Algae Product Innovation
Needs, drivers, gaps & possibilities

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MARINE BIOTECHNOLOGY WORKFLOW

- Drugs
- Elicitors
- Biofuels
- Food
- Enzymes
- Biopolymers
- Organic compounds

- **Processes**
- Basic research
- Ecosystem Management
- Bioremediation

Biotechnology Toolbox:
- biodiscovery
- mol. biology
- biochemistry
- microbiology
- ...omics
- etc.

__Value chain_____

How to Farm a Better Fish?

The world now produces more farmed fish than beef – and that's just the beginning

Feeding the World

By 2050 w'll need to feed 2 billion more people.
How can we do that without overwhelming the planet?

NATIONAL GEOGRAPHIC

The development of new bioresources

Process Design and Economics for the Production of Algal Biomass:
Algal Biomass Production in Open Pond Systems and Processing Through Dewatering for Downstream Conversion

Algal Biomass Production Process Engineering Analysis

Production Pond Design: Leidos Raceway Pond, SIZE 10-acre
All Values in 2011$

MBSP (Minimum Biomass Selling Price):		**$491 /US Dry Ton (AFDW)**
Contributions:	CO2 and Nutrients	**$112 /US Dry Ton**
	Cultivation	**$278 /US Dry Ton**
	Other Production	**$101 /US Dry Ton**
Total Biomass Production (AFDW Basis)		0.19 MM US Ton/yr
Total Biomass Yield (AFDW Basis)		37.5 US Ton/acre/yr
		84.1 Metric tonne/ha/yr
Internal Rate of Return (After-Tax)		10%
Equity Percent of Total Investment		40%

2016 BILLION-TON REPORT

Advancing Domestic Resources for a Thriving Bioeconomy

Volume I | July 2016

U.S. DEPARTMENT OF ENERGY

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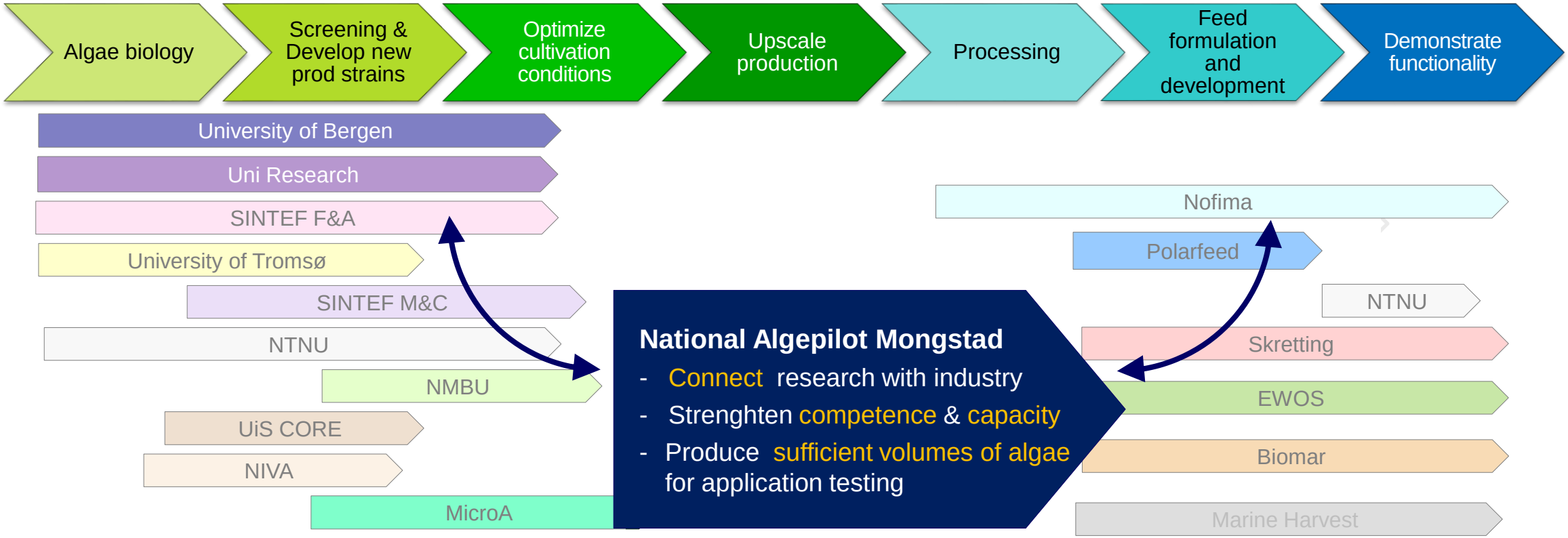
Roadmap for microalgae based aquafeed



National Algaepilot Mongstad

Public-Private Partnership

Government	6 mill
University of Bergen	6 mill
Seafood Research Fund	3 mill
Hordaland County	2 mill
Municipality councils	1 mill

National platform for the industrialization of microalgae

- Connect research with industrial needs for new value chains
- Explore various wastestreams (CO_2, nutrients, residual heat)
- Produce volumes for application testing
- Continuous evaluation of techno-economics and lifecycle assesments

Screening-, optimisation- and cultivation in Bergen (Uni R &UiB)

<1 ml

10-100 ml

100-400 ml

2 x 25 L

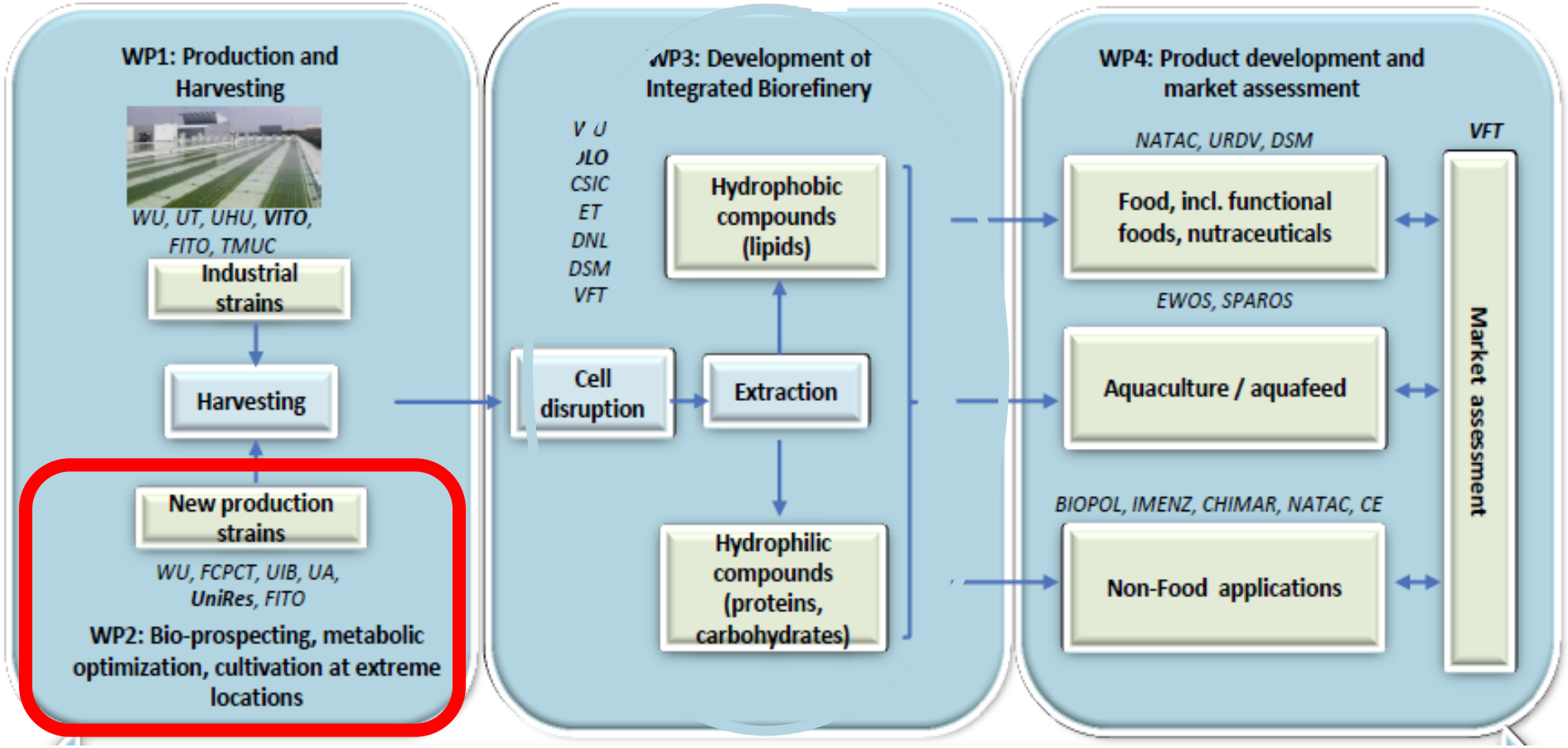
250 L

Upscale production & optimization at NAM pilot facility (Uni R, UiB & CO2Bio AS)

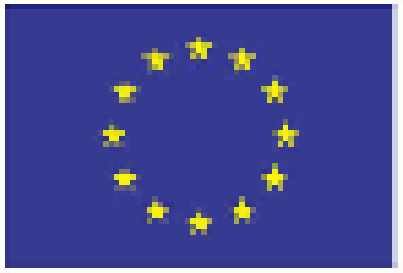
Pilot facility, lab and greenhouse
Prod capacity 250 - 3500 L

Automated & controlled environment
LGem tube reactors w/LED

Evodos 25
Contin. centrifuge



MIRACLES
SPECIALTIES FROM ALGAE



Aquaculture feed

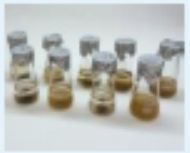
Food & Nutraceuticals

Non-food specialties

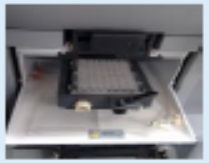
Industrial screening criteria

Sampling

Enrichment

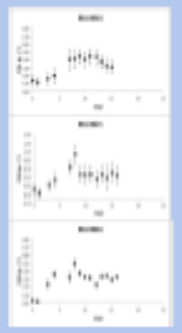


Isolation

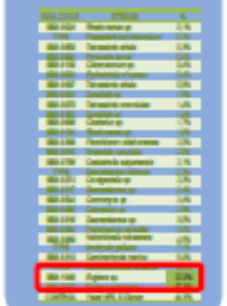


Cultivation

Screening



Selection



	Environmental samples collected	Enrichments cultures in lab	Clonal cultures plated (FACS)	Clonal isolates established for cultivation	Screened strains	Candidate strains
Sub-tropics, Gran Canarias, Spain	213	639	-	70	24	9
Altiplanic lagoon Antofagasta, Chile	69	360	19200	66	20	13
Arctic/Nordic, Bergen, Norway	58	110	10560	149	43	5
Total	**337**	**1 109**	**38 400**	**285**	**87**	**27**

Downstream processing

Application testing

Demonstration

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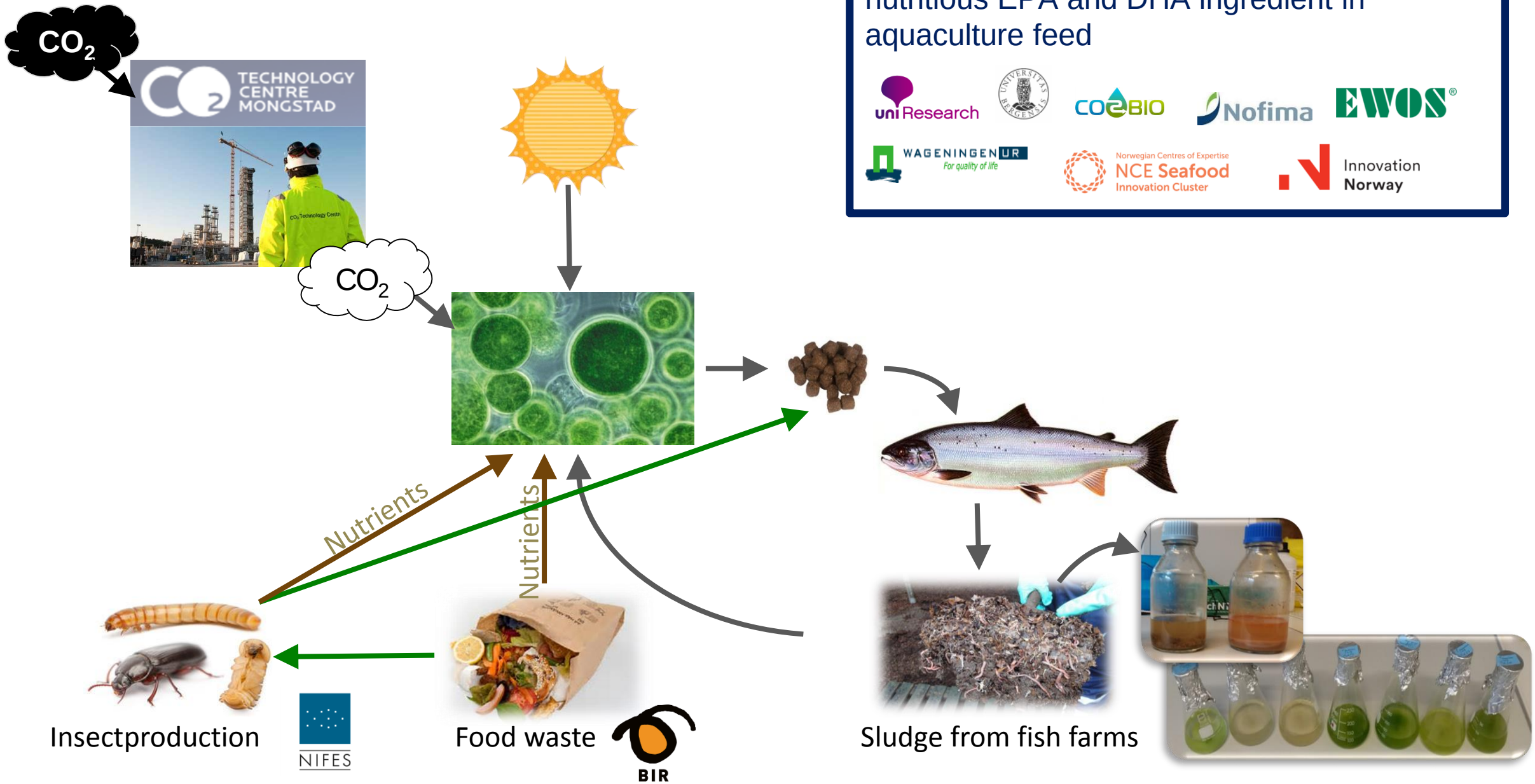
MIRACLES

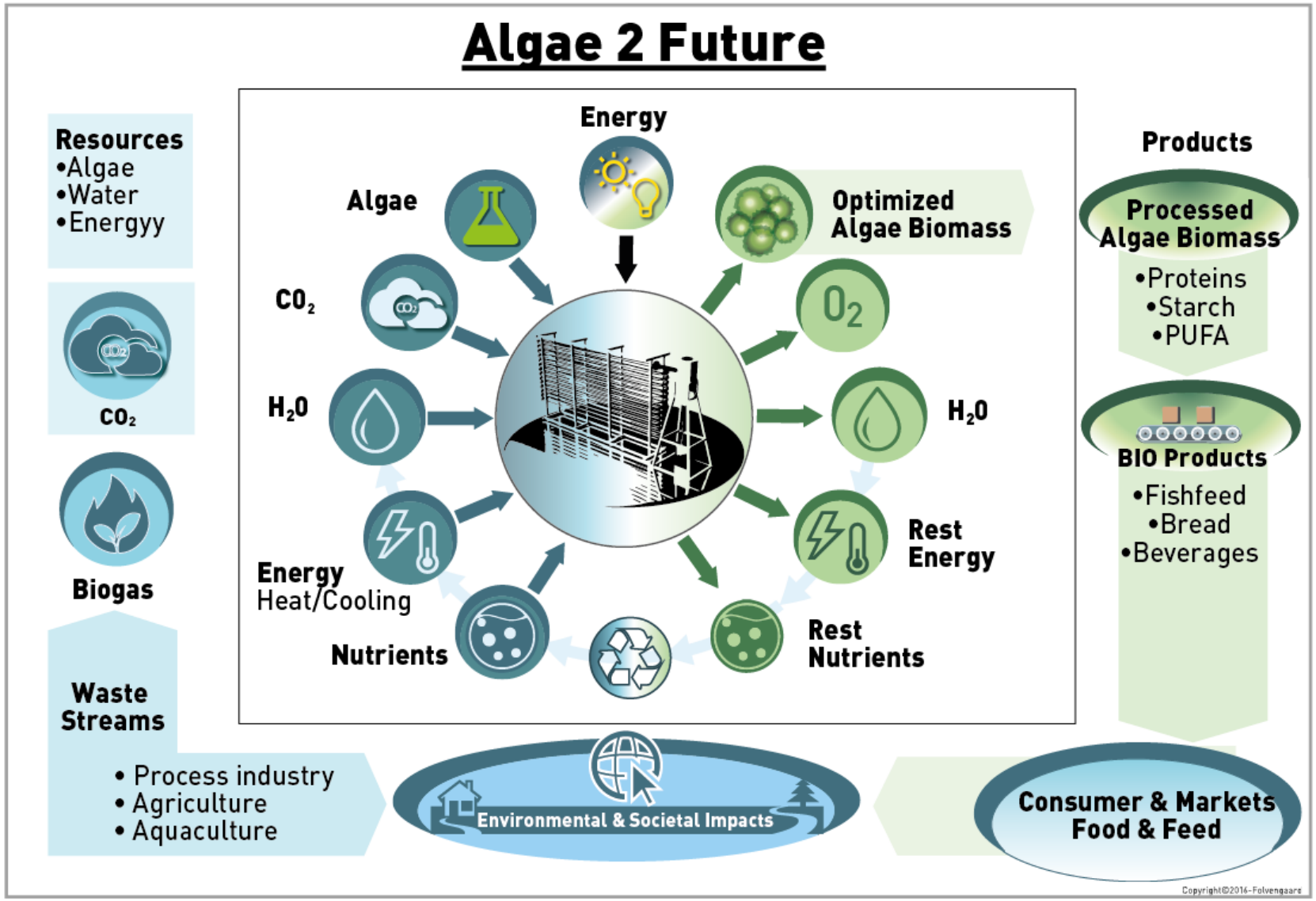
SPECIALTIES FROM ALGAE

CO2Food (2016-2019, 11 MNOK)

Using waste streams as a resource for production of phototrophic microalgae as a nutritious EPA and DHA ingredient in aquaculture feed

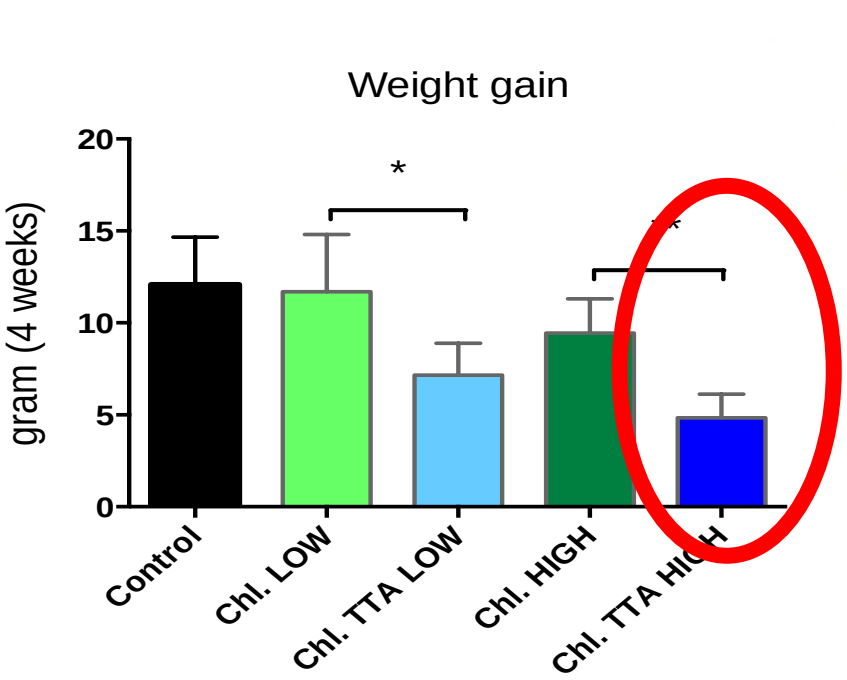


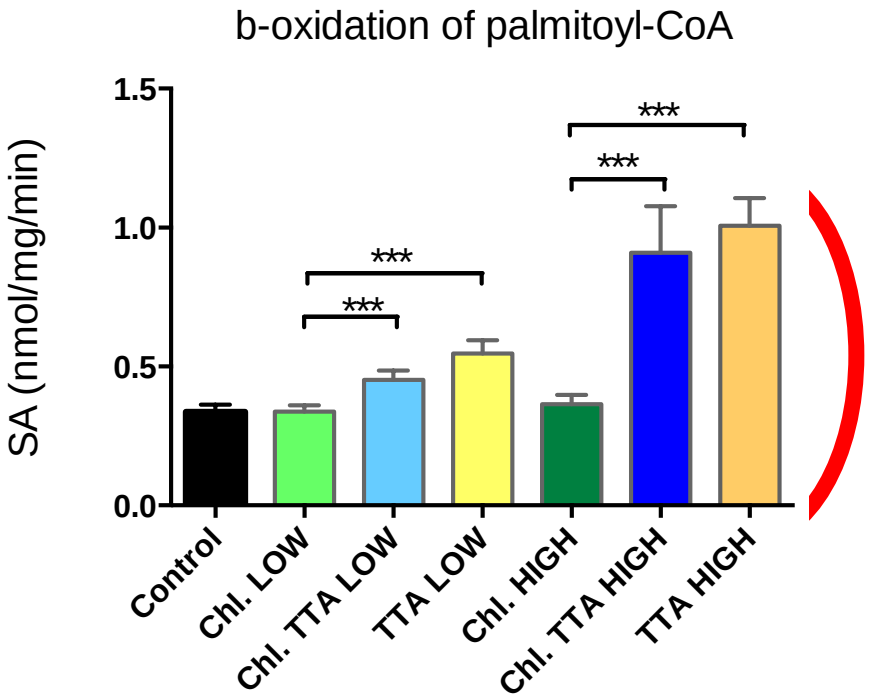
Algae2Future (2017-2021, 55 MNOK)



" Fish feed-case" drives development of novel ideas

- Microalgae as a vector for bioactive component
- Increased metabolism, b-oxidation and weight loss in mice
- New *ingredient* and *production* method enabled by competence and pilot capacity





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Some recommendations experienced from the previous projects and efforts

Early industry involvement

- Highlight pre-competetive challenges
- Setting concrete spec's for bioprospection
- Block funding used to gain industry interest by taking ideas to POC

Integration of expertize across disciplines

- Building consortia along the complete value chain
- Possibility-makers to meet sector-experts

Upscale & Pilot facilities

- Enabling ideas to POC
- Demonstration in close-to-industry scale/conditions
- Enough biomass for application testing

Product differentiation follows the «Base case»

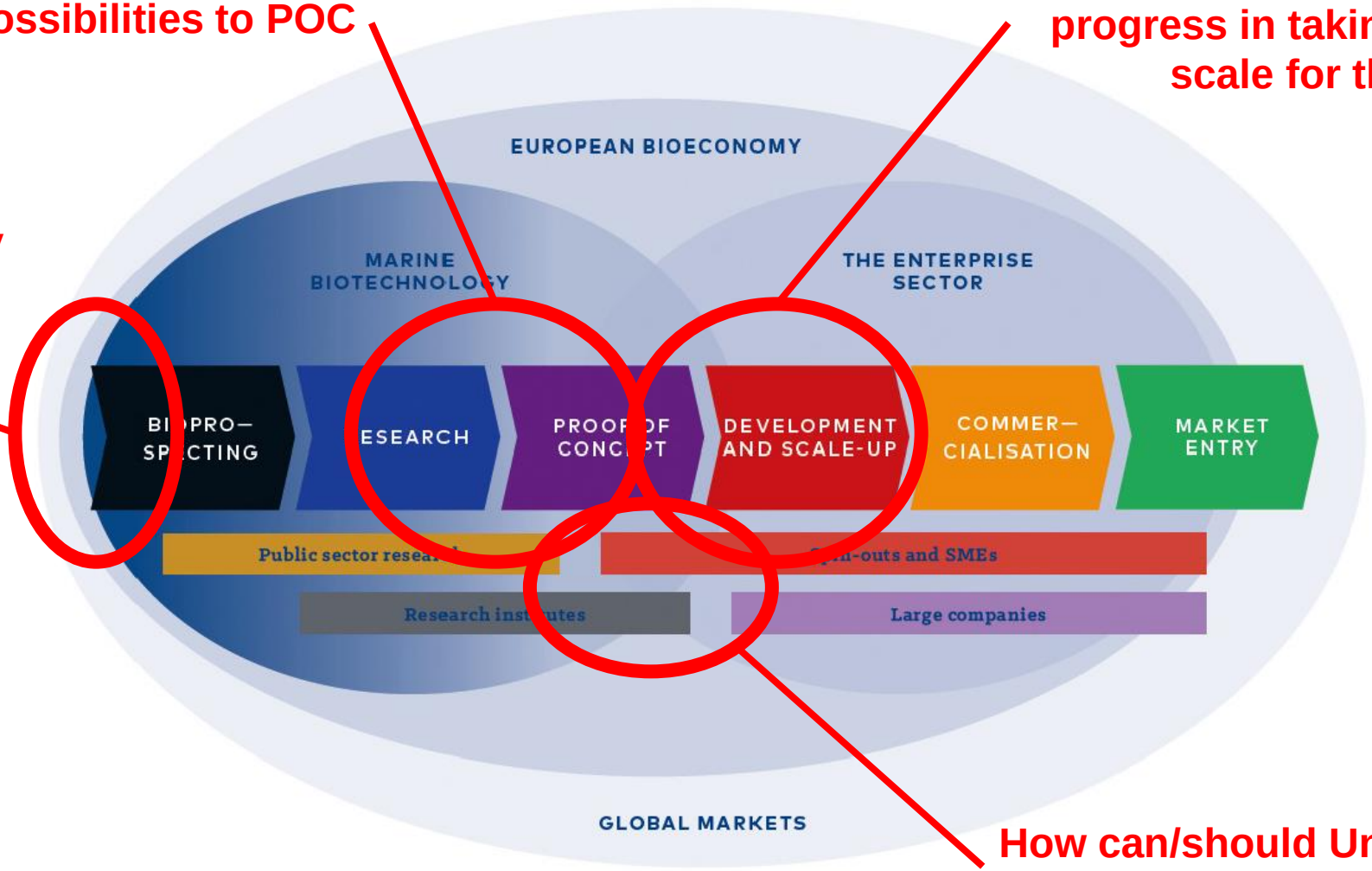
- Competence & capacity creates momentum
- Critical mass attracts novel product ideas and lead to diversification and innovations

Closing comments to the Roadmap

Lack of funding of research possibilities to POC

Funding of advanced upscalepilot facilities to enable progress in taking ideas into relevant scale for the industry to engage

Early Industry Involvement in low TRLs



How can/should Universities & Research Institutes engage further up the TRL?

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Enabling biotechnology to really be a key driver of the Bioeconomy

Thanks!