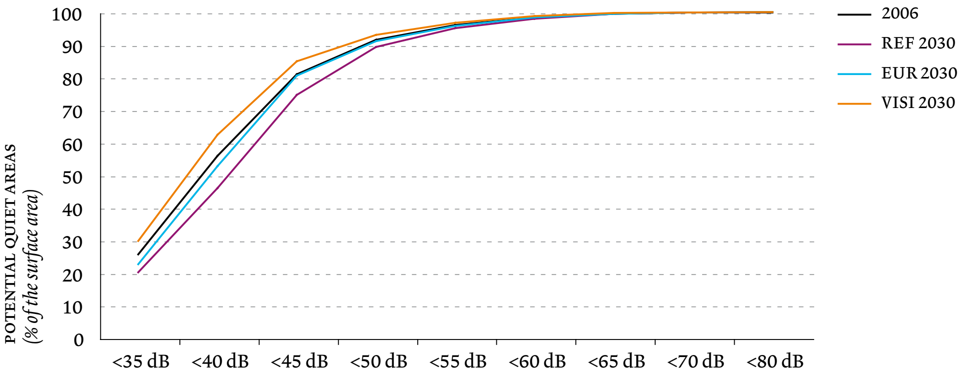


values including the positive effect of an improved façade insulation in housing

Disturbance to quiet areas

Quiet zones in the city and quiet areas require special attention because they are a retreat of a restorative nature for residents of noisy, busy zones. Characterising quiet areas requires a multiple criteria approach and a thorough observation of the terrain. After all it is impossible to predict every local disturbance. However it is possible to estimate the disturbance due to road traffic noise in regions that are marked as potentially quiet on the basis of a model. FIGURE 13.5 shows the percentage of the area of potential quiet areas in Flanders for all the different scenarios (in total 2.9 % of the territory) exposed to noise levels below the given limit. One of the criteria for quiet areas is that the L_{A50} level must be sufficiently low. It may be derived from this that the disturbance to the quiet areas by traffic on busy roads arises from a L_{Aeq} of 35 to 45 dBA. A clear trend is visible with levels of this size. In the REF scenario the

FIG. 13.5 *Percentage of the surface of potential quiet areas with contributions to the road traffic noise on the modelled roads lower than the given L_{Aeq} during the day in the REF, EUR and VISI scenarios (Flanders, 2006 and 2030)*



area of undisturbed potential quiet areas decreases by 5 to 10 percentage points, in the EUR scenario there is a status quo to a slight decrease. In the VISI scenario the area of undisturbed potential quiet areas increases by 5 to 10 percentage points, all in the period between 2006 and 2030.

13.3 Air traffic

Exposure to noise and noise maps for air traffic

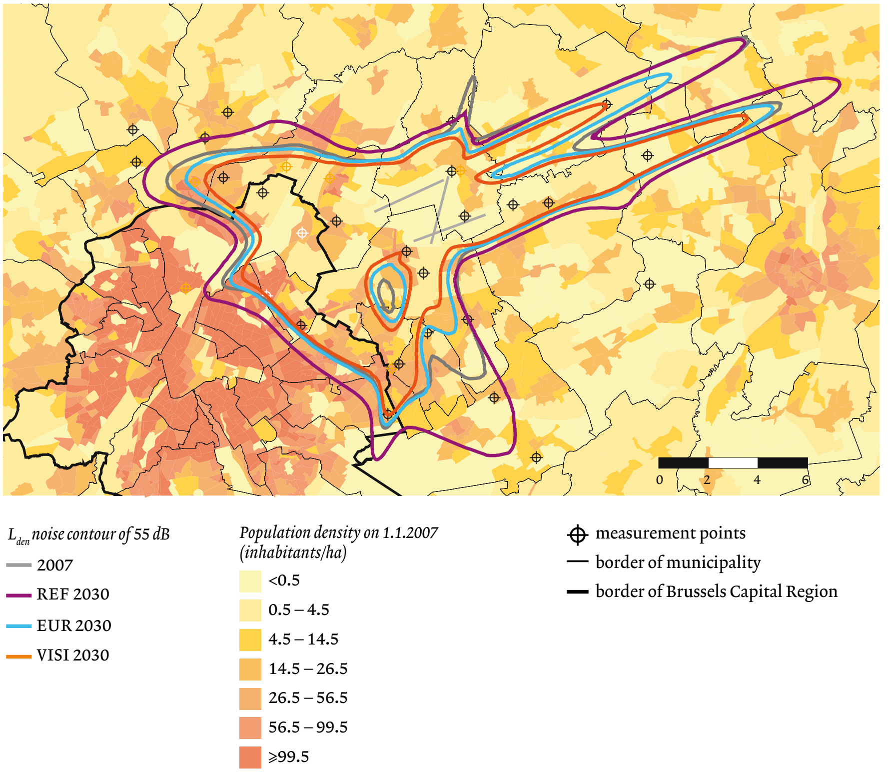
Brussels Airport

FIGURE 13.6 shows the L_{den} noise contour of 55 dB around Brussels Airport both for the reference year 2007 and for 2030 for the three scenarios. The figure shows that the region with the calculated noise level above 55 dB (the 55 dB noise contour) for the REF scenario in 2030 is significantly larger than in 2007. The measures determined in the REF scenario consequently do not succeed in compensating for the anticipated growth in the intensity of the traffic. In the EUR scenario and the VISI scenario however the 55 dB contour is smaller than the contour in 2007.

The more detailed development of the surface area and the number of inhabitants within this noise contour confirm this trend (FIGURE 13.7). Only the zone on the territory of the Flemish Region has been taken into account.

The L_{den} contour shows an average noise level, again taking account of the need for quiet in the evening and night period. Both in the REF and EUR scenarios the significant decrease in the surface area and number of inhabitants within the L_{den} noise contour of 55 dB in 2010 is striking. Especially if the conclusion of an increased intensity of traffic compared to 2007 is taken into account. The decrease in

FIG. 13.6 *L_{den} noise contour of 55 dB around Brussels Airport in the REF, EUR and VISI scenarios (2007 and 2030)*

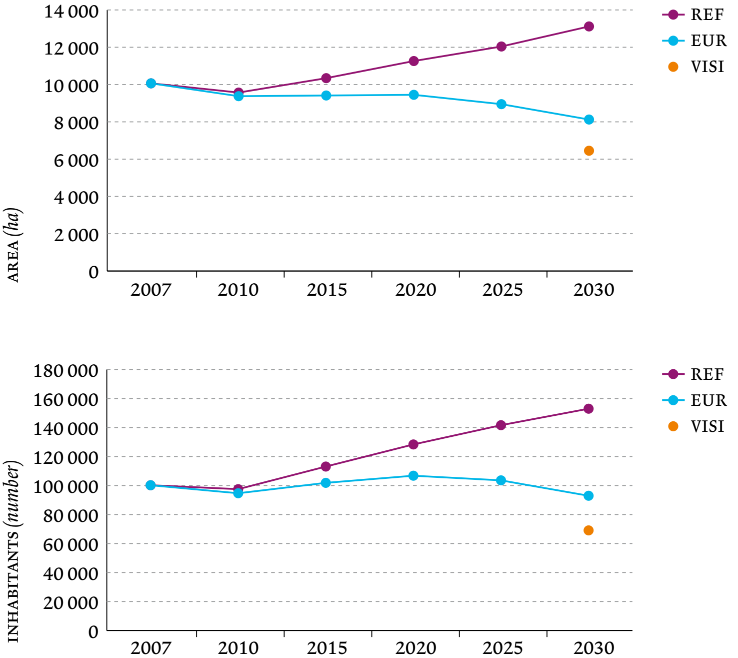


2007 is used here as the reference year because, as the most recent available year, it forms the main basis for calculations.

the surface area and number of inhabitants is a result of a set of measures produced through the agreement at the Federal Ministerial Council of 19 December 2008. The measure with the largest impact is limiting the maximum number of night-time slots to 16 000 in the operational night-time period (11 PM to 6 AM), which reduces the number of night flights by 25 000 to a maximum of 16 000. This operational night-time period is not completely the same as the night period from the European Environmental Noise Directive (11 PM – 7 AM). Extra traffic (and corresponding noise) may be expected for the morning period from 6 AM to 7 AM and is also included in the formulation of the scenarios.

Another measure that gives rise to a decrease in the noise contours, is extending the Quota Count system (QC) for individual aeroplane movements and making it stricter. This system was previously already used at Brussels Airport and results in the noisiest aircraft being rejected from the night-time and morning period. The existing QC limits are decreased for the operational night-time period (11 PM – 6 AM) and the morning period (6 AM – 7 AM). The first QC limits have been introduced for

FIG. 13.7 *Evolution of the area and the number of inhabitants on the territory of the Flemish Region within the L_{den} noise contour of 55 dB around Brussels Airport in the REF, EUR and VISI scenarios (2007-2030)*



the day and evening period. As a result the nosiest aircraft, which often have a major impact on the noise contours, will disappear from the fleet.

From 2010 the area and number of residents within the L_{den} noise contour of 55 dB will increase as a result of the increase of traffic intensity by 2.6 % per annum. The REF scenario assumes a renewal of the aeroplane fleet, in which aeroplanes that meet the most modern requirements (i.e. the ICAO chapter 4 limits) replace the older aeroplanes at a normal age (30 years). However, this renewal does not fully nullify the increase in traffic intensity: indeed a large part of the current fleet already fulfils the new limits.

The EUR scenario is based on a more positive modernisation of the aeroplane fleet. Each aeroplane is replaced at thirty years of age by an aircraft that has 3 dB lower noise emissions on departure and 4 dB on landing. This improvement in noise emissions corresponds with the development determined over recent years on the market. Due to this modernisation of the fleet the area within the L_{den} noise contour of 55 dB falls below the 2010 level despite the increased traffic intensity. However the number of inhabitants in 2030 remains approximately equal to the number in 2010 because the increase in population density was integrated in the calculation.

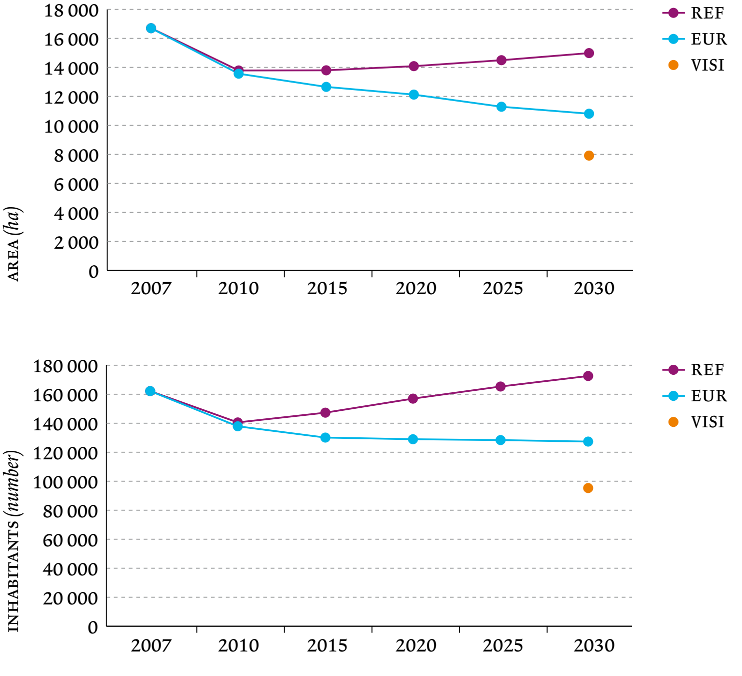
Due to a number of additional measures in the VISI scenario (no night flights, modernisation of the entire fleet of aeroplanes) the area and the number of inhabitants in 2030 fall below the level of 2007, even if the total intensity of traffic increases sharply.

The same development as for the L_{den} noise contours can be found for the frequency contour of 1x above 70 dBA during the night-time period (FIGURE 13.8). This contour line connects the places where one aeroplane on average exceeds the 70 dBA level once a night (11 PM – 7 AM) on an annual basis. Consequently it represents the places where there are noise peaks due to aeroplane traffic. After the sharp fall in 2010 due to the limitation of the number of night-time flights to 16 000, an increase of this frequency contour still remains in the REF scenario. This is because the intensity of the traffic increases in the morning period between 6 AM and 7 AM. As a result of the modernisation of the fleet, the number of inhabitants within this contour remains approximately constant in the EUR scenario.

Oostende-Brugge airport

A limited number of movements for cargo transport with large and older types of crafts (which also partly fly in the night-time period) determines the L_{den} noise contours around the Oostende-Brugge airport in the 2007 reference year.

FIG. 13.8 *Evolution of the area and the number of inhabitants of the Flemish Region within freq. 70, night noise contour of 1x above 70 dBA around Brussels Airport (2007-2030)*



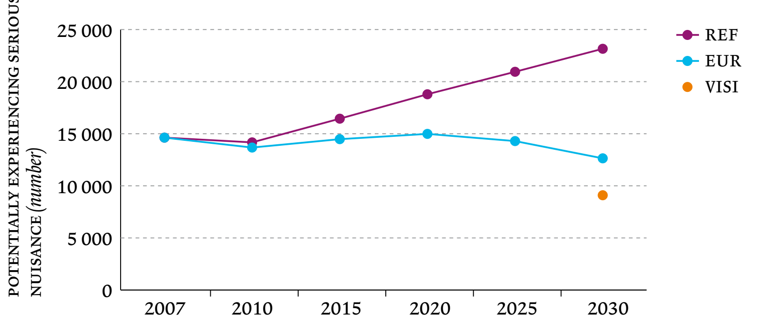
However the airport's environmental permit gradually limits the maximum QC of flights during the night-time period. As a result a number of types of air crafts will no longer be able to operate at the airport during the night-time period or the flights must be moved to the day-time period. This ensures a sharp decrease of the number of inhabitants within the L_{den} noise contours for 2010 and 2015, both in the REF scenario and in the EUR scenario. After 2015 the number of inhabitants again increases in the REF scenario through a further increase of the intensity of traffic on the airport despite the assumed renewal of the fleet as also applied for Brussels Airport. The more intensive modernisation of the fleet in the EUR scenario does succeed in keeping this number of inhabitants approximately constant until 2030. In the VISI scenario the Oostende-Brugge airport also realises a sharp decrease in the number of inhabitants within the L_{den} noise contour of 55 dB in 2030 compared to 2007. This decrease is due to a prohibition of night-time flights and a complete modernisation of the aeroplane fleet by quieter crafts.

People potentially experiencing serious nuisance from air traffic

Brussels Airport

The development of the intensity of traffic, the measures from the Federal Agreement of 19 December 2008 on Brussels Airport and the innovation of the fleet of aeroplanes impact the number of people potentially experiencing nuisance in the same way as the exposure on the basis of the L_{den} parameter (FIGURE 13.9). Taking the anticipated effect of an improved façade insulation (in accordance with the new insulation standard NBN S01-400-2) into account only has a limited effect. There is also a reduction in the number of people subject to serious nuisance in 2010 in the first instance both for the REF scenario (-3 %) and the EUR scenario (-7 %) compared to 2007. This number rises to +58 % compared to 2007 in 2030 for the REF scenario, and

FIG. 13.9 *Amount of people potentially experiencing serious nuisance within the L_{den} noise contour of 55 dB around Brussels Airport for the three scenarios on the Flemish Region territory (2007-2030)*



values including the positive effect of an improved façade insulation in housing decreases to -14 % compared to 2007 for the EUR scenario. The VISI scenario expects a decrease by 38 % compared to 2007 in 2030.

Oostende-Brugge airport

The development of the number of people potentially experiencing serious nuisance also develops in the same way for the Oostende-Brugge airport as the exposure to $L_{den.}$ A very significant decrease of the number of people potentially subject to serious nuisance is expected through the stricter limitation of noisy crafts for 2010 when compared to 2007. The decrease is respectively -34 % in the REF scenario and -42 % in the EUR scenario. Due to this sharp decrease in 2010 the number of people potentially experiencing serious nuisance may also be expected to remain under the 2007 level in 2030 in all three scenarios (respectively -5 %, -38 % and -49 % for the REF scenario, EUR scenario and VISI scenario), despite the increase of the traffic intensity.

13.4 Conclusions for policy

Despite the measures already planned at a European and Flemish scale, the anticipated growth in road traffic means that the exposure of the population to environmental noise levels that are generally described as unhealthy in the scientific literature and by the WHO increase continuously in the REF scenario between 2006 and 2030. The percentage of Flemish residents who potentially experience serious nuisance due to road traffic noise also continues to rise.

Exposure and potential serious nuisance from rail traffic decrease in the REF scenario. On the one hand this is due to the break with the trend as described in Chapter 6 Transport and on the other hand due to the introduction of the European TSI. A decrease in exposure is anticipated for air traffic both at the Brussels Airport and the Oostende-Brugge airport in the short term. This is due to the measures planned at a Flemish and federal level. These measures do not, however, succeed in compensating for the noise as a result of the growth in traffic intensity in the longer term.

The EUR scenario assumes that the government will take additional thorough measures as regards road and rail traffic noise in the noise action plans drawn up in the context of the European Environmental Noise Directive (END). It must be possible effectively to reduce the exposure of the population to high levels of environmental noise and the potential serious noise nuisance. This is apparent from the measures considered acceptable in the simulations. The percentage of the area of potential quiet areas that are not continuously disturbed by road traffic noise is also significantly higher in the EUR scenario than in the REF scenario. This is on condition that the measures are not only implemented locally by the most exposed locations (black spots).

In air traffic a further modernisation of the aeroplane fleet results in more quieter aircrafts – a trend that is already in progress in the market – ensures that the increased traffic intensity neutralises the growth of exposure.

A decrease in exposure is only feasible in the long term however with the package of measures given in the VISI scenario, including a thorough renewal of the fleet.

The recommendation to policy is not to allow the drafting, approval and execution of noise action plans (in accordance with the European Environmental Noise Directive) from being a dead letter and to allow these action plans to go further than the roads, railways and agglomerations that are a part of the European directive. This is possible by taking adequate measures with positive effects for the entire territory. Spatial planning policy and guidelines for the layout of roads and the choice of road surfaces must certainly not be lacking from here.

LIKE TO KNOW MORE?

If you would like to know more, you can consult the scientific report, which forms the basis for this chapter:

Botteldooren D., Dekoninck L.,Van Renterghem T., Geentjens G., Lauriks W. & Bossuyt M. (2009) Lawaai. Scientific report, MIRA 2009, VMM, www. milieurapport.be.

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Botteldooren D., Dekoninck L. & Gillis D. (2008) Zwarte punten voor geluidshinder door straatverkeer in Vlaanderen. Steunpunt Mobiliteit & Openbare Werken - Spoor Verkeersveiligheid.

SLO (2008) Schriftelijke enquête ter bepaling van het percentage gehinderden door geur, geluid en licht in Vlaanderen. SLO2 – meting, Flemish government, Department for the Environment, Nature & Energy.

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14 Flanders in transition?

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OUTLINES

- The impact and speed of climate change, the end of fossil fuel stocks and unstable energy prices set great challenges for society. A sustainable low carbon economy where the use of fossil fuels and greenhouse gas emissions are minimal is essential and at the same time also opens up interesting investment prospects.

- A sustainable low carbon economy cannot be realised solely with product and production process optimisation. Structural changes are needed in the systems that fulfil social functions such as the energy, materials, mobility, food and housing systems. Such changes require a lot of time. Consequently, the transition to a sustainable low carbon economy must be started now.

- Initiating the transition to a sustainable low carbon economy requires thinking in a system perspective, steering the actions and decisions of individual actors with a supported long-term vision, and developing and scaling up innovations that fit with it.

- Traditional policy instruments are necessary for this but are inadequate. Additional policy is required aimed at long-term structural changes (25 to 50 years) and serving as the strategic orientation for the 'regular' policy (aimed at the short- to medium-term). This kind of transitional approach can help realise the breakthroughs and the green economy in which the Flemish Coalition Agreement, the Pact 2020 and Flanders in Action are investing.

- Transition processes require networks in which forward-thinking actors from government, business life, civil society and science are involved. Leadership is expected from the government, amongst other things through stimulating policy integration at a larger scale than today, by creating spaces for experimentation and by investing in networks. This also requires a transition in the culture and method of the government itself.

Introduction

The previous chapters of this Environment Outlook 2030 describe the extent by which Flanders achieves the intended environmental quality in various scenarios. The visionary scenario is the furthest reaching. This scenario sets ambitious targets: by 2030 greenhouse gas emissions must have decreased by 50 % compared to 1990, even by 60 to 80 % by 2050. This means that Flanders must develop into a low carbon economy, an economy in which the use of fossil fuels and greenhouse gas emissions (mainly CO_2) are minimal. This development to a low carbon economy is part of a broader transition to a sustainable society. A high quality of life is striven for without exceeding the environmental capacity and with respect for national and international justice.

This raises the question of how the transition to a low carbon economy can be initiated and what role the government and other actors can play in this. The first part of this chapter explains why the transition to a sustainable low carbon economy is needed and must be started now. Historic transitions and processes that played in them provide knowledge about the circumstances in which transitions occur. This is considered in the second part of this chapter, after which the framework of analysis is applied to the energy system. The energy system is one of the crucial systems for switching to a low carbon economy. The sections below include a number of handles for policymakers and other actors who want to tackle the transition to a sustainable low carbon economy.

14.1 Urgently required: transitions

The raw material stocks and the regeneration capacity of the earth are limited. Indicators such as the ecological footprint indicate that the ecological capacity of the earth is more than exceeded at this moment (WWF, 2008). Furthermore, according to the most recent estimates by the United Nations, the world population will increase by over 30 % between now and 2050. If 'western' production and consumption patterns are adopted worldwide this will result in a huge additional pressure on man and environment. Consequently, a structural change of direction is required, in the first place in industrialised countries.

Climate change is an important example of exceeding ecological capacity. Based on the scenarios of the Intergovernmental Panel for Climate Change (IPCC), the EU leaders held the opinion in 1996 that the average global temperature increase compared to the pre-industrial level must be limited to 2 °C to prevent the most dangerous and irreversible effects of climate change. To stay below this 2 °C limit, industrialised countries must decrease their greenhouse gas emissions by 80 to 95 % by 2050 compared to 1990, according to the most recent IPCC report. Furthermore fossil fuel stocks are finite. The low carbon economy presented in the visionary scenario in this Environment Outlook 2030 is therefore crucial in the long term.

The drastic reduction in emissions required for a low carbon society cannot be realised simply by implementing innovative products and production processes. Structural changes are necessary in the socio-technical systems that fulfil social needs such as heating, lighting, housing, travelling and nutrition. A socio-technical system is a complex, connected whole including knowledge, technology, institutions, structures, physical infrastructures, practices and habits, formal and informal rules, and actors on both the supply and demand side.

Thus, the visionary scenario for households and trade & services demands a fundamental change to the housing system (see Chapter 3 Households and trade & services). This not only relates to the use of new technologies (e.g. highly developed use of renewable sources of energy) but also redesigned planning and organisational structures (e.g. decentralised energy provision at a district level), actors who operate differently (for instance the construction of extremely low energy housing requires adjustments in the construction sector), new and existing institutions that implement new rules and frameworks of ideas (e.g. extremely low energy housing becomes the norm), etc.

Such fundamental, structural change processes in socio-technical systems are described as transitions (Rotmans *et al.,* 2001). Transitions have always taken place. Consider the industrial revolution in the second half of the 19th century. The ICT revolution is a more recent example, which resulted in completely new communication and information processing technologies, practices, institutions and structures over the last four decades. The development of social security is an example of a predominately non-technological transition, in which a new system was set-up to offer minimum protection to workers and to raise the standard of living.

Transitions are characterised by convergent changes at an economic, social, cultural, technological and institutional level. These are therefore complex processes in which many actors are involved and that change structures and practices that are deeply embedded in society (Loorbach, 2007). Naturally, such processes require time: transitions generally take place over several generations. Consequently in order to realise a low carbon economy by 2050 the transition must be initiated now.

This kind of transition also offers pronounced opportunities. For instance a low carbon economy may offer a solution to unstable fuel prices, which are the result, amongst other things, of the dependence on a limited number of exporting regions. In financially hard times the possibility of a low carbon economy and, in the broader sense, a green economy, also offers attractive investment perspectives to a lot of governments. The British government, the European Commission, the Obama administration and the United Nations Environment Programme (UNEP) have all set up studies and initiatives.

The major social partners in Flanders recognise the need for transitions to sustainable systems. Flanders is facing major social challenges such as the financial and economic crisis, the energy issue, climate change and mobility problems. The Flemish Government, the social partners and the organised civil society consequently concluded a future pact for Flanders in January 2009. This so-called Pact 2020 reflects their joint long-term vision and strategy and formulates targets and actions for 2020. Amongst others, the Pact 2020 explains the intention to take major steps in the transition to a sustainable energy system, sustainable materials management and sustainable mobility. All these systems are crucial for the switch to a sustainable low carbon economy. The Flemish Coalition Agreement 2009-2014 also includes starting points for transitions. The breakthroughs, the renewal of the DNA of the Flemish economy, the green economy and the major projects for social renewal which the Flemish Government invests in, may find inspiration and strategic orientation in the transitional approach. The Flemish Government also confirms that it wants to continue the current Flemish transition processes in sustainable housing and building (DuWoBo) and sustainable materials management (Plan C). It now comes down to putting these intentions into action.

14.2 When do transitions arise?

The research into transitions tries to understand how transitions occur and thereby wants to give a strategic insight to initiate and accelerate transitions to sustainability. Important lessons may be drawn from a good understanding of (historic) transitions and mechanisms that play a role in this for our present society to succeed in the transition into a more sustainable society.

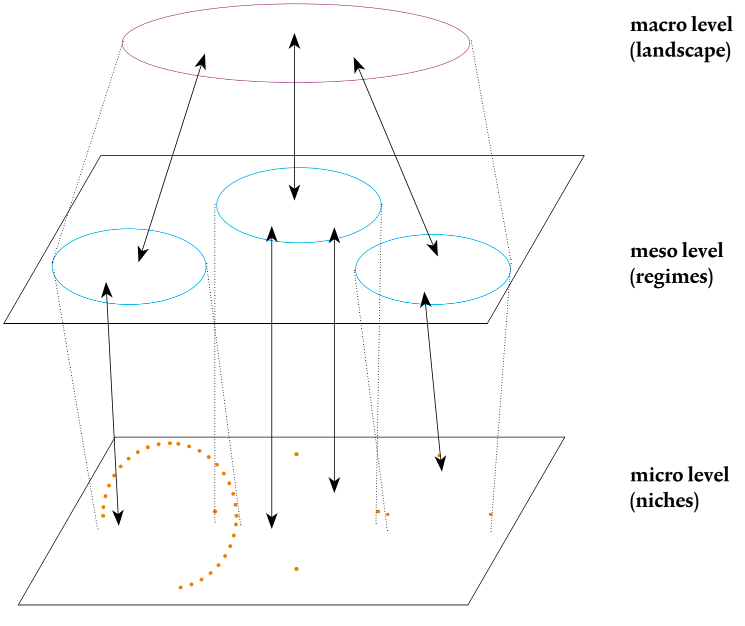
The multilevel perspective

Transition researchers use the multilevel perspective (MLP) for the description and analysis of transitions (Geels, 2005). According to this perspective transitions arise when developments at different scale levels reinforce each other. These levels are often indicated as the regime, niches and the landscape and they may be described as follows (FIGURE 14.1):

- The regime is the 'prevailing' way to meet social needs, the people, technologies, institutions and structures that ensure them and the rules and frames of reference that are applied. Or further: the dominant structure, culture and practices. For instance, the regime for passenger transport is determined to a significant extent by the car and everything needed to drive it: the industrial structure (e.g. car producers), the maintenance and distribution network (e.g. car salespeople, garages), the logistics supply system (e.g. petrol stations, petroleum companies), the artefact itself (the car with all its components), the road infrastructure and the traffic system, the regulation (e.g. traffic regulations, insurance policy), the preferences and skills of the driver, the symbolic and cultural meaning of the car (e.g. freedom, individuality), the perceptions of the problem (e.g. as regards safety and traffic problems), the directions for finding solutions and frameworks of reference applied (e.g. to solve traffic jam problems). A network of actors and social groups (from engineers to car drivers and interest groups) allows the regime to operate day after day and continuously reproduces it.

- The niches include the radical innovations, new methods to meet social needs, practices that deviate sharply from the usual way of doing things. This may relate to technological innovations (e.g. solar powered electric cars), but also to socio-cultural innovations (e.g. carpooling) or combinations of these (e.g. working from home or telecommuting). They may be initiated by entrepreneurs but also by consumers and social movements. The practices and technologies in niches are initially not very stable and are not high-performing but are supported by small, dedicated networks. The existence of a niche does not say anything about its desirability or sustainability.
- The landscape relates to the major social developments in the field of politics, culture and world views (e.g. globalisation and individualisation), to natural characteristics that are hard to influence and generally change slowly (e.g. the climate,

FIG. 14.1 *The multilevel perspective of transition theory*



Transitions in socio-technical systems may be understood as a result of the interaction between different levels. Transitions take place against the background of a slowly evolving landscape that has a strong impact on the evolutions in the other levels. Regimes comprise reasonably stable networks and markets, familiar technologies, institutions and infrastructures, rules that structure activities. Niches are the least stable but may rely on innovators and entrepreneurs who are prepared to take risks.
Source: Geels (2005), Kemp & van den Bosch (2006)

biodiversity, natural resources) and unforeseen events (e.g. Chernobyl). They form the wider environment in which regime and niche players have to act but on which those players do not have any direct influence.

Regime is generally stable

A regime is generally stable. The various elements that are part of the regime are linked to each other and interdependent. The example for the passenger traffic regime illustrates this clearly. Stability is created for instance because people and organisations in the regime are interconnected. They have established interests, obligations and commitments, mutual agreements that cannot simply be broken. The material components of the regime are another important stabilising factor. The car itself, the production lines, the road infrastructure, garages, etc. cannot simply be changed drastically. They often represent large investments and their components and subsystems are often technically complementary. All kinds of users, both companies and consumers, have adjusted their behaviour to it, are familiar with it and know how to use it.

The mutual connections in the regime result in what is called co-evolution in transition theory: if one part of the regime changes, all the other parts will also change. The combination of stability and co-evolution explains why socio-technical regimes do not generally change radically but gradually. Car companies put new technologies and cars on the market to improve their market position, which results in counteractions from other companies to prevent them from losing their market share. In turn this has an effect, for instance on the purchasing behaviour of consumers. Or the government may consider acting in a regulatory fashion for certain improvements. In the 'play' that develops between the actors, the system and rules may gradually change. However due to the mutual dependence and interconnection this will rarely take place brusquely. At the time that a lot of social systems are confronted with sustainability issues, stability in the regimes may prevent breakthroughs.

Conditions for transition: mature niches may break through when the regime is under pressure

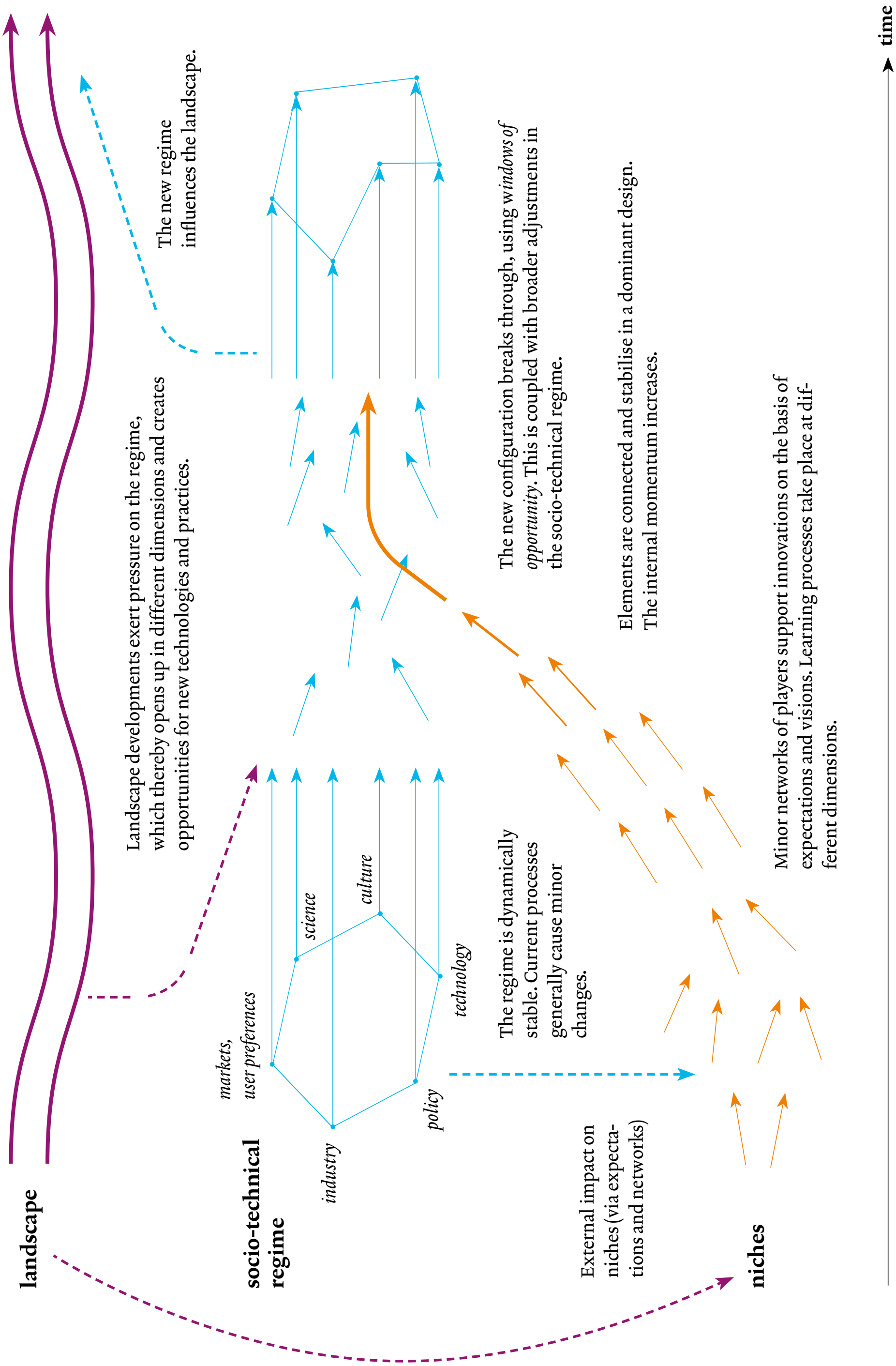
Nevertheless it is apparent from historical research that there are also periods in which the stability of the regime is increasingly disrupted and more radical changes occur. Technologies and practices that are in the niches and deviate strongly from the regime are then given the opportunity to break through. They will then compete with the existing regime and may eventually replace it or thoroughly change it.

However, simply because a radically different niche exists does not mean it will break through. A central insight of the multilevel perspective is that the interplay between the levels is fundamentally important (FIGURE 14.2).There must be sufficient pressure on the regime to open up possibilities to change the regime: so-called *windows of opportunity* in which innovation can develop. This pressure may be the result of developments at a landscape level or of growing contradictions in the regime itself. If *windows of opportunity* open up then niches that already enjoy a certain level of maturity have more chance to break through. We will briefly explain these three factors:

- The regime is put under pressure due to changes to the landscape. Important developments to the landscape at this time include climate change, the financial crisis and population pressure. It may also relate to incidents like the nuclear disaster at Chernobyl. These factors put regimes and the prevailing approach of thinking and acting under pressure. For instance, climate change forces us to consider our customary methods for energy supply or transport.
- The regime is put under more pressure due to growing internal contradictions. The logic of the regime makes it hit its own boundaries. The traffic jam issue is a striking example in the mobility regime. Traffic jams arise due to a combination of external causes (e.g. town and country planning) and internal logic aimed at constantly faster, further and more. Other problems that the mobility regime creates itself are the level of fatalities and injuries, the emissions of harmful substances, noise nuisance and use of space. Our customary method of transport is thereby put under pressure through internal processes.
- Due to pressure from the landscape and/or through internal regime contradictions *windows of opportunity* may then open, windows in space and time in which deviating niches have the opportunity to break through. These niches can change the regime, with the actors involved in it, the prevailing culture, the practices, institutions, etc. In the case of the mobility regime, various types of niches try to respond to the problems of the regime and to landscape pressure: technologies like hybrid and electric cars, replacing car use with public transport, cycling or walking but also formulas like satellite offices, working from home and carpooling. Niches must have a certain level of maturity to break through: the technology or practice must be sufficiently developed and tested, there must be a network behind it that has some influence and people must be convinced that the niche practices offer an effective answer to the problems with which the regime is struggling. Multiple niches will often exist beside each other, which all try to benefit from the instability of the regime. Which niche or which combination of niches eventually gains the upper hand is impossible to predict at the beginning of a transition.

Large social transitions are consequently the result of the interaction between landscape, regime and niches. They generally take place over a long term, roughly 25 to 50 years and many actors are involved in them. This relates to a broad perspective on change and innovation: technology, institutions, regulations, policy, socio-cultural meanings, networks of actors and practices by consumers are a part of it. This type of insight also gives indications of how policymakers and other players who

FIG. 14.2 *A dynamic version of the multilevel perspective*



The cohesion in the regime may be disrupted due to pressure from landscape developments and internal regime issues. At that time niches have a chance to break through and to change the regime fundamentally. New technologies and practices are integrated, new players are a part of the service.

Source: based on Geels & Schot (2007), Kemp & van den Bosch (2006) want to stimulate sustainability transitions may strategically orient themselves:

- thinking in the long term;
- trying to make connections between growing contradictions in regimes, pressure from the landscape and niches developing to maturity;
- supporting promising niches but keeping sufficient options open;
- making connections between policy domains that are relevant for a transition;
- developing forms of reflexive steering in which learning processes are central, including adjustments resulting from this and an institutional organisation that must be able to cope with them.

We return to these and other policy implications in parts 4, 5 and 6 of this chapter.

14.3 Energy system on the road to transition?

The energy system is one of the systems that are crucially important for the switch to a low carbon economy. When we look at the energy system from a multilevel perspective, it is clear that the regime, the landscape and the niches are in a state of flux.

Energy regime is under pressure

The current energy regime is mainly based on petroleum and natural gas for heating and transport, whereas the largely centralised electricity production is primarily based on nuclear energy, natural gas and coal. As a result of these structural characteristics, the regime comes under pressure from landscape factors and problems that it has caused itself.

The European Union (EU) is for example highly dependent on imports for its fossil fuels. Moreover the main fossil fuel stocks are concentrated in a few, often politically unstable regions. The EU consequently has little control over supply and pricing and this makes the economy vulnerable. The reality of this problem is proven by the numerous geopolitical conflicts and the unstable, sometimes worryingly high prices of recent years. At the same time we witness a huge economic growth in countries like China and India, which also demand their share of the fossil fuel pie. Some people fear that a situation may already develop in the medium term in which global demand will exceed the supply of conventional oil and gas. Furthermore, particularly in relation to petroleum there are increasingly more indications of 'peak oil': the conclusion that global production is at its maximum and may only decrease in the coming years (De Almeida & Silva, 2009).

The dominance of fossil fuels in the current energy regime is one of the main causes for climate change. Greenhouse gases are not only created at combustion but also in transporting fossil fuels from exporting regions. The electricity production from nuclear power stations may have a better track record than fossil fuels as regards the emission of greenhouse gases, however there is still no appropriate solution for the growing amounts of radioactive waste. Safety aspects also form a major obstacle to the further development of nuclear power. Furthermore uranium stocks are finite. In addition, centralised, large-scale electricity production struggles with heat and transport losses.

Attention to these problems is increasing and policymakers are taking initiatives to tackle them. As a result the regime is put under pressure to change, *windows of opportunity* develop in which deviating niches have the chance to break through. Due to the increasing fear for climate change the EU has set the so-called 20-20-20-target. This must lead to lower greenhouse gas emissions, a larger share of renewable energy and better energy efficiency. The Flemish Government, the social partners and the organised civil society also undertake in the Pact 2020 to diversify the energy supply further, to increase the production capacity structurally with a view to maximum supply security, to allow the share of renewable energy to grow and to ensure competitive prices. Furthermore, decentralised electricity production, smart electricity meters and intelligent power grids will be stimulated.

Increasingly more countries are consciously trying to use regime problems such as the uncertainty of supply, unstable prices and climate change as opportunities for economic development. The economic crisis offers extra chances to restructure economies on a sustainable basis. As already mentioned above, the Flemish Government recognises the opportunities for the switch to a green economy in its 2009-2014 Coalition agreement.

Niches are ready

At the same time an entire series of niches grew that deviate to a greater or lesser extent from the practices in the energy regime and that generally answer the problems in that regime. The diversity of niches is large. They may be found both on the supply and the demand side and may relate to renewable energy or more conventional technology. Some alternatives have already gained market share, for instance wind turbines and low energy light bulbs. Other niches are ready to be applied on a wide scale, are in a pre-commercial phase or still in development: photovoltaic cells, micro co-generation, passive house technology and zero energy housing, smart energy networks, green chemistry, etc. In addition there are niches with services or product service combinations such as energy audits, relighting or pre-financing by energy service companies. The sustainability of certain niches, including the co-firing of biomass, new nuclear options and carbon storage are currently the subject of passionate debate. Some argue that these technologies maintain the current regime and slow down the transition to a truly sustainable energy system. Others see these technologies as a transitional phase or even as a part of a new regime.

Furthermore a niche includes more than a new technology or service. A niche is essentially a network of actors who develop a new technology or practice and build-up knowledge around that innovation, develop business models, experiment, lobby, etc. A new niche also means new actors and the creation of new relationships. For instance buyers also become suppliers of power to the grid in the decentralisation of electricity production. New cooperative agreements (e.g. for collective energy systems at a district level) and new connections between niches also develop. For instance, the heat from the servers in the datacenter of the Flemish Environment Agency is recuperated for a district heating system.

But will society reap the maximum benefits from the transition?

The patterns that played a role in the past in transitions can now also be found in the energy system: strong landscape pressure, severe regime problems, a range of growing niches. As a result a lot of opportunities arise to initiate a transition in the energy system. To realise the drastic reductions in emissions by 2050 required to avoid the most harmful effects of climate change, it is necessary to seize the opportunities now. Just like every transition, the transition of the energy system requires fundamental, structural changes to the entire society: in infrastructure and technology on the supply and demand side, spatial planning, regulations, institutions but also in the way of thinking and acting amongst companies and consumers, the steering method of the government, etc. And the majority of those structural changes have not yet or have only just been initiated.

Furthermore the energy transition may not simply go in any direction. The intention is to develop into a *sustainable* energy system, as is also recognised in the Pact 2020 by the social partners. This means an energy system that contributes to a high quality of life but within the environmental limits and with respect for a fair division worldwide. That leaves multiple interpretations open but not just any. The social debate about this issue still has to start to a large extent. Although sustainability has gradually become an established term, in the energy debate it is still lower on the agenda than concerns such as competitive strength, prices and security of the supply.

14.4 Influencing transitions: an overview of the ingredients

Why is a transition approach necessary?

The considerations above raise the question of what approach is required to start transitions or to speed them up and to orient them in the direction of sustainability, and what role the government and other actors may take in this.

This debate is still recent. Democratic societies generally show a mixture of three types of policy approaches:

- a traditional top-down steering by the government (e.g. via regulation);
- a market-oriented approach that primarily works via pricing instruments (e.g. subsidies and taxes);

- a type of *governance* that invests in broad, transparent networks by public and private partners, in which policy is developed by thinking, doing and learning together. The government can initiate those networks but the initiative may also come from others. Furthermore, the government does not necessarily have the lead over it. It is a partner, alongside the other actors but one that gives a direction, creates conditions, makes connections and opens up opportunities. Leadership is consequently expected from the government both as regards content and process.

In the scientific debate on sustainability transitions preference is given to the latter approach: a form of *governance*. After all, a transition is a long-term process that takes place at different levels and between many actors and domains and that responds to structures and practices that are deeply embedded in society. The government cannot only realise the radical 'system innovations' required for this via regulations or pricing instruments.

This is not to say that regulations or pricing instruments will become unnecessary from now on, on the contrary. It comes down to searching for how different approaches complement each other. In this way pricing instruments, which amongst others are intended to internalise the environmental costs in the prices, are very important to initiate and accelerate the transition to a sustainable low carbon economy. For instance this is apparent from the visionary scenario for energy production. In that scenario, green power certificates, guaranteed minimum prices and high CO_2 prices in the European emissions trading system make it possible to reduce the greenhouse gas emissions from power production in Flanders by two thirds (see Chapter 7 Energy production).

However, internalising the environmental costs in the prices is not an easy matter, especially if the policy is inadequately coordinated on an international level. Furthermore, more is required than pricing instruments. A green tax system or creating new markets for environmental assets such as emission rights may offer an answer to one form of 'market failure': the external environmental costs of the production and consumer behaviour that are not included in the market price. But another form of market failure plays a role in transitions, namely the fundamental uncertainty of the future markets. This uncertainty makes it impossible to calculate the return on investment for certain investments, even if the environmental costs are entirely visible in the current prices. This is because other future costs and benefits are not adequately known if there are still too many possible scenarios. The functioning of the market may only be restored and the business risk for investments in radical innovations again controlled to a certain level if a shared future expectation is created. A shared future expectation moreover not only influences the investment decisions but also the decisions, practices and habits of consumers, researchers, etc. A supported long-term vision, backed by the government with a stable policy framework is a powerful instrument to create such a shared future expectation.

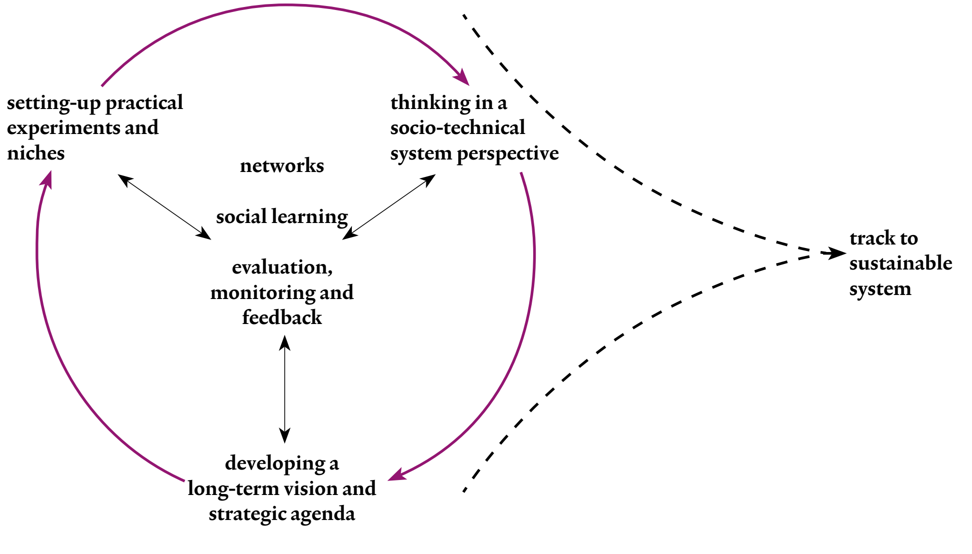
The effect of pricing instruments is also limited in the short term by the fact that regimes are stable. Because of this stability, the economic action of individual players is spontaneously aimed at further maintaining and optimising the existing systems. Radical innovations that deviate strongly from the regime have little chance. Pricing instruments may for instance ensure that the demand for electric cars increases compared to diesel and petrol cars. But there must also be loading points, investments to expand the capacity of the electricity grids, standardisation of plugs and batteries, etc. To correct this 'system failure' and to accelerate the development and breakthrough of radical innovations, it is necessary to bring together actors, to define a vision, to set-up joint experiments, etc.

Ingredients for a transitional approach

Summarizing, it may be said that traditional policy instruments are necessary but insufficient to get the development and breakthrough of radical system innovations off the ground. As described above it is also essential to steer the actions and (investment) decisions of individual players with a supported long-term vision, to bring actors together, to set-up experiments together, etc. An additional, specific policy approach is required for that in which (pro)active government works together with other actors. We describe this approach here as transition governance: a combination of methods to try to speed up transitions and steer them in a sustainable direction. Two important notes here are:

- A clearly described, universally applicable recipe for transition governance does not exist. Scientific literature on this subject does put forward a number of usable 'ingredients' (see also FIGURE 14.3). A number of these elements are considered in what follows, with reference as to why they are necessary and what role the government and other actors could take.

FIG. 14.3 *Characteristics of transition governance*



- It would completely contradict the complexity and uncertainty of transitions as described above to propose transition governance as an infallible recipe. It is a process of searching, trying, learning, succeeding and sometimes failing, of small and larger steps. However always with a strategic long-term objective in mind, such as the transition to a sustainable low carbon economy.

Thinking in a socio-technical system perspective

In order to be able to influence transition processes, reality must be considered from a system perspective. The systems responsible for meeting social needs – such as the energy system, the materials system, the mobility system, the food system, the housing and building system and the care system – almost all struggle with persistent problems: complex, difficult to solve, socially and institutionally deeply embedded and a source of a lot of sustainability problems. Examples have been given previously in the text from the mobility and energy system. Such problems cannot be resolved purely with new products and technologies. They require an approach at a socio-technical system level, whereby an image is formed of the various connected components of the system.

The need for such an approach at a socio-technical system level may be illustrated on the basis of the visionary scenario for transport (see Chapter 6 Transport). This scenario particularly acts on the 'mode of transport' system, amongst others through an increased share of electric cars, plug-in hybrids and hydrogen driven cars, the increase of the number of passenger kilometres by bike and by public transport and replacing a part of the truck kilometres by rail and inland shipping transport. There is much less intervention on the demand for transport, specifically the number of vehicle kilometres. The assumption is that the number of truck kilometres will decrease due to better economic and planning organisation, higher loading factors and larger trucks but we cannot really say this is a thorough change to the mobility system. Despite far-reaching technological measures the indicative target of the visionary scenario in the transport sector – a reduction of greenhouse gases by 50 % in 2030 compared to 1990 – will not be achieved. To realise greater gains, the number of vehicle kilometres must fall even further. In other words, the system must be extended from the 'mode of transport' technology to the 'mobility' function so that space is made for a combination of diverse innovations: technological, socio-cultural, institutional ... A long-term perspective of system innovation may then broaden the outlook, for instance to far-reaching redesign of space, to new mobility concepts but also, for instance, to the regionalisation of production and consumption, to transport systems that work at lower speeds and in shorter distances or to new modes of transport (e.g. pipeline transport).

In more general terms the system perspective shows that the transition to a sustainable low carbon economy is almost irrevocably coupled to another view of what a thriving society is. A lot of different lifestyles are possible but citizens will develop new daily routines and have other ideas of what a good life is, companies will search for new business models, other institutions will give shape to society. In addition to the major role for traditional innovation actors (business, knowledge institutions, governments) in a transition there is also a clear role, for instance, for the social economy, organisations in the socio-cultural sector, associations and citizens' initiatives. The Flemish transition processes on sustainable housing and building (DuWoBo) and sustainable materials management (Plan C) certainly give the good example here by also developing initiatives around new forms of housing and living districts (DuWoBo) and around product-service combinations and responsible consumers (Plan C).

The system perspective also makes the need for policy integration clear. Indeed, the innovations needed for sustainable systems or a low carbon economy exceed the traditional fields of individual policy domains. Different policy domains (environment and energy, transport, economy, science and innovation, etc.) will consequently have to combine their strengths.

The innovation policy will also have to adapt. For instance, traditional innovation studies approach the issue of a low carbon economy almost exclusively from the perspective of new technologies that are required, amongst others, in the energy or mobility system. A redefinition of innovation theory and innovation policy appears to be necessary in at least three fields in a transition context:

- from innovation primarily in function of economic growth towards innovation aimed at solving much broader social questions;
- from innovation that primarily thinks in terms of technology to the integration of technological, institutional and socio-cultural innovations;
- from process and product innovation to system innovation.

Developing a long-term vision and strategic agenda

The transition literature generally pays a lot of attention to the formulation of long-term visions. These are images towards which the system should finally develop. Such a long-term vision is not formulated in the form of unequivocally defined objectives but rather as a broad orientation that leaves space for different paths. The formulation of visions for the future has various purposes:

- offering a strategic orientation, which social actors and policy can aim at;
- generating a learning process whereby the view of today and possibilities for the future change.

Strategically speaking a long-term vision is intended to 'attract', to influence the future expectations and actions of social actors, for instance in decisions over long-term investments. A broadly supported vision ensures some congruence in the actions of divergent individuals and parties. It makes it possible to formulate short-term solutions in relation to the outlook.

The government plays an important role in the success of a vision. Research has shown that a reliable government that sets long-term policy objectives and consistently acts to them, has a major impact on actions by social actors and certainly on investment decisions of companies, including in sustainable energy technology. If the government has doubts and does not know what direction it wants to move in then entrepreneurs will be less willing to take risks and innovations will stagnate. The government must be able to implement such an orienting vision and develop a (more or less) cohesive strategic agenda on that basis. This is not easy. The government must in fact also progress through a kind of transition: towards a learning organisation, which responds flexibly to new developments in society, with officials who work across policy domains and are not put into a straightjacket that discourages initiative. Management plays an important role in this.

In order to generate recruiting power, a learning process must also occur during the development of a long-term vision. During the process of vision formation one considers the problems from a system perspective which the existing regime is struggling with on the one hand, and the various types of innovations that might possibly offer a solution to those regime problems and that allow the system to develop in a sustainable direction on the other. In that way existing patterns of thought may be broken. Ideas that are stuck in a rut may change, new insights and new opportunities for action may spring up, beyond that which the established actors consider the normal state of affairs. Those learning effects may for instance break through the traditional thought patterns that energy supply can only be assured by investing in production capacity. They may lead to the insight that energy supply may also be guaranteed by drastically decreasing the energy demand. This insight may in turn open up a new range of opportunities for innovation.

It is important that those learning effects are not considered too idealistically. New modes of thought require time and it is not obvious to reformulate one's own interest so that it gradually fits within a communal interest. Sometimes interests simply remain incompatible. Therefore, not every vision formation process will result in new insights and not every vision has the same recruiting power. It is a question of navigating between images on the one hand that appeal to the imagination, innovative and creative (but without appearing utopian and infeasible) and on the other hand concrete images that are experienced as too directive and only suited to a limited group of actors.

To increase the chance of success it is recommended to give interactively and participatory shape to visions and to do so for at least two reasons. Firstly new insights are primarily the result of confrontations between ideas and of an introduction to a diversity of options. It is consequently important that a sufficiently diverse group is involved in the formation of a vision. The transition literature argues mainly to involve niche actors and forward thinking regime actors in the formulation of images of the future; existing ideas about a system may only change in that way. Established regime actors will not tend to question the system of which they are part fundamentally. Secondly an interactive approach is required so that the actors involved may identify with the vision. Visions may open up a potential for change but that must also be realised in practice. Identification is crucial for this.

Setting up practical experiments and developing niches

Transition governance is not limited to drawing visions, setting-up participatory processes and initiating learning processes. It also explicitly targets practical experiments in which innovations that may fit in a more sustainable system are tested on a small scale. It is possible to learn at different levels from such experiments: about the knowledge development and exchange required between businesses, the sustainability aspects of the innovation, the extent by which it fulfils user requirements, social acceptance, conditions for application, etc.

Experiments have a strategic finality: bringing a sustainable system (e.g. a sustainable energy or mobility system) closer. Setting-up experiments where niches subsequently develop and trying to link those niches to regime problems is, indeed, an important strategy for those wanting to influence transitions. A portfolio approach in which multiple routes are tested in parallel is advisable in this to avoid an early *lock-in* to a single path.

Setting up experiments and developing niches is certainly not the exclusive domain of the government. Nevertheless both central and local governments, in all policy areas, may play an important role by creating shielded experimentation areas. An example of this includes the educational testing sites where schools try out innovations on a limited scale for a definite period, separate from certain rules. Creating space for experimentation is possible amongst others via (a combination of) subsidy systems (e.g. for renewable energy), regulations and practical experiments (e.g. electric cars for municipal services). The government can kill two birds with one stone, by creating shielded space for experimentation. The breakthrough of the niches is stimulated by testing innovations and creating a market and a contribution is made to the solution of urgent social problems. Innovation thereby becomes more than the motor for the economy, it becomes the motor for sustainable development. An example of this is the Flemish catch-up operation for school building. While all new schools must comply with strict energy standards, the government is also investing in the construction of 24 passive schools. In this way a space for experimentation and a market are created for the application of the passive house standard in large public buildings, the energy bills for the schools are reduced substantially and a contribution is made to the reduction of greenhouse gas emissions.

But as mentioned the government is only one player, albeit an important one. For instance, passive construction was not invented by the government. Trendsetting businesses, knowledge centres and scientific institutions, consumer organisations, NGO's and association life play at least an equally important role when they want to respond to transition ideas. This also benefits the diversity of the niches. In general, transition literature pays a lot of attention to technological niches and that is certainly interesting from a business perspective. Business may however also develop niches for services or product-service combinations, in the same way as the social economy or socio-cultural sector. Sustainable non-technological niches may also develop from associations that challenge the regime (such as food teams, carpooling or Local Exchange and Trading System (LETS) groups; also see the inset text *How EVA works on reducing meat consumption* for an example of non-technological innovation).

There is still a lot of work to be done in the field of consciously developing and allowing niches to mature. Research has shown that niches must in fact be seen as innovation systems that have to fulfil a number of functions to bring the innovation to development (TABLE 14.1) (Hekkert *et al.*, 2007). The functions must each separately be fulfilled properly, but if they strengthen each other the technology or service has more chance of breaking through. This function approach has as yet mainly been applied to technological innovations but is certainly also usable for the development of non-technological niches.

Fleshing out the functions is again the shared responsibility of entrepreneurs, other actors and the government. The government can play a role at different levels. For instance, it has an important function to 'give guidance to the search' (F4).

How the EVA works on reducing meat consumption

According to the Food and Agricultural Organization (FAO), the agricultural organisation of the United Nations, cattle breeding is responsible worldwide for 18 % of the total greenhouse gas emissions. Moderation of meat consumption should consequently be a key element in the transition to a sustainable low carbon economy. In transition terms this means that the innovation 'eat less meat' must break through in the existing dietary regime. In a sustainable scenario vegetable products and not animal products would form the basis of our daily eating habits. The organisation EVA vzw (Ethical Vegetarian Alternative) tries to convince the wider public of the benefits of eating less meat. To allow this innovation to gain a foothold an investment is made in learning by experience: users learn about the benefits of the innovation by trying them out themselves in practice. For instance EVA organises cooking lessons and cookery workshops for private individuals and for chefs from restaurants and industrial kitchens. This also makes it clear why learning by experience does not have to be limited to technological demonstration projects.
Nevertheless an innovation can only truly break through if it becomes part of the habits and routines of businesses and consumers.
EVA is trying to introduce vegetarian meals in our dietary habits through the 'Thursday Veggie Day' campaign. The strength of this campaign is based on two aspects. On the one hand preventing the consumer from losing interest too quickly by aiming at minor behavioural changes (one day a week). On the other hand the concept, by presenting a specific day as the vegetarian day, sticks better in people's minds. In due course people may thereby associate Thursday to vegetarian meals 'out of habit'.
Naturally the government may also play a major role in the breakthrough of 'eating less meat', primarily by setting a good example itself. This is possible, for instance, by providing vegetarian meals in all government restaurants (public institutions, hospitals, etc.), following on from current initiatives such as internal environmental care or green purchasing policy. In May 2009 the city of Ghent set a good example by officially naming Thursday veggie day. The main meal in city restaurants (personnel restaurants, canteens in the city's schools) is now vegetarian on Thursdays. At the same time the government has to avoid sending contradictory messages, for instance in the public awareness messages that praise the quality of meat.

If the government is in any doubt and if it frequently changes its objectives, then the innovation will have difficulty getting off the ground or may fall apart again. However if the government creates a clear and stable framework with the necessary financial mechanisms, then the innovation may develop much more easily. This has also already been mentioned in the discussion of the importance of the long-term visions and targets. The second crucial function, F5 'market formation', is necessary to go beyond the development phase. The government can also intervene here, for instance by introducing systems such as the electricity grid feed-in compensation or forms of innovative contracting where the government is itself a requesting party. The government may also implement 'additional policy' when certain system functions are not or hardly fulfilled. Developing that insight does require a system perspective of innovations instead of the linear innovation model that still often dominates at the moment. The linear innovation model assumes that innovation starts by overcoming technical barriers, after which diffusion of new technology must be regulated on the market.

TAB. 14.1 *Functions of technological innovation systems*

System functions	Meaning
F1 Entrepreneurial activities	Without entrepreneurs there is no innovation. Their role is to transform the potential of knowledge development, networks and markets into business opportunities.
F2 Knowledge development	Research and knowledge development are at the heart of innovation. This may relate to how the technology or service works but also to the user requirements, social acceptance, the role of regulations, etc. Learning by experience is a major component of this.
F3 Knowledge diffusion in networks	In essence a niche is a network that tries to promote its innovation. If it is not possible to learn from experience and knowledge consequently remains with one party, this obstructs the development of the niche.
F4 Guidance of the search	Whether businesses and other innovators want to invest depends on the future expectations. Policy aims, visions, standards ... may greatly influence expectations.
F5 Market formation	A new technology or service must compete with the prevailing practices. Temporary protection from competition or the creation of a demand are options here (via quota, measures, tax exemptions ...).
F6 Resources mobilisation	Sufficient human and financial resources are necessary to take innovation beyond the experimental phase.
F7 Creation of legitimacy/counteract resistance to change	The players in the niche must find support for their innovation. They often have to find strategies in this to combat established interests.

Source: based on Hekkert *et al.* (2007)

The innovation system approach shows that networks are crucial for setting-up innovative experiments and developing niches. An innovation cannot break through without a broad, transparent network of actors who believe in the innovation and want to make a contribution to realise the necessary knowledge development and exchange, to develop legitimacy for the change process, to realise sufficient support to continue innovations, etc. The participants in this kind of network vary from researchers, businesses, investors and government to social organisations and citizens.

The government may follow-up on how different functions are met and where additional support is needed. It must consequently invest in networks in a targeted way. 'Investing' does not mean always creating new networks. There are already a lot of innovation networks, from networks that are mainly aimed at the development of technological niches to networks that are explicitly aimed at sustainable systems like DuWoBo and Plan C (see the inset text *The innovation network Cleantechplatform.be*). The government may adjust existing networks in relation to the long-term vision and harmonise them and also set-up new networks where necessary.

Social learning on the agenda

Learning plays an important role in the transition governance process, both during the vision formation and when setting-up practical experiments and developing niches. The learning processes are in themselves important for acquiring new insights. The learning experiences may in turn be used to adjust the long-term vision, the practical experiments and the niche development. As indicated above it is not

The innovation network Cleantechplatform.be

Cleantech is a collective name for products, services and processes on the basis of technologies that optimise the use of natural resources and minimise the environmental impact. The promise of economic value added combined with environmental profit is important here.

On 27 March 2009 the University of Hasselt and the investment company for Limburg launched the Cleantechplatform.be. The goal of this network is to develop the Cleantech activities further in Limburg and Flanders by strengthening partnerships between businesses, investors, administrations, consumers and knowledge centres.

Experts on the content (researchers and government), investors and businesses are brought together in do-tanks with regard to specific themes. Every do-tank searches for meaningful Cleantech technologies, knowledge and projects. All relevant and supported actors (province of Limburg, businesses, knowledge institutions, investors) try to integrate the existing and new networks of the various do-tanks in broader social networks via a think-tank and network activities.

In practice the coordination of existing networks and initiatives sometimes proves more important than setting-up new networks. For instance the coordination of existing networks (knowledge institutions, Limburg Development Agency, Sustainable Building Support Office Limburg, investors, Centre for Sustainable Building) is the main task of the do-tank on energy and building(s). The Sustainable Building Support Office Limburg already guides and stimulates many sustainable building projects. It was apparent within the Cleantechplatform.be that the Sustainable Building Support Office Limburg sought a better link with knowledge institutions (new (building)technology) and investors. Links with the government, sector and civil society already existed.

possible to define the purpose of the transition process – a more sustainable system – exactly and to indicate precisely which route should be taken. Vision formation may give a broad orientation but complexity and uncertainty are characteristic of a transition. Gradually learning about the purpose and path to it is a necessity for all parties involved.

Learning can take various forms. First order learning is gaining new knowledge and the transfer of that knowledge. The various scenarios in this Environment Outlook 2030 provide information about possible developments of sectors and environmental themes in Flanders. This new knowledge may, for instance, inform policy and other actors about the effectiveness of specific measures and technologies and thereby steer their action. This type of knowledge is also crucial for the development of niches (functions F2 and F3 in TABLE 14.1).

However, equal importance is placed in transition theory on a different type of knowledge and learning, namely second order learning. In this type of learning one not only seeks solutions for a problem, but one also tries to reformulate the definition of the problem itself by questioning prevailing frameworks of thought and implicit assumptions. The question is then no longer simply 'Are we doing things well or could we do them better' but also 'Are we still doing the right things'. For instance to solve a (future) problem of traffic congestion, one should not only consider how the (future) traffic flows may be directed correctly but also whether those traffic flows are truly necessary. Second order learning may be stimulated amongst others by long-term thinking in terms of socio-technical systems and multilevel perspectives and through the interaction between insights and practice (learning by experience and experience while learning), for instance in practical experiments.

Second order learning takes place throughout a process of social learning: people reflect on their starting principles, values and practices in discussions with each other in order to find new solutions to problems. As a result their framework of reference changes, problems are redefined and new perspectives for action are opened up. Naturally this seamlessly follows that argued above concerning the importance of long-term thinking. And again: social learning should not be considered too idealistically. Even if insights change, actions do not always follow them. But it is possible to build further on new insights.

14.5 The best-known preparation method: transition management

Defining ingredients is one thing but from a policy perspective the next question is then how these may be implemented, where and by whom. Should policy now fully concentrate on forming visions, experimenting and learning, setting-up networks and participatory processes?

As already mentioned, legal, financial, economic and social policy instruments remain essential. Transition theory and transition governance are actually a new generation of policy concepts that search for supported and workable solutions for new problems that arise and that are more complex, such as climate change. Previous generations of policy concepts and instruments remain necessary but they are supplemented and put in a different context.

In its National Environment Policy Plan 4 the Netherlands was the first to concentrate on transition governance in 2001. Processes were set-up in the domains of energy, mobility, agriculture, and biodiversity and natural resources. In the meantime there are also processes in progress in the care and healthcare sector. Various ministries and many social actors are involved in the processes. There are also two transition governance processes in progress in Flanders: DuWoBo, which is aimed at sustainable housing and building and Plan C that is aimed at sustainable material management. All these processes have similar characteristics:

- they have been set-up as an additional line of policy to the regular policy;
- they are aimed at the long-term and at structural change to socio-technical systems;
- they have sustainability as a strategic goal;
- forward-thinking niche and regime actors are cooperated with;
- practical experiments are set-up to make long-term visions concrete and to develop niches.

Furthermore a specific model was often, but not exclusively, applied, the so-called transition management model. This model tries to combine the various ingredients of transition governance into a single methodological package. The two Flemish transition processes also apply this method.

The transition management model was developed in the Netherlands and is a detailed method to initiate and speed up a sustainability transition for a specific social system (Loorbach, 2007). The model uses a number of typical instruments such as a transition arena, sustainability visions and transition images, transition paths and transition experiments. The central instrument is the transition arena, a place where a limited group of forward-thinking regime actors and niche actors meet. The transition arena is intended to come to a common understanding and definition of the problem for the system that has to be tackled and to develop a sustainability vision for that system. In a second phase the arena is extended with new participants who contribute, amongst other things, to identifying relevant themes and subsystems and to the development of possible transition paths to achieve the visions. The transition agenda brings all the work together and is, in fact, a common action and innovation plan to stimulate sustainability in a specific system. However it does not stop at an agenda: in the next phase transition experiments are set-up to learn and verify whether the transition paths proposed also contribute to the desired change in reality.

The first transition process in Flanders that followed the transition management model approach – DuWoBo – was initiated in 2004 by the Flemish environmental administration. The Dutch researchers who developed the model were directly involved in this process. The second transition management process, Plan C, was started in 2006 by the Public Waste Agency of Flanders (Openbare Vlaamse Afvalstoffenmaatschappij or OVAM). Both processes succeeded in putting a complete transition agenda on paper. Both DuWoBo and Plan C formulated a vision with various transition paths. Both are currently in the stage of setting-up and learning from experiments (see inset text *Plan C and DuWoBo: a few projects*). The two processes are relatively well known in the environmental domain and reach a few hundred people. The oldest process, DuWoBo, succeeds in exercising a certain influence on setting the agenda in the Flemish housing and

Plan C and DuWoBo: a few projects

Eco building pools: spreading knowledge via networks

The transition agenda of DuWoBo, the Flemish transition process on sustainable housing and building, is based on four targets. The 'Close the cycle' target is intended to close the materials and energy cycles. One of the projects following on from this target is the eco building pools project of the Flemish Institute for Bio-ecological Building and Housing (Vlaams Instituut voor Bio-Ecologisch Bouwen en Wonen or VIBE vzw) and its partners. The bio-ecological sector has over 25 years of experience in low energy and water saving construction with as little chemical and/or harmful materials and substances in and around the building as possible. However it is still a niche market. The aim of the eco building pools is to expand the market for bio-ecological construction and renovation via networking. Traditional contractors and architects are brought together with bio-ecological architects and contractors and learn to work with bio-ecological materials and techniques through training (theory and practice), demonstrations, model projects and an exchange of experience. In that way the 'Knowledge diffusion in networks' function of the 'bio-ecological construction' innovation system is fulfilled (Table 14.1).

Chemical leasing: from products to services

Plan C, the Flemish transition process on sustainable materials management, started with a project *on chemical leasing*. *Chemical leasing* is a business model in which the operating profit is not generated from the product turnover but from providing a chemical service. The customer does not pay for an amount of chemical product but for the performance of the product, e.g. cleaned components, painted surface, galvanised parts, etc. The responsibility for the product is kept by the producer and service provider. As a result the latter is motivated to optimise the process and to limit the use of the volumes of substances. This means fewer chemicals are used, they are used better and surplus or residues are taken back by the leasing company which takes responsibility for the recycling so that the materials cycle may be closed. In the first phase of the project, experts explore the potential of *chemical leasing* in Flanders. A number of pilot projects will be started in a following phase. The aim of these pilot projects is to learn about the application and acceptance of *chemical leasing* in Flanders. The analysis of the potential and pilot projects are the first steps in a long-term innovation path.

building sector. The initial experiments of Plan C can also rely on extensive interest. Apart from these tangible results, both processes also have other effects:

- they stimulate long-term thought processes on sustainable development in their field;
- they create a broader knowledge basis concerning system innovations and transitions;
- they ensure networking between organisations and individuals which hardly knew each other previously and thereby generate synergy and a support base;
- they introduce new participation processes in policy formation.

The typical characteristic of the transition management model is that it initially operates in the shadow of regular policy. This makes it possible to consider long-term developments without restraint and to take creative paths. Both DuWoBo and Plan C have consequently also been set-up as experiments in innovative environmental policy. However, now the processes have been started, policy must ensure the preconditions for their operation. And that is where some things get stuck, for instance in the provision of means of action, support from the management structure, support from experiments, flanking by a regulating framework and flow through of developed insights into regular policy. The Dutch energy transition also shows that new factors start to play a part when transition management processes move more to the centre of policy. For instance, traditional conflicts of interest and power relations start to play a larger role amongst other things because established regime actors try to get a grip on the process (Kemp *et al.*, 2007).

In short, Flemish transition management processes can at this point present a good track record. Results have particularly been achieved in the field of the formation of a long-term vision and in dynamizing new networks. However further investments are needed in both processes to give the setting-up of experiments and the development of niches a chance and to make connections to regular policy.

14.6 Conclusions for policy

Traditional policy instruments, in particular pricing instruments, are essential but insufficient to start and speed up transitions to sustainable systems and a sustainable low carbon economy. In order to get the radical system innovations needed for transitions off the ground, it is essential:

- to think in a system perspective so that one gains an insight into a broad range of technological, institutional and socio-cultural innovations.
- to give direction to the actions and (investment) decisions of individual actors by formulating a broad, supported long-term vision for socio-technical systems. This long-term vision must be backed up by a stable policy framework.
- to experiment with innovations that fit with the long-term vision and to develop and scale up niches around those innovations.

This requires a specific policy approach, a form of *governance* in which the government and other social actors can cooperate in developing policy. This is typically framed as an additional line of policy aimed at long-term structural change (25 to 50 years) and that must serve as inspiration and strategic orientation for the 'regular' policy, which is aimed at the short and medium term.

The Flemish Coalition Agreement 2009-2014, Flanders in Action (ViA, the future project of the Flemish Government), and the Pact 2020 comprise multiple points of departure to set-up this kind of long-term policy path: changing the DNA of the Flemish economy, realising breakthroughs, setting-up major projects for social innovation, putting a green economy on the right track. The analytical framework and policy approach of the transition framework may contribute to realising this type of ideas. Next, we try to give an overview of points of departure and working methods to speed up the transition to a sustainable low carbon economy in Flanders.

Developing transition governance as a long-term policy path

A transition is a long-term process that reaches far beyond the time horizon of a government and even far beyond the agreements of the Pact 2020. If policymakers are convinced of the need and potential of a transition to a sustainable low carbon society then it is necessary to open a new type of policy path that dares to look over a period of 25 to 50 years. The traditional economic consultation process, solely with the conventional social actors, works at a sector level and strives for consensus in the short term. This consultative model is aimed at the optimisation of existing socio-technical systems. A consultative model that starts from transition thinking however and thereby involves more policy domains and forward-looking regime and niche players, works at a system level and strives for a broad but supported long-term vision. This creates space for radical system innovations.

It is clear from the experiences from the transition processes DuWoBo and Plan C that operating in the shadow of regular policy provides an opportunity to consider long-term developments without restraint and to take more creative paths. Importantly, the government must create a stable framework to support such processes and to translate the long-term vision into practice.

The long-term path may be slotted into various current policy processes, just consider ViA (e.g. the breakthrough of the Green city district) or Pact 2020 (transition of the energy, mobility and materials system). The major projects for social renewal from the Flemish Coalition Agreement are also possible instruments for a transition, on condition that clear system innovation criteria are applied. Other current processes include the new Environmental policy plan, the Mobility plan in the pipeline and the Flemish Strategy for Sustainable Development. Recent developments include the innovative sector consultation in the economic policy and the formulation of a sustainable employment and investment plan in execution of the Flemish Coalition Agreement, which also consider long-term agendas for economic transformation. A systematic screening of the various policy domains may undoubtedly provide further points for departure.

Creating space for experimentation

Obviously visions and agendas cannot be the end. The actors involved, including the policy domains, must undertake to set-up practical experiments and to develop niches. These are extremely important for testing the visions formulated in practice and for learning what does and what does not work. The government may create shielded spaces for experimentation for this, e.g. via projects that test innovations over a set period and on a limited scale, exempt from certain rules.

Of course, experiments must also be scaled up and niches must develop around them. The functional approach of innovation systems indicates which processes must be stimulated in this (TABLE 14.1). The interpretation of those functions is a shared responsibility of researchers, businesses, investors, government, social organisations, etc. The government plays an important role in setting out a long-term vision and supporting that vision with a clear and stable policy framework with consistent and persistent priorities (the 'guidance of the search' function). It also has a role in market creation and in implementing additional policy when specific functions are not or hardly fulfilled.

Investing in networks and in the functions they should fulfil

Broad, transparent networks are crucial for fulfilling the various innovation system functions. The government must monitor how the various functions are fulfilled and where additional support is needed. In other words, it must invest in networks in a targeted way. However it is not always necessary to create new networks. The government can adjust existing networks in relation to the long-term vision for a sustainable low carbon economy and harmonise these, and set-up new networks where necessary.

Involving enough niche players and forward-thinking regime players in those networks is important. Established regime players will be less willing to fundamentally question the system in which they participate due to their position and interests.

Stimulating policy integration

The multilevel perspective makes the need for policy integration clear. For instance six ministries are involved in the energy transition in the Netherlands, with the ministry of economic affairs, which is responsible for energy, taking the lead. If Flanders wants to make meaningful progress towards a sustainable low carbon economy, then an integrated approach with a strong frontrunner is crucial.

Policy fields may for instance integrate each other's objectives or strategically coordinating objectives may be integrated in multiple domains. For example, in the case of the transition to a low carbon economy, the target to decrease greenhouse gas emissions by 60 to 80 % in 2050 compared to 1990 (visionary scenario of the Environment Outlook 2030) or by 80 to 95 % (reduction needed according to the IPCC to remain under the 2 °C threshold) may be accepted as a central assumption in areas such as the environment and energy, transport, economy, science and innovation. Concretely this must become apparent in the choices made: in the projects set-up, the technology policy followed, the research stimulated, the educational programmes formulated, the networks supported, etc. This seems an impossible task without sufficient coordination and cooperation between the various departments. In due course policy integration will consequently also undoubtedly influence the culture and organisation of the government.

Working on a learning government

A transition approach requires new competences for the government. It will have to evolve into a learning organisation that can respond flexibly to new social developments, that can integrate long-term visions and translate them into short-term actions, that can deal with the uncertainties characteristic of transitions and that can interactively give shape to a transition policy. Amongst other things this requires civil servants who can work across policy domains and are not put into a straight-jacket that discourages initiative. Management plays a major role in this.

A transition approach also requires the development of knowledge and capacity at various levels. The transition framework is still almost unknown in Flanders and this is consequently also true for how to work with it. Investment is required in this and also in the capacity to learn lessons from practice. Investments must be made both in learning about the content (what direction do we want to take, what experiments do we need for that, what do they deliver, etc.) as well as in learning about the process (how do we achieve future visions in a correct way, how can we involve forward-thinking actors, how can experiments be scaled up, how do we make connections between long-term visions and short-term actions, how do we make choices, etc.).

Again: a transition does not stand or fall through the government alone. But in order consciously to speed up transitions and to steer them in the direction of sustainability, the government's role is crucial. If society agrees that transitions are necessary, the government may be expected to mobilise the knowledge and capacity to show leadership as regards content and process.

LIKE TO KNOW MORE?

If you would like to know more, you can consult the scientific report, which forms the basis for this chapter:

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ABBREVIATIONS

AB: hot-rolled asphalt
ACW: umbrella organization of Christian Employee Organizations
Aeq: acid equivalent
ATF: Acoustics and Thermal Physics Department (K.U.Leuven)
BAT: best available technique
CCS: carbon capture and storage
CEDD: Centre d'Etudes du Développement Durable
CHP: co-generation of heat and power
CIW: Coordination Commission Integrated Water Policy
CNG: compressed natural gas
CODA: Veterinary and Agrochemical Research Centre
DAR: Services for the General Government Policy
END: Environmental Noise Directive
ENT: environment and nature targets
EnVOC: Environmental Organic Chemistry and Technology Research Group (UGent)
EPC: energy performance certificate
EPIC: energy performance and indoor climate
EPR: agricultural parcel register
ETS: European emission trading system
EU: European Union
EUR: Europe scenario
EVA: Ethical Vegetarian Alternative
EWI: Department for the Economy, Science and Innovation
FAO: Food and Agricultural Organization
FEBEG: Federation of Belgian Electricity and Gas companies
FEBIAC: Belgian Automobile and Two-wheel vehicle federation
FPB: Belgian Federal Planning Bureau
FSSP: Flanders Spatial Structural Plan
GDE: gross domestic energy use
GDP: gross domestic product
GEC: gross electricity consumption
GHG: greenhouse gas
GPC: green power certificate
HFC: hydrofluorocarbon
HIVA: Higher Institute of Labour Studies
HRF: High Council of Finance
IAB: International Labour Office
IEA: International Energy Agency
IGEAT: Institut de Gestion de l'Environnement et d'Aménagement du Territoire
IIASA: International Institute for Applied Systems Analysis
ILVO: Institute for Agricultural and Fisheries Research
INBO: Research Institute for Nature and Forest
INM: integrated noise model
INR: Institute for National Accounts
INTEC: Department of Information Technology (UGent)
IPCC: Intergovernmental Panel on Climate Change
IPPC: Integrated Pollution Prevention and Control
IWT: Flemish Institute for promoting Innovation through Science and Technology in Flanders
KjN: Kjeldahl nitrogen
KMI: Royal Meteorological Institute of Belgium
K.U.Leuven: Catholic University Leuven
LNE: Environment, Nature and Energy Department
LPG: liquefied petroleum gas
LTT: long-term target
LV: Agriculture and Fisheries Department

MAP: Manure Action Plan
MBO: environmental policy agreement
MCM: environmental costing model
MINA: Environmental Policy Plan
MIRA: Flanders Environment Report
MMIF: multimetric macro-invertebrates index Flanders
MOW: Mobility and Public Works Department
NARA: Flanders Nature Report
NEC: National Emission Ceilings
NMBS: National Belgian Railway Company
NMVOC: non-methane volatile organic compounds
OPS: operational priority substances - model
OVAM: Public Waste Agency of Flanders
PAN: peroxyacetyl nitrate
PEGASE: plannification et gestion de l'assainissement des eaux
pkm: passenger kilometres
PM: particulate matter
POM: Provincial Development Agency
PV: photovoltaic
PVO: pure vegetable oil
QC: quota count
REF: reference scenario
RUP: spatial execution plan
SERV: Social and Economic Council for Flanders
STEG: steam and gas turbine or gas turbine with combined cycle
STEM: Technology, Energy and Environment Research Centre (UA)
TAW: Second General Levelling
TEW: Faculty of Applied Economics
TOFP: tropospheric ozone forming potential
tonkm: tonne kilometres
TSI: technical specification of interoperability
UA: University of Antwerp
UGent: University of Ghent
ULB: Free University of Brussels (Université Libre de Bruxelles)
UN: United Nations
UNECE : United Nations Economic Commission for Europe
UNEP: United Nations Environment Programme
VEA: Flemish Energy Agency
VELT: Association for Ecological Life and Gardening
VHA: Flemish Hydrographic Atlas
ViA: Flanders in Action
VISI: visionary scenario
VITO: Flemish Institution for Technological Research
vkm: vehicle kilometres
VLAREM: Flemish environmental permits regulation
VLM: Flemish Land Agency
VMM: Flemish Environment Agency
VMW: Flemish Water Board
VOKA: Flemish Economic Union
VREG: Flemish Regulatory body for the Electricity and Gas market
VSD-model: very simply dynamic model
VUB: Free University of Brussels (Vrije Universiteit Brussel)
WFD: European Water Framework Directive
WHO: World Health Organisation
WLD: work loss day
WWTP: waste water treatment plant

CHEMICAL SYMBOLS

BOD: biochemical oxygen demand
CH_4: methane
CO: carbon monoxide
CO_2: carbon dioxide
COD: chemical oxygen demand
HFC: hydrofluorocarbon
N: nitrogen
NH_3: ammonia
NH_4^+: ammonium
NH_x: reduced nitrogen compounds (NH_3 and NH_4^+)
NO: nitric oxide
N_2O: laughing gas or nitrous oxide
NO_2: nitrogen dioxide
NO_3: nitrate
NO_x: nitrogen oxide, both nitric oxide and nitrogen dioxide
NO_y: collective term for oxidised nitrogen compounds (NO, NO_2, NO_3^-, HNO_3 ...)
Nt: total nitrogen
N_2: nitrogen gas
O_2: oxygen
O_3: ozone
P: phosphorus
PAH: polycyclic aromatic hydrocarbon
PFC: perfluorocarbon
Pt: total phosphorus
SF_6: sulphur hexafluoride
SO_2: sulphur dioxide
SO_x: collective term for sulphur oxides

UNITS

Aeq: acid equivalent
CO_2-eq: CO_2 equivalent
DALY: disability adjusted life year
dB: decibel
dB(A): A-weighted decibel
g: gramme
ha: hectare
J: Joule
m: metre
Mton: megatonne = 10^6 tonnes
PJ: petajoule
ppm: parts per million
toe: tonne of oil-equivalent
tonne: 1 000 kg
Wh: Watt-hour

GLOSSARY

A

Acid equivalent (Aeq): unit to measure the level of acidification of polluted substances. This unit makes it possible to compare different acidifying substances to each other. One acid equivalent corresponds to 32 grammes of sulphur dioxide, 46 grammes of nitrogen dioxide or 17 grammes of ammonia.

Acidifying emissions: sum of the emissions of sulphur dioxide, nitrogen oxides and ammonia to the air. The acidifying effect depends on the neutralisation by bases and buffering in the soil and water.

Aerosol: a gaseous suspension of fine solid and/or liquid particles.

Ageing: rising proportion of the elderly in the population, in which the 'elderly' are generally understood as the 65-plus age group.

Agricultural parcel registration: registration of all agricultural plots for which the farmer applies for an income subsidy.

Al:Bc-ratio: ratio of the concentration of aluminium to the concentration of the cations potassium, sodium, calcium and magnesium in the soil.

AOT40ppb-forests: excess above 80 µg/m³ of all hourly ozone concentration values between 8 AM and 8 PM (Central European Time) over the months from May to September.

AOT40ppb-vegetation: excess above 80 µg/m³ of all hourly ozone concentration values between 8 AM and 8 PM (Central European Time) during the months of May, June and July.

AOT60ppb-max8h: excess above 120 µg/m³ of the highest 8-hour average ozone concentration per day, added across all the days in a calendar year.

A-weighting: adjustment by weighting a measured noise at the frequency-dependent sensitivity of the human ear.

B

Base saturation: share of the exchangeable cations in the total cation exchange capacity of a soil.

Battery electric vehicle: vehicle with an electric drive line that takes its energy entirely from a rechargeable battery.

Biochemical oxygen demand: amount of oxygen per litre of polluted water that microorganisms need to breakdown degradable organic matter (biochemical reaction). The determination is carried out as standard at 20 °C for 5 days.

Bio-CHP: co-generation (CHP) that uses biomass instead of fossil fuels.

Biofuel: liquid or gas fuel for traffic that is produced from biomass.

Biological Valuation Map: inventory and evaluation of biological environment. The inventory takes place on the basis of a predefined list of units, that stand for types of vegetation, land use and small landscape elements. The evaluation is *best professional judgement* based on rarity, replaceability, vulnerability and biological qualities of the biotopes.

Biomass: biological degradable fraction of products, waste and residues from agriculture of biological origin (including vegetable and animal matter), forestry and related industries, as well as the biologically degradable fraction of industrial and household waste.

Breach formation: breach of a dike or a natural dune ring.

Brent-oil: original crude oil extracted from the Brent oil field in the North Sea. Today Brent-oil is the benchmark for determining the price of equivalent oil. In this way the oil production in Europe, Africa and the Middle East is priced on the basis of the price of Brent-oil.

Bronchodilator: medicine that assists in widening the bronchi (the branches of the trachee) and is used amongst others in the treatment of asthma.

Brushwood: herbaceous vegetation in which, in the absence of management, a high level of accumulation of humus occurs, whereby weaker herbs (perennials, small types, rosette plants, etc.) lose ground in the face of the stronger, generally highly competitive herbs.

C

Carbon intensity: amount of CO_2 emitted as a result of energy use and other energy related CO_2 emissions (processing emissions in chemistry and emissions relating from the non-energetic use of fuels in other sectors) per unit of gross domestic product at constant prices.

Chemical leasing: business model in which the operating profit does not come from the product turnover but from the provision of a 'chemical service'. The customer does not pay for the amount of chemical product but for the product performance, e.g. cleaned components, painted area, galvanised parts, etc. The producer and service provider retain responsibility for the product. As a result the latter is motivated to optimise the process and to limit the use of the volumes of chemicals.

Chemical oxygen demand: amount of oxygen required per litre of polluted water to breakdown the organic substances completely (via oxidation, a chemical reaction).

Clean development mechanism: cooperative agreement between an industrialised country (donor country) and a developing country (guest country; without own Kyoto target). The donor country thereby invests in projects for reducing emissions in the guest country in exchange for emissions credits. These credits may then count towards the emissions quota of the donor country.

Cleantech: collective name for products, services and processes on the basis of technologies that optimise the use of natural resources and minimise the environmental impact. An important element here is the prospect of economic added value combined with environmental benefit.

Climate: average weather over a long period. Statistical description (in terms of averages and variability) of a number of relevant weather parameters such as temperature, precipitation and wind over a longer period (e.g. 30 years).

CO_2 equivalent: unit of measurement used to indicate the global warming potential of greenhouse gases. CO_2 stands for carbon dioxide and is the reference gas against which other greenhouse gases are measured. For instance because the warming potential of CH_4 is 21 times higher than that of CO_2 with the same mass of gas, 1 tonne CH_4 corresponds to 21 tonnes of CO_2 equivalents.

Co-generation (CHP): simultaneous conversion of energy into power (mechanical energy) and heat (thermal energy) with practical use. Depending on the process and use the heat is supplied at different temperatures. The power drives a

generator for electricity or sometimes directly a machine (pump, compressor ...).
Conservation target: the target for nature conservation. These are tasks for the government to preserve and improve nature. Europe wants Flanders to formulate these conservation targets before 2010 for the different habitat types.
Constant prices: valuation method that expresses an economic variable to the prices for a specific basic year and thereby forms an indication of a volume measurement. The impact of inflation and price fluctuations is removed in constant prices.
Critical load: maximum allowable deposition per unit of area for a specific ecosystem without – according to current knowledge – causing long-term harmful effects.
Cross sector assumption: assumption that is the same for all scenarios and all MIRA sectors in the Environment Outlook 2030.

D

Decibel (dB): is a logarithmic unit of measurement that is used to show the intensity of a noise, the noise level.
Decoupling: occurs when the growth speed of a pressure indicator is lower than the growth speed of an activity indicator or an economic indicator (expressed in constant prices). The decoupling is absolute if the growth of the pressure indicator is zero or negative. The disconnection is relative if the growth of the pressure indicator is positive but not as great as that of the activity or economic indicator.
Degree days: a unit used to determine the heating requirements in a year. Each average daily temperature is compared to a constant daily average of 15 °C, i.e. every degree that the average daily temperature is below 15 °C is called a degree day. The total of all those days in the year gives the number of degree days per year. The higher the number of degree days, the colder it was and the more fuel will have been needed for heating. An average / normal year has 2 087.6 degree days.
Dejuvenation: decreasing share of young people (to 18 years of age) in the population.
DeNOx, DeSOx: post-treatment techniques that use catalytic agents respectively to convert NO_x and SO_2 in flue and exhaust gases into less harmful substances.
Deposition: quantity of a substance or group of substances that are deposited from the atmosphere onto a region, expressed as a quantity per area unit and per unit of time (e.g. 10 kg SO_2/ha.y).
Derogation: in the context of the manure policy derogation means an exemption rule to the general fertilizer standard of 170 kg N/ha from animal manure. The derogation allows fertilization greater than 170 kg N/ha.
Diffuse source: non-localised source of pollution generally highly, homogenously spatially spread.
Disability Adjusted Life Years (DALY): number of healthy life years that a population loses due to illness. It is the sum of the years lost due to deaths from the illness (life years lost) and the years lived with the illness, taking account of the severity of it (illness year equivalents).
Discount rate/discounting: discounting comes down to taking the opportunity cost for financial funds into account. The discount rate shows what these funds could have yielded in the best available alternative use, instead of spending them on the environmental policy. In the Environment Outlook 2030 a (social) discount rate of 4 % is taken into account.
District: administrative division in a province that includes multiple municipalities.

E

Eco-efficiency: comparison of the environmental pressure on a sector/region (emissions, resource use) with an activity indicator for that sector/region (production, volume, gross added value, etc.). A profit in eco-efficiency only results in a profit for the environment if the pressure also decreases in absolute figures.
Emission: emission or discharge of substances, waves or other phenomena from sources, generally expressed as an amount per unit of time.
Emission right: transferable right to emit emissions (e.g. 1 tonne CO_2 equivalent).
Emission trading system (ETS system): a system within which a market price is formed for the emission of 1 tonne of CO_2 or 1 tonne of greenhouse gases.
Employment: number of people in work (waged and self-employed). In the context of the National accounts (IAB definition) the following are included in employment: all persons who have effectively worked at least one hour during the reference period or who were temporarily not at work during the reference period (e.g. due to illness) but do retain a formal bond with their job.
Employment (according to workplace): in employment statistics the persons involved are allocated to the location of their main activity.
Employment (domestic): employment on the territory (as opposed to national employment that measures the employment of the residents of a country).
Energy intensity: amount of energy used per physical or economic unit of activity. At the level of a country or region the gross domestic product (GDP) at constant prices is used as a unit of activity.
Epidemiology: science that studies the distribution of diseases and disease determinants within a population in time and space.
Euro x: term created in the early 90s to indicate which environment related vehicle generation it concerns. An Euro 4 vehicle is more recent than an Euro 1 vehicle and complies with stricter European emissions limits.
Evapotranspiration: joint water lost via the soil, vegetation and their component parts to the atmosphere. This is all precipitation that is not discharged via a watercourse but ends up in the atmosphere due to direct evaporation or absorption by plants and animals followed by transpiration.
External cost: damage cost related to negative side effects of social activities. These are generally not (completely) taken into account in the pricing mechanism and are consequently shifted to society, other countries or future generations.
External health cost: damage cost to health related to negative externalities.
Externality: side effect of social activities that has an unwanted impact on other persons, crops, buildings, materials, environment, ecosystems, etc. Externalities may be negative (e.g. the majority of emissions) or positive (e.g. landscape provision by agriculture).

F

F-gases: collective name for fluorinated greenhouse gases in the Kyoto basket, HFCs, PFCs and SF_6.
Flanders Spatial Structural Plan: policy document, published in 1997, that gives the context for the desired spatial structure in Flanders. It gives a long-term vision of the spatial development and is intended to provide coherence in the preparation, determination and execution of decisions that concern town and country planning. The time horizon of the RSV is 2007 and comprises a number of binding clauses that are important amongst others for nature conservation.

Flemish Diamond: region that extends between the cities of Antwerp, Ghent, Brussels and Louvain.
Flood risk: predicted average annual damage as a result of flooding in a specific region. This risk is calculated as the product of the theoretical damage at a determined depth of flooding and the probability that this flood occurs. The risk is expressed in euro/(m^2.year).
Fragmentation: division of spatial wholes in smaller or less cohesive pieces.

G

Green heating: heating generated from renewable energy sources: on the one hand large-scale applications (generally) of biomass and on the other, relatively small scale use of (thermal) solar power, wood-fired boilers and wood-burning stoves, geothermal heat pumps and heat exchange pumps.
Green power: electricity generated by using renewable energy sources.
Gross consumption of energy: sum of the energy raw materials supplied for energy purposes to all sectors outside the energy sector (electricity and refineries). This includes the consumption of electricity and heat by the energy sector itself and the grid losses in the production and distribution of electricity and heat. Non-energetic final energy use by industry is not included.
Gross domestic energy use (GDE): total primary energy use of a country or region reduced by the energy exports and the bunker fuel for international shipping and aviation. It is also the sum of energy use by all end users on the one hand and the energy losses (e.g. through transformation) and the energy use of the energy sector itself on the other.
Gross Domestic Product (GDP): indicator to show the economic wealth of a region or country. It is the sum of the gross added value (at base prices) produced in that region or country over one year, increased by product related taxation minus product related subsidies.
Gross floor area (GFA): sum of the floor area of all stories of the protected volume of a building measured on the outside. The protected volume is the volume of a building with climate control, established on the basis of the external dimensions.

H

Heavy metals: eight elements considered as priority by the Third North Sea Conference: As, Cd , Cr , Cu , Hg , Pb , Ni and Zn. Many of these elements are crucial for supporting biological life as trace elements. However at higher levels they become toxic, may accumulate in biological systems and represent a significant health risk.
Hot tap water: sanitary hot water.
Households: singles or two or more persons who have or wish to have an enduring communal household. The definition of households in the Environment Outlook 2030 is limited to the energy use of and in the home, i.e. to living itself.
Hybrid car: car that uses at least two sources of energy or engine, e.g. combustion engine and electric engine.

I

Increase in traffic intensity in dB: relative increase of traffic intensity, Q, between year x and year y expressed in dB = $^{10}\log$ (Qy/Qx).
Industrial residual heat: heat production by an installation that cannot be usefully used inside the industrial operation.

K

Kjeldahl nitrogen: total of all ammonia nitrogen and organic nitrogen (originating from living or dead material).

L

L_{A50}: median value of the instantaneous noise levels over a specific period.
L_{Aeq}: A-weighted equivalent noise pressure level, energetic average level that takes the frequency dependency of the sensitivity of the human ear into account.
L_{den}: L_{Aeq} penalised with 10 dB for night hours and 5 dB for evening hours, meets the need for rest during the evening and night.
Level of employment: ratio between the (national) employment and the population of working age.
Level of fertility: ratio between live births and the female population between 15 and 49 years of age.
Living district: type of town planning in which a certain area is provided per inhabitant at a district level for green space, housing, relaxation, shopping and working. The management of flows and networks such as water, energy, transport, nature, renewable resources, raw materials and materials is based on the three step strategy: 1. preventive and efficient use of environment and space, 2. maximum use and production of local renewable resources, and 3. maximum prevention of nuisance and burden transfer. There is the possibility of intensive innovation, such as alternative forms of housing (e.g. kangaroo-housing). Energy production is organised at a district level instead of for individual homes. Living districts may, amongst others, be realised by tackling blots on the landscape or by expansion within the city limits.

M

Macro-invertebrates: invertebrate water organisms visible with the naked eye (e.g. snails, leeches, beetle, fly, mosquito or dragon fly larvae ...).
Macrophyte: higher plant.
MAP3: manure policy effective since 1 January 2007.
Micro-CHP: small-scale form of co-generation (with capacities between 3 and 10 kWe); the heat is mainly used for heating a house.
Modal shift: shift from one mode of transport to another.

N

NEC-Directive: European National Emission Ceilings Directive (2001, 2001/81/EC) intended to limit emissions into the air of acidifying, eutrophying and ozone forming substances. This directive imposes maximum emission ceilings on the EU-15 member states for the four gaseous pollutants SO_2, NO_x, NMVOC, and NH_3. These are stricter than the emissions ceilings of the Gothenburg protocol.
NET60ppb-max8h: number of days per calendar year in which the highest 8-hour average ozone concentration for that day is greater than 120 µg/m^3.
Night slots: aircrafts' right to depart or land during night-time hours.
Noise pressure level: level of noise pressure expressed in decibel (dB). The noise pressure is the small overpressure caused in the air due to the passing of a sound wave and is observed, amongst others, by the human ear.

O

Open space: aggregated land use categories agriculture, nature, multifunctional forest, recreation, water and other space in the land use model.
Ozone precursor: precursor substance, a substance which creates ozone through the action of sunlight. Nitrogen oxides and non-methane volatile organic compounds (NMVOC) are the most important ozone precursors.

P

Percentage point: measure used to give the absolute difference between values expressed in percentages. For instance: if an annual growth increases from 2 % to 3 % this may be expressed in relative terms as an increase by 50 % or in absolute terms as an increase of 1 percentage point.
Person kilometres: total number of kilometres covered in a specific time by all persons who travel with a specific category of transport.
pH: level of acidity, measured as the level of hydrogen ions. The negative logarithm of the amount of hydrogen ions varies between 0 and 14. Between each unit there is a 10-fold difference, the higher the pH, the greater the number of hydrogen ions. pH 7 is neutral, pH <7 is acid and pH >7 is a base.
Phytobenthos: vegetable organisms, attached to a fixed substrate (soil, plants).
Phytoplankton: microscopic vegetable organisms that float in water.
Plug-in hybrid vehicle: hybrid vehicle with a battery, which can be recharged using an electrical socket on the electricity grid.
PM2.5: fraction of particulate matter with an aerodynamic diameter smaller than 2.5 µm.
PM10: fraction of particulate matter with an aerodynamic diameter smaller than 10 µm.
Pollutant load to the surface water: load that finally ends up in the surface water, directly or indirectly via sewers not connected to WWTP after (partial) treatment. This is specified to variable and/or target group.
Polycyclic aromatic hydrocarbon (PAH): collective name for a few hundred organic compounds that have different benzene rings as a base structure. Benzo(a)pyrene is the most well-known and also the most toxic of the group.
Potential GDP: GDP with 'normal' level of use of production capacity, to be considered as the balanced level in which there is neither over nor under use of the production factors.
Primary energy: total energy content of the fuel purchased plus the amount of fuel needed to generate the purchased, secondary energy carriers such as electricity and heat (steam and other).

R

Relative risk: incidence of the disease in the exposed group divided by the incidence of the disease in an unexposed group.
Relighting: switch to a lighting system with a low energy consumption through technological improvements to components, by adjusting the lighting or through the optimal use of passive lighting.
Residential expansion area: division provided in spatial planning, which is, in principle, intended as reserve space for building housing. If there is no more space available in the 'ordinary' housing areas, these may be divided into plots.
Retrofitting: modification of existing vehicles (e.g. freight vehicles) to lower noise technology.
Rolling noise: noise caused by a wheel rolling over a road surface.
Rural region: region in which open space predominated but which also includes some elements of urbanization and infrastructure, which is functionally related to the open space.

S

Second General Levelling (TAW): reference level for the sea level measurements at the Belgian coast, established in 1947 by the National Geographic Institute as a vertical reference level for all of Belgium.
Serious nuisance: level of nuisance suffered by an average person surveyed expressed as a score greater than 72 % on a continuous nuisance scale. Or, in Written Environmental Research (WER), by designating the label 'serious nuisance' or 'extreme nuisance'.
Sewer overflow: construction on a sewer or wastewater collector whereby a part of the effluent may be evacuated to the surface water when the sewer or collector threatens to be under pressure (completely full).
Smart grid: energy network that combines without any problem centrally generated energy with distributed and renewable energy production on the one hand transferable energy demands and storage options on the other. This is a power grid that is very well able to absorb the variable peaks and drops in production – e.g. characteristic of wind and solar power – for instance by means of management on the demand side, and in that way to coordinate the supply and demand.
Socio-technical system: complex, corresponding set of elements (including knowledge, technology, institutions, structures, physical infrastructures, practices and customs, formal and informal rules and players on both the supply and consumption side) which together fulfil a social function or need.
Spatial accounting: quantitative determination of tasks of the most important spatial functions after consideration of spatial needs of social activities in the Flanders Spatial Structural Plan.
Stirling engine: an engine in which a constant amount of working gas is alternately expanded through heating and compressed by cooling. The working gas is usually air, for that reason this is also called a 'heated air engine'.
Structural characteristic: physical characteristic of surface waters: meandering, river slope, nature of the sediment, alternating depths and shallows (*pool-riffle* sequence), type of bank areas, bank structure ...
Structural level of unemployment: level of unemployment that may be considered incompressible in the long term.
System innovation: combination of technological, structural and cultural changes that result in social functions or needs to be fulfilled in an entirely new way.

T

Target load: maximum permissible deposition level in which a proposed soil chemical status is respected in the ecosystem from a specific target year.
Temperature inversion: situation in which the temperature does not decrease with the height but is higher in the upper aerial strata than in the lower aerial strata. As a result the polluting substances cannot spread in the higher aerial strata but stack up in the lower aerial strata.
Tertiarisation: increase in the importance of services in the economy compared to agrarian and industrial activities.
Tonne kilometres: number of kilometres covered per tonne transported with a specific category of modes of transport, multiplies by the number of tonnes of goods transported.
Toxicology: study of the harmful effects of substances on living organisms with the aim of estimating the risks for exposure to these substances to man, animal and environment and to limit the undesirable effects.

Trade & services: the trade & services sector includes the following subsectors: trade, hotel and catering, offices and administration, education, healthcare and social services, municipal amenities and socio-cultural and personal services (including WWTPs and waste processing). The liberal professions and self-employed persons also fall under trade & services. Energy use for industrial buildings (e.g. operating hall) are included in the industry sector.

Transition: fundamental, structural changes in socio-technical systems.

Trias Energetica: a strategy developed by the Technical University of Delft to achieve the most sustainable energy supply possible, in which one would in the first phase reduce energy use insofar as possible and in the second phase use sustainable sources of energy (solar, wind, environmental heat, biomass) as much as possible and in the final phase for the possible remaining energy use to use the finite sources of energy (such as natural gas) as efficiently as possible.

U

Urbanised area: aggregated land use categories housing & trade, business and industrial sites, ports and infrastructure in the land use model.

Urbanised area: area where intense spatial, cultural and socio-economic cohesion and acquisition exists between various human activities (living, services, employment, etc.), where dense development predominates and where it is desirable to stimulate and concentrate building development. Urbanised area is a policy term from the Flanders Spatial Structural Plan.

V

Vehicle kilometres: total number of kilometres driven by a specific category of modes of transport within a definite time span.

W

Water body: distinct area of surface water, such as a lake, storm water balancing tank, reservoir, a stream, a river, a canal, transitional water or a part of a river, stream, canal or transitional water (can also be used for groundwater).

Water system: geographically defined, connected and functional body of surface water, water course sediment, groundwater, banks and technical infrastructure including the ecological communities present therein and all corresponding physical, chemical and biological features and processes.

Working age population: population from 15 to 64 years of age.

Z

Zoning plan: a map which shows for each housing area whether the wastewater treatment is public or must be provided privately.

COLOFON

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