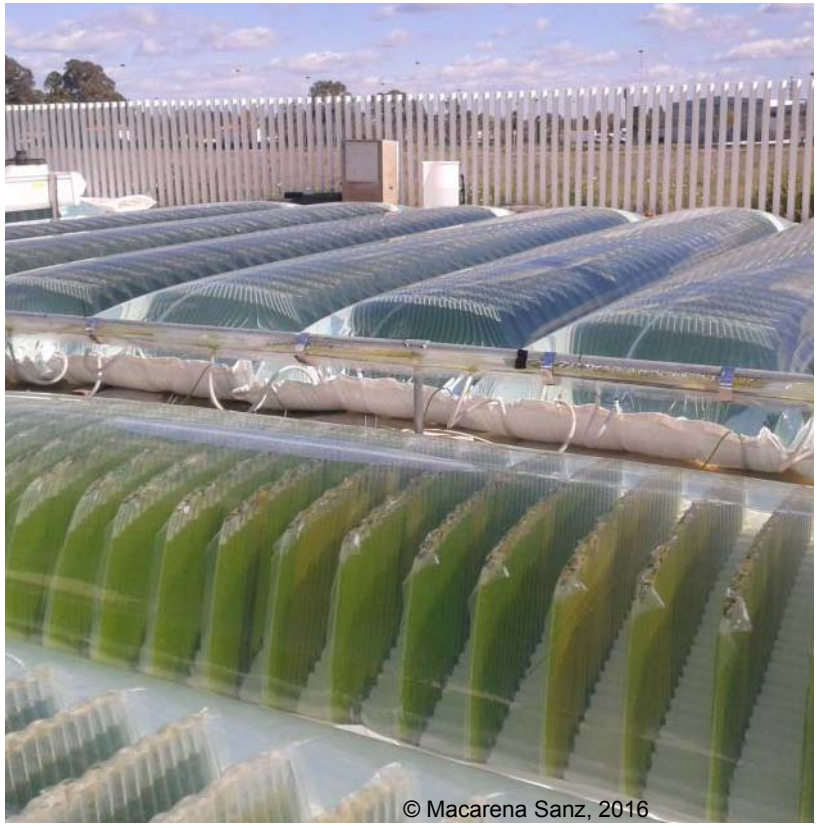
Nachhaltigkeitsbewertung von Biotreibstoffen aus Mikroalgen

Ergebnisse aus dem Projekt FUEL4ME



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Netzwerk Algen

Graz, Österreich

3. April 2017

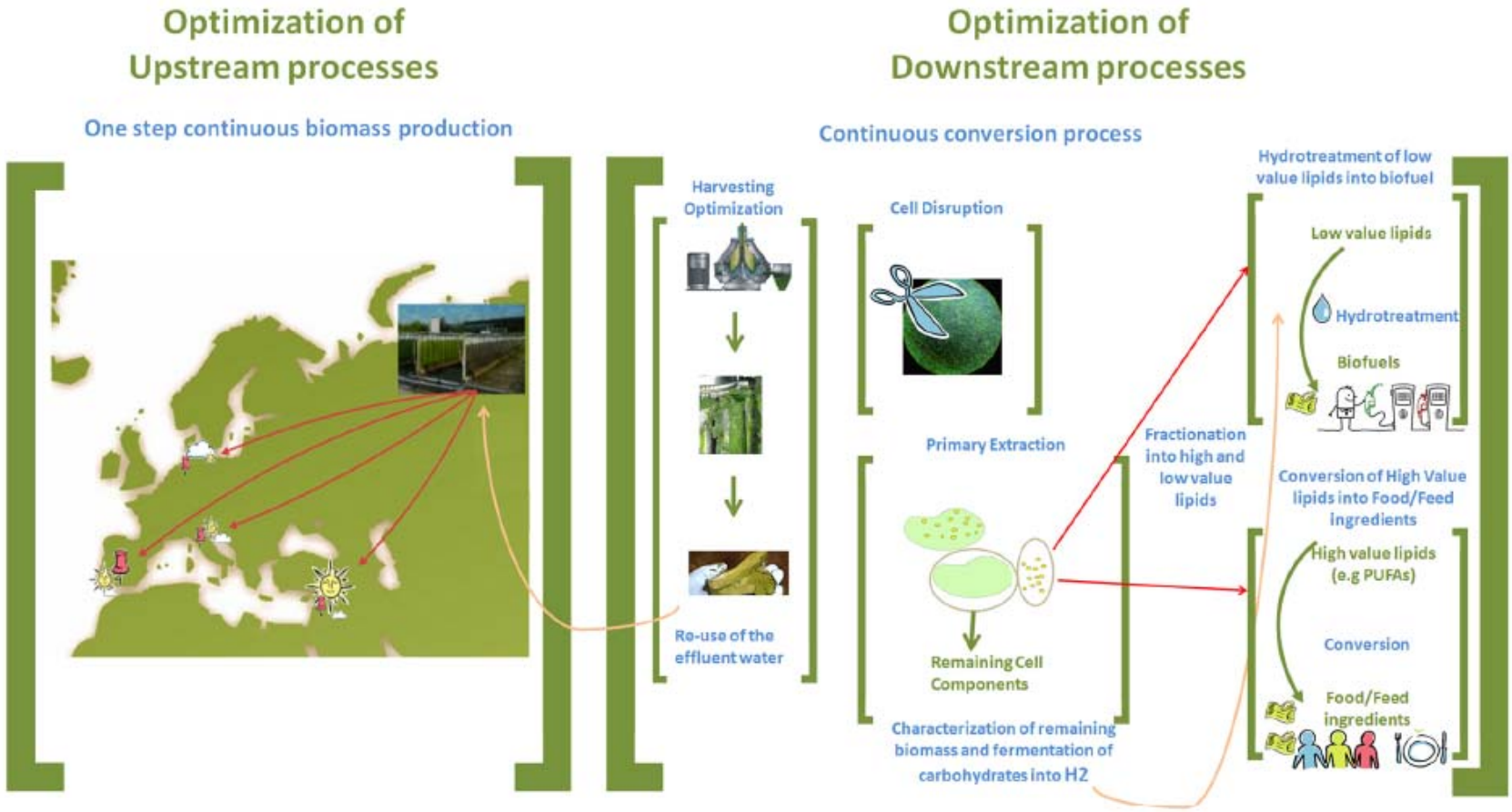
FUEL4ME

Future European League for Microalgal Energy

- Project funded by program FP7-ENERGY-2012-1
- Project coordinator:
  Wageningen University & Research (Wageningen, Netherlands)
- 10 project partners
- Project duration: January 2013 – December 2016
- Overall aim:
  - Establishing a sustainable chain for continuous biofuel production using microalgae as a production platform
  - Thereby making 2nd generation biofuels competitive alternatives to fossil fuels

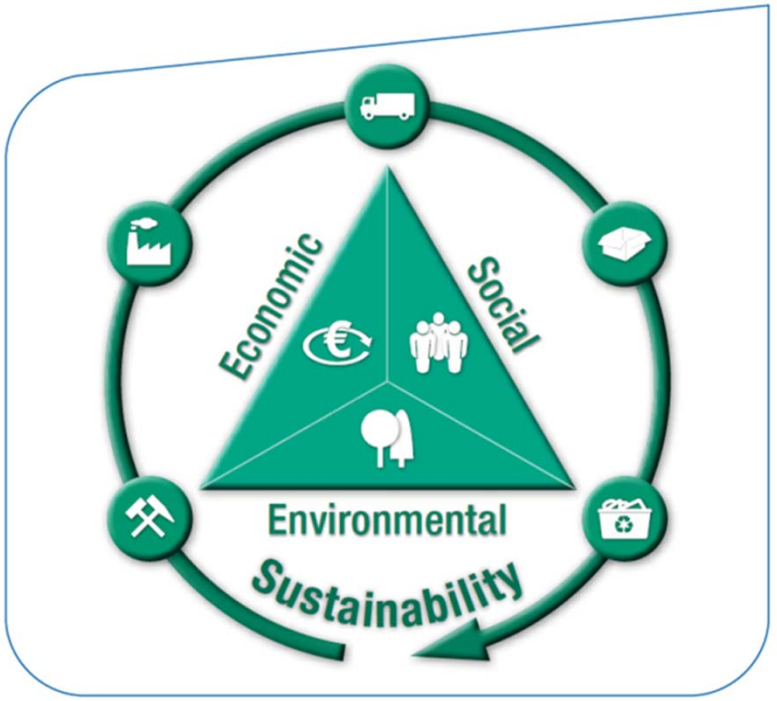
http://www.fuel4me.eu/

Production Process: From Algae Cultivation to Biofuel



Sustainability Assessment

- Outline and assess the sustainability of a continuous production and conversion process
- Includes environmental, economic and social aspects
- Based on the whole value chain
- Compared to conventional systems
- Determine economic feasibility and environmental sustainability



Selection of Sustainability Indicators in LCSA

Environment

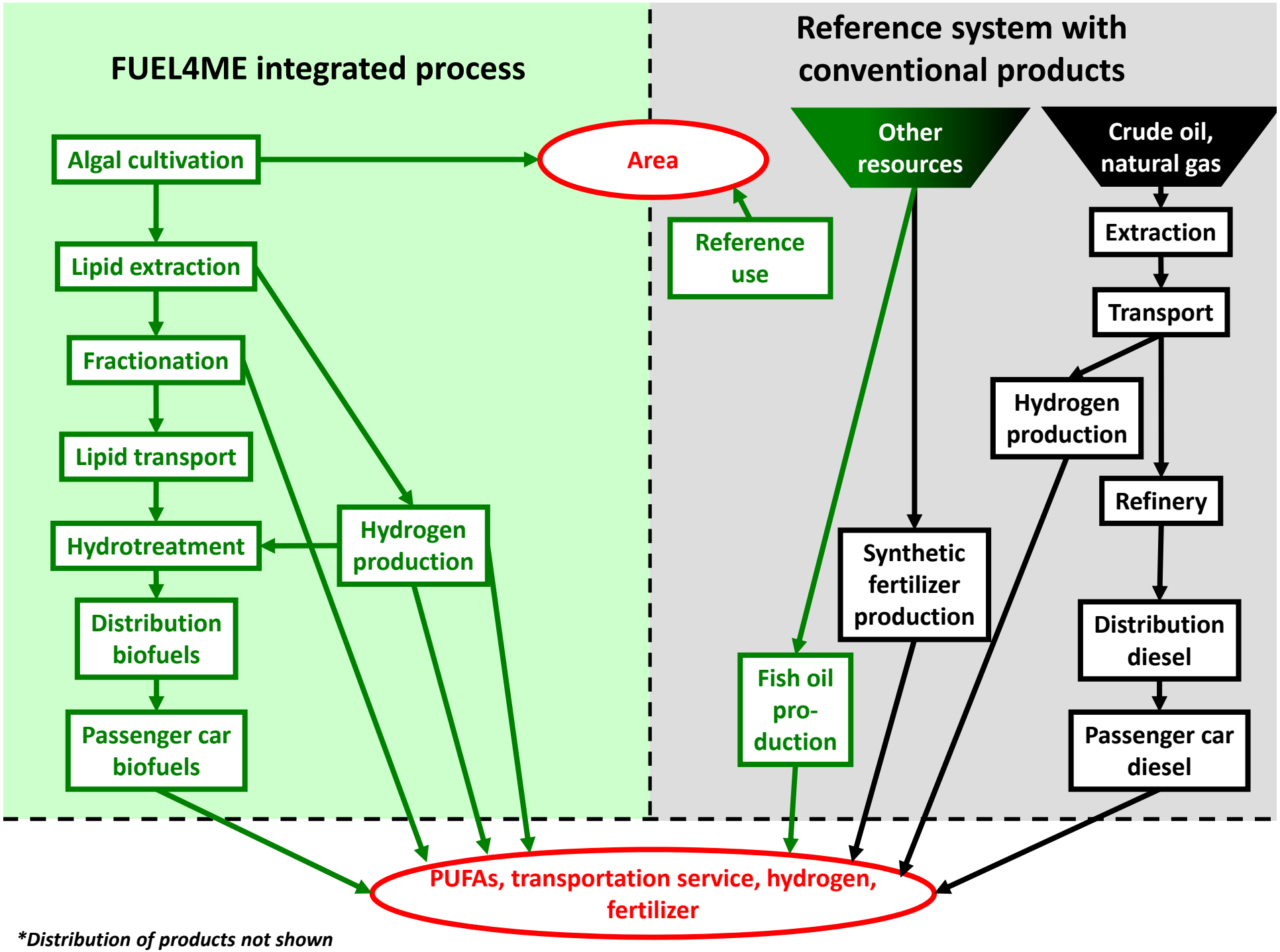
- ✓ **GHG** emissions (t CO_2-eq/a)
- ✓ **Primary energy** demand (GJ/a) (renewable, fossil, other)
- ✓ **Area** demand (ha/a)

Economy

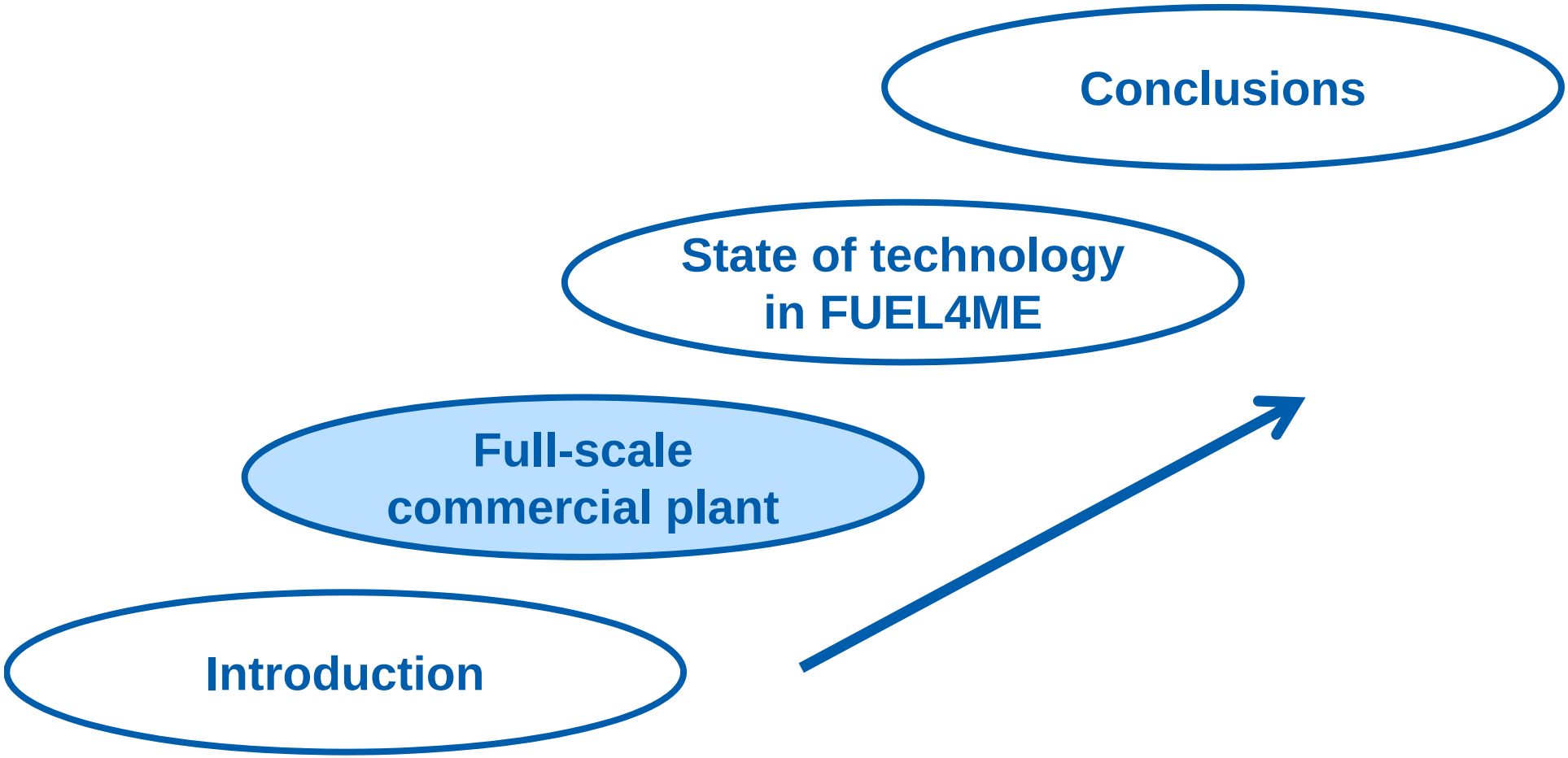
- ✓ Production **costs** (€/a)
- ✓ **Revenues** from products (€/a)
- ✓ **Value** added (€/a)
- ✓ **Employment** (persons/a)
- ✓ **Trade** balance (€/a)

Social

- ✓ **Workers**
- ✓ Consumers
- ✓ **Local community**
- ✓ Society
- ✓ **Value chain actors** (excl. consumers)


FUEL4ME integrated process
Reference system with conventional products
Algal cultivation
Lipid extraction
Fractionation
Lipid transport
Hydrotreatment
Distribution biofuels
Passenger car biofuels
Hydrogen production
Area
Reference use
Other resources
Crude oil, natural gas
Extraction
Transport
Hydrogen production
Refinery
Synthetic fertilizer production
Fish oil pro-duction
Distribution diesel
Passenger car diesel
PUFAs, transportation service, hydrogen, fertilizer
*Distribution of products not shown

Overview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Modelling to fulfill three Main Targets for Commercialization

Production costs (possible revenues):

- Algal biomass: < 2,000 € / t_{DM}
- Algal oil for biofuels: < 900 € / t_{oil}
- PUFA: 11,000 – 15,000 € / t_{PUFA}

GHG reduction (according to RED):
≥ 60% (≤ 33.5 g CO_2-eq/$MJ_{biofuel}$)
with transport 2 g CO_2-eq/$MJ_{biofuel}$
processing 1.3 – 1.7 g CO_2-eq/$MJ_{biofuel}$ (with H2 from algae residues)

Cumulated fossil primary energy demand:
≤ 0.3 MJ_{fossil}/$MJ_{biofuel}$

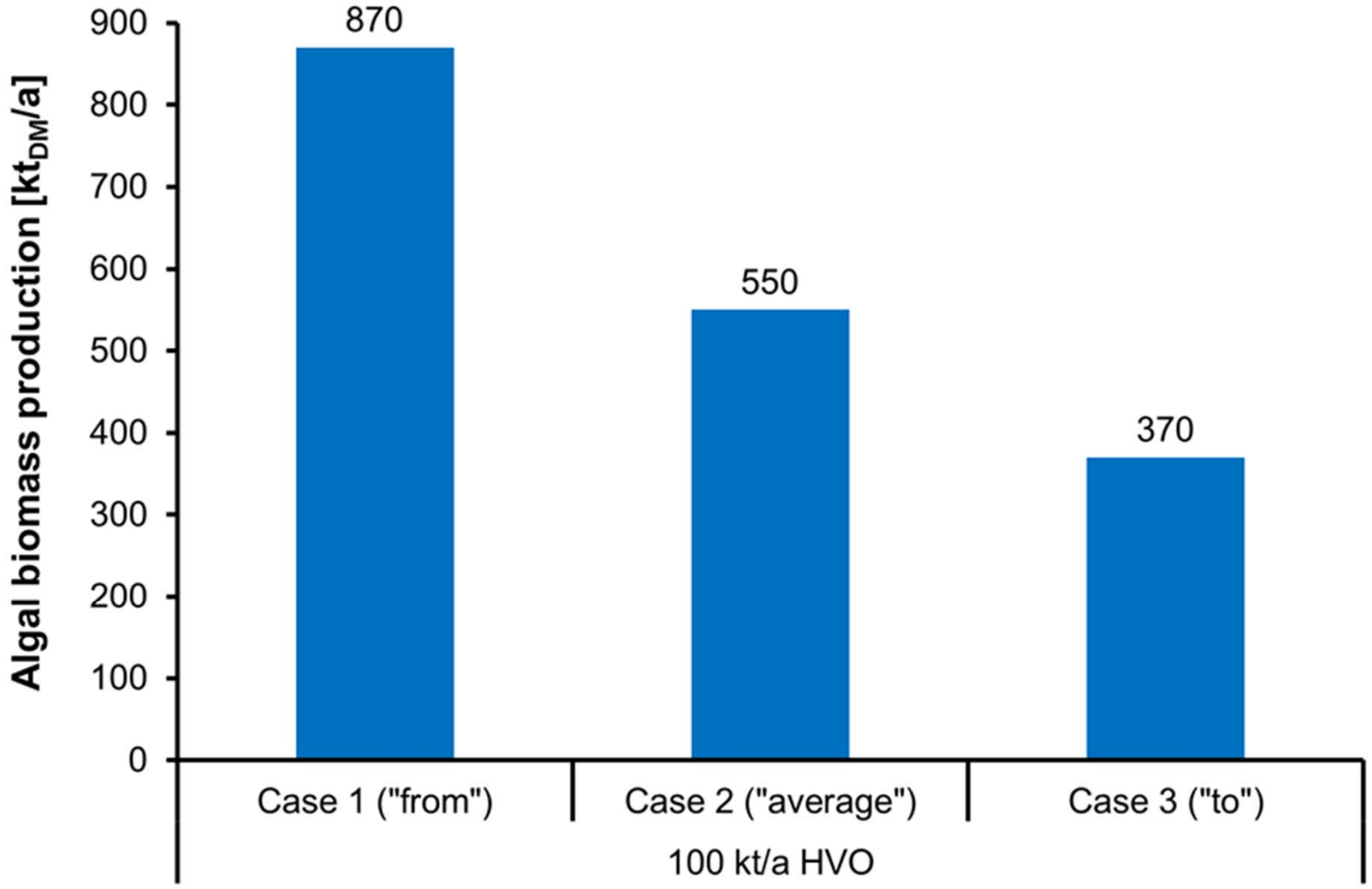
Development of three Cases for 100 kt Biofuel Production

- **Definition** of 3 Cases based on the assumptions

- **Each Case has specific values** out of the assumed value ranges, e.g. lipid yield: 18 – 35 t/(ha*a)
  - Case 1: favourable conditions, naming „from“
  - Case 2: average favourable conditions, naming „average“
  - Case 3: very favourable conditions, naming „to“

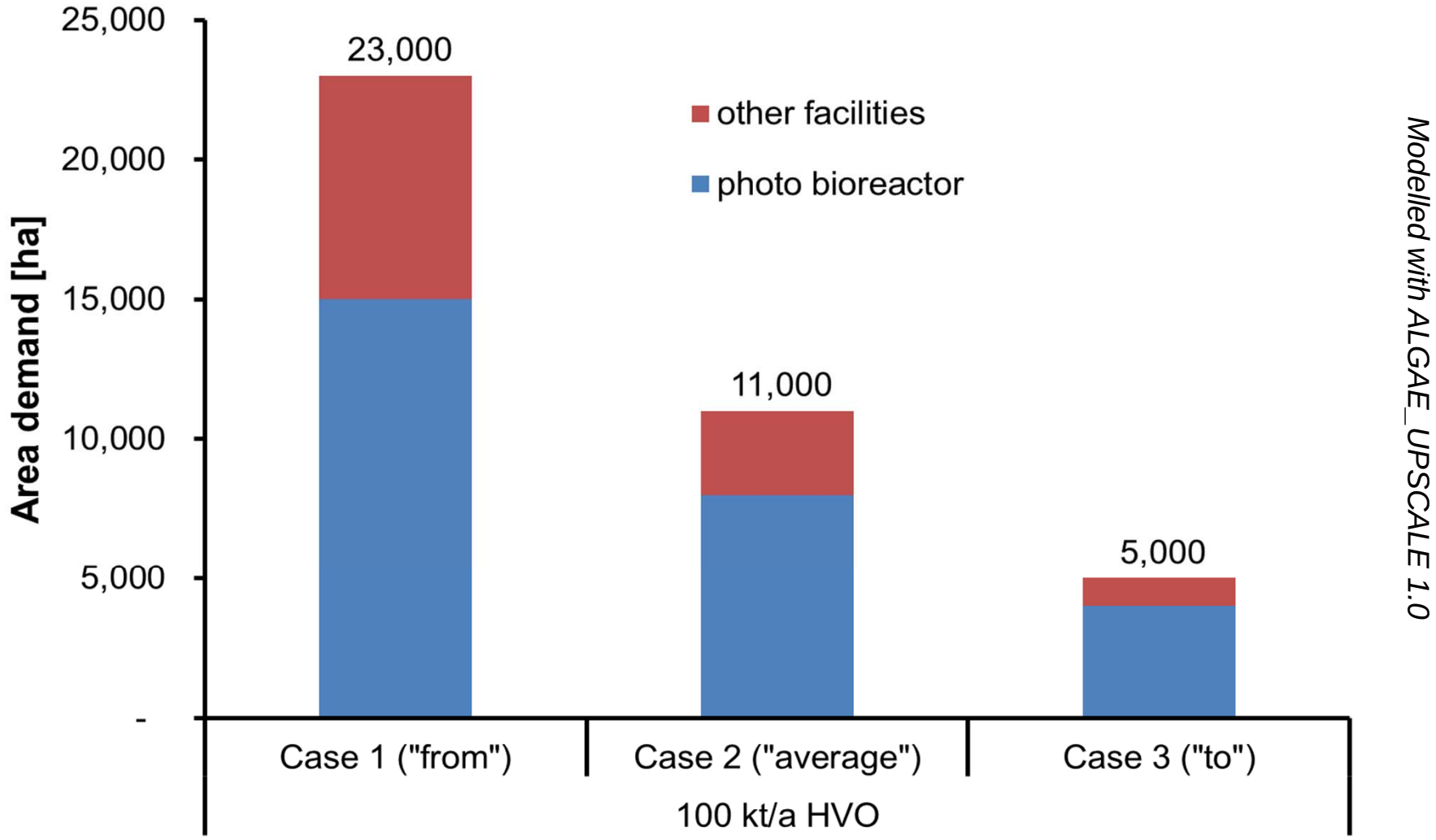
- To define **guiding values** and **sustainability indicators** for a full scale integrated microalgal-based process

Estimated Algal Biomass Production



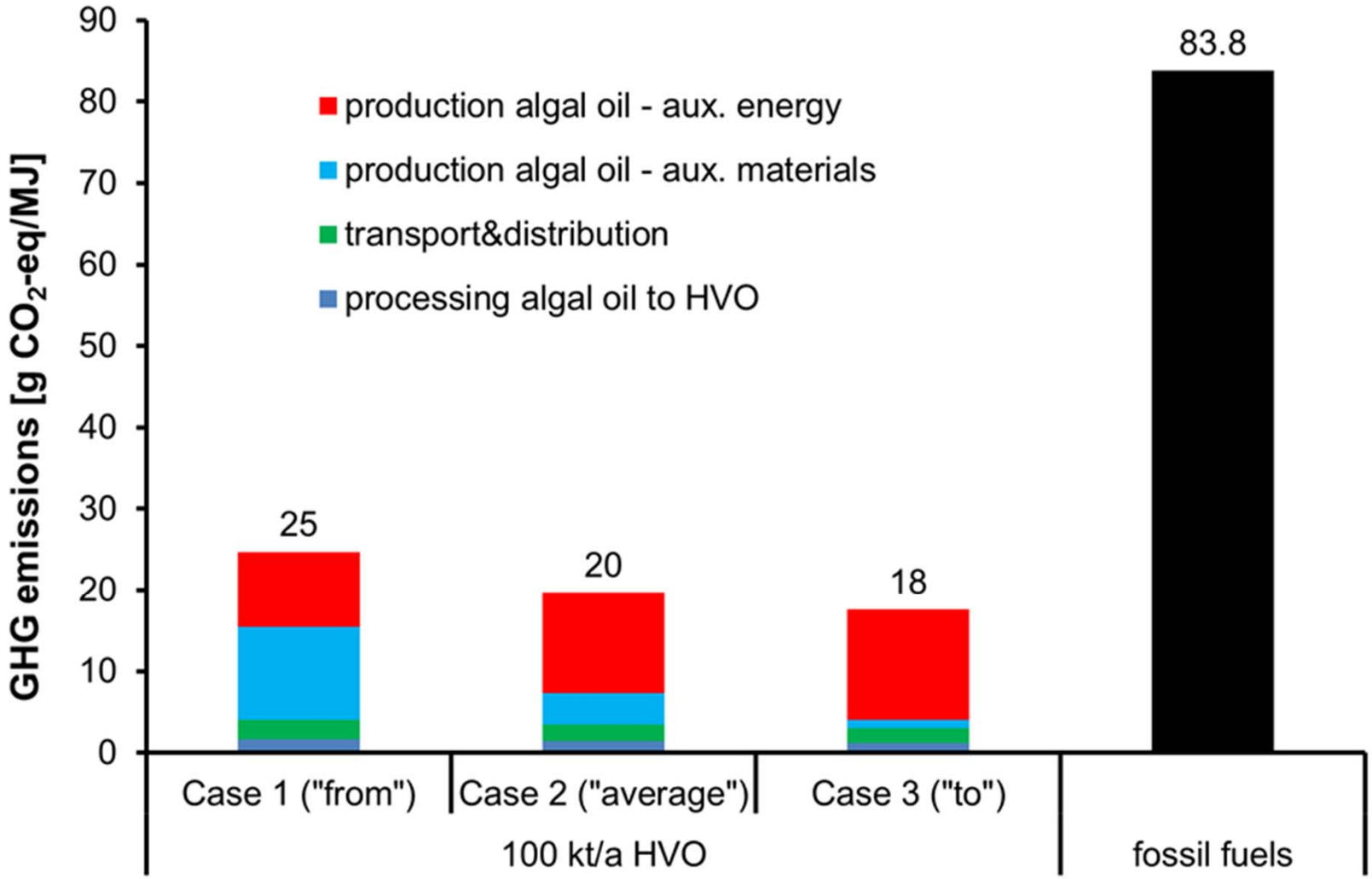
Modelled with ALGAE_UPSCALE 1.0

Estimated Area Demand



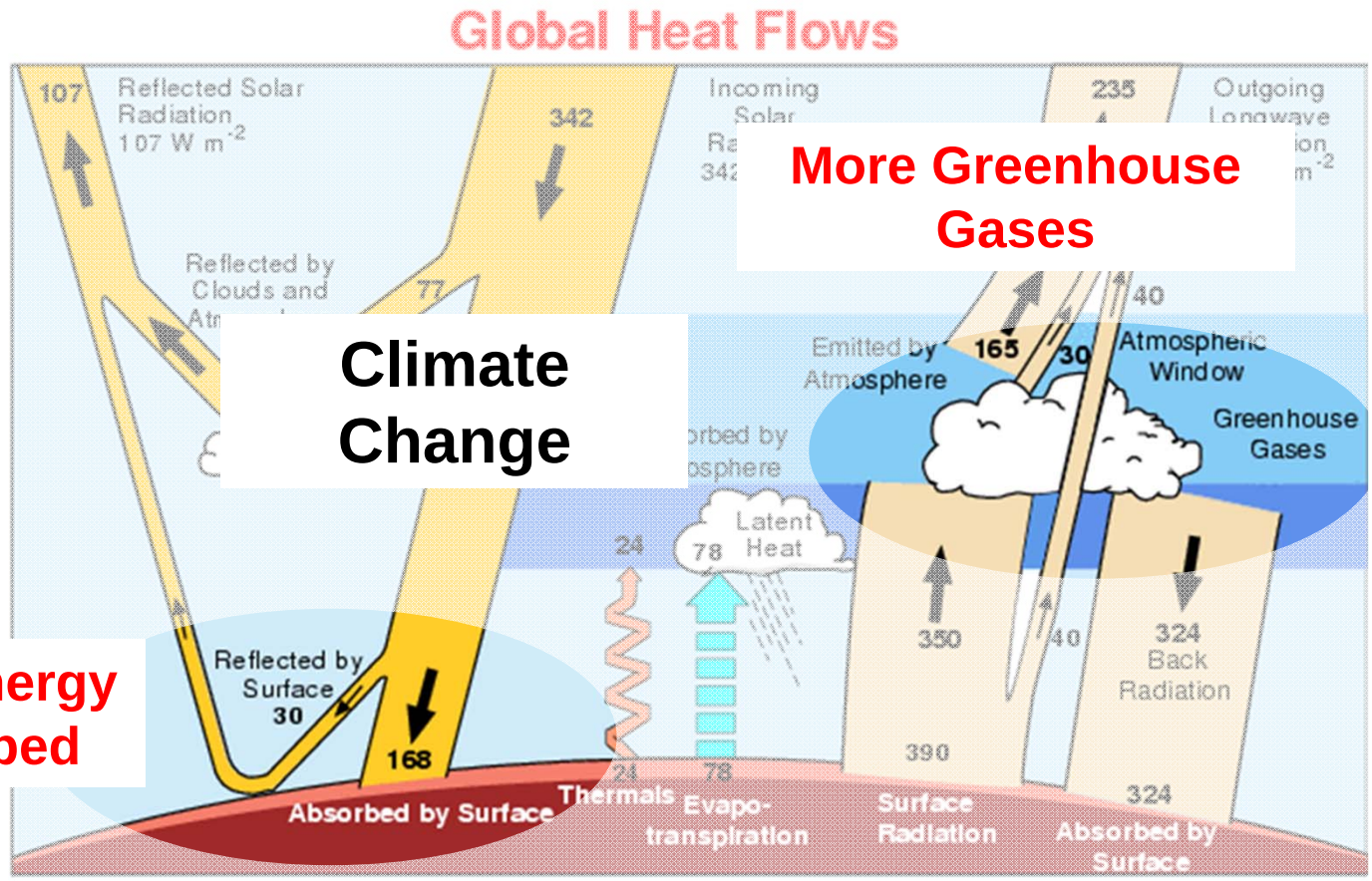
Modelled with ALGAE_UPSCALE 1.0

Estimated Greenhouse Gas Emissions of HVO (according to RED Methodology)



Modelled with ALGAE_UPSCALE 1.0

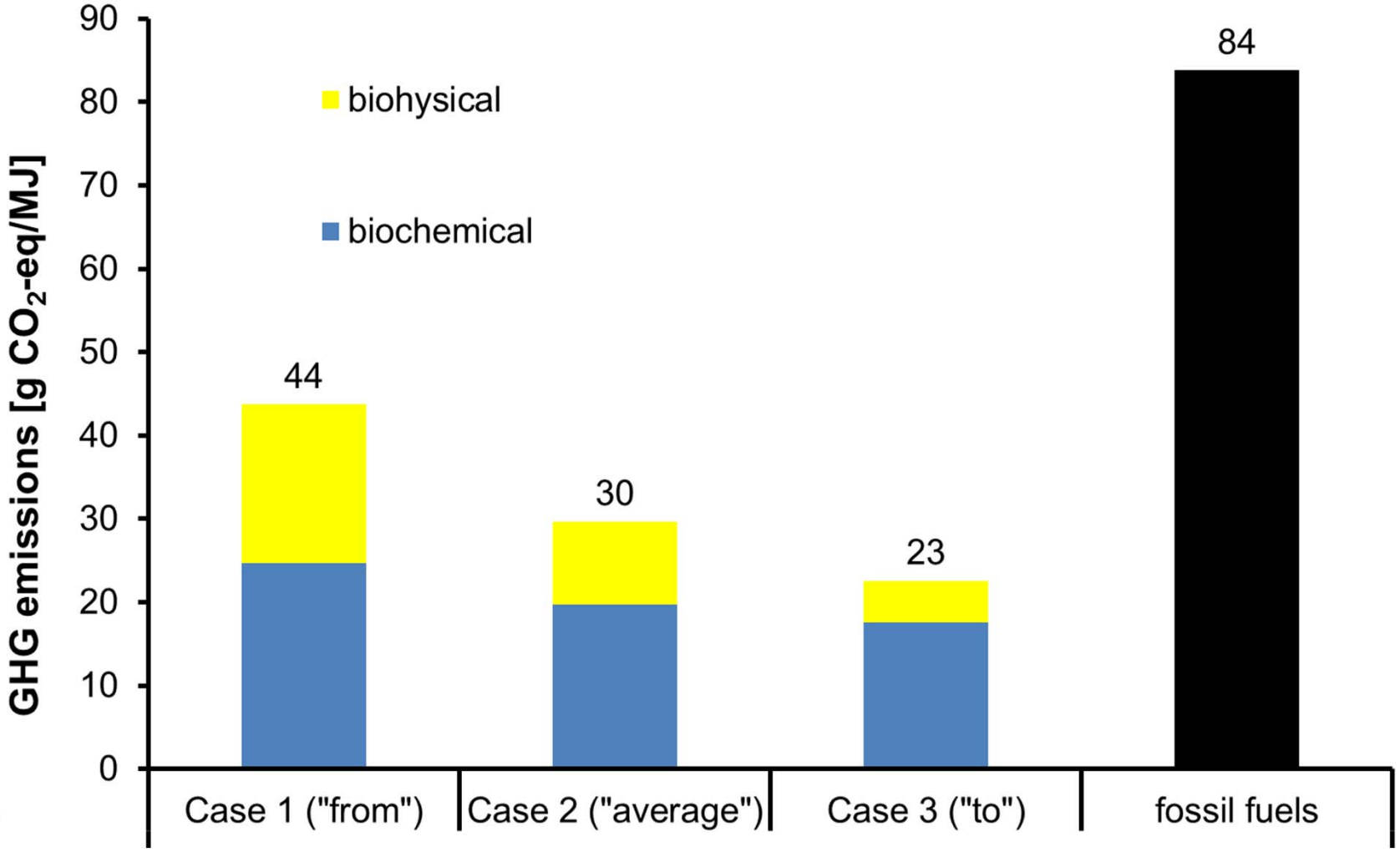
Earth's Annual and Global Mean Energy Balance



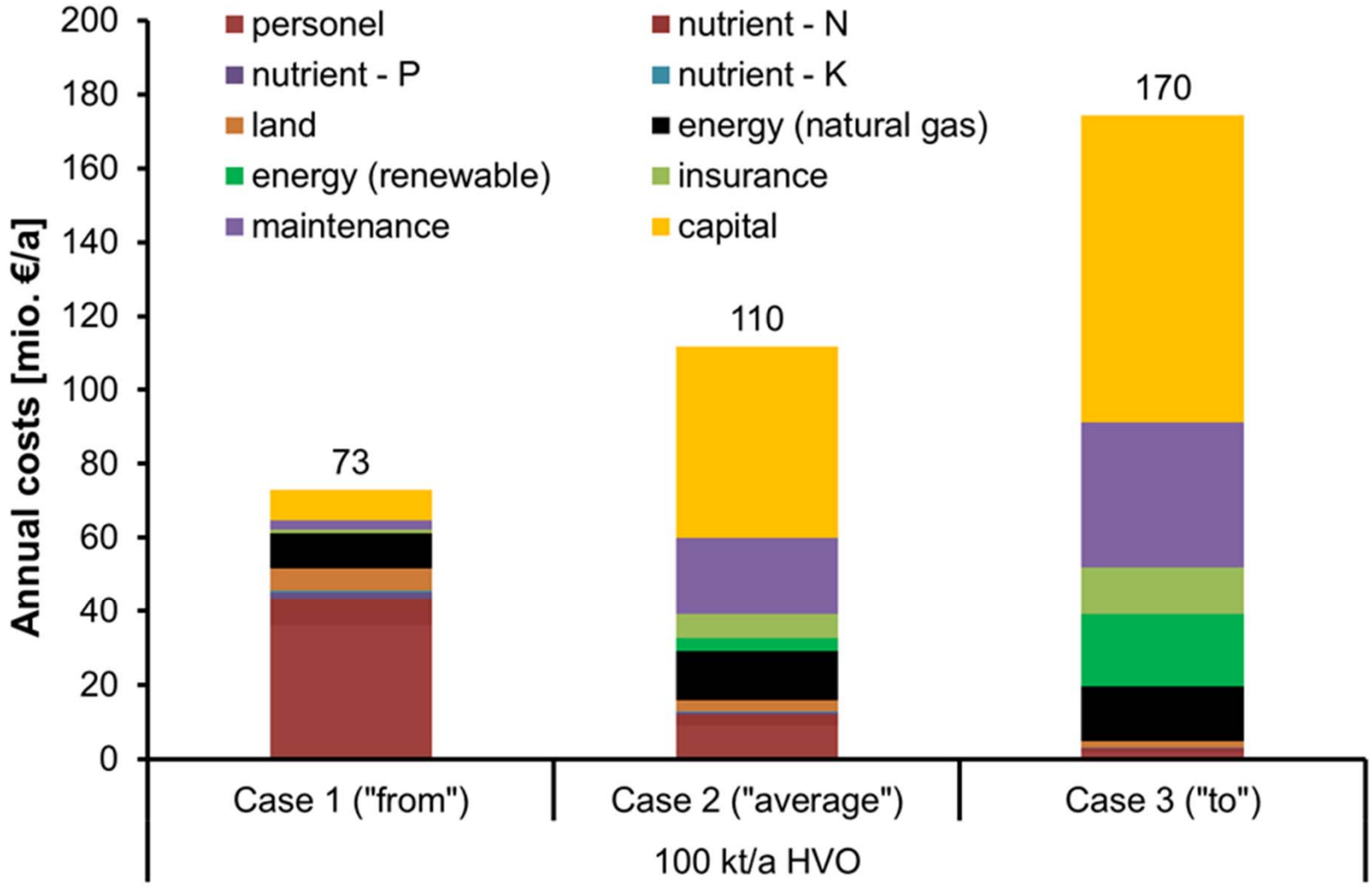
More Energy Absorbed

from Windows to the Universe® (http://windows2universe.org)

GHG Emissions incl. Biophysical Impacts (Albedo)



Estimated Share of Annual Costs of Algal Oil Production



Modelled with ALGAE_UPSCALE 1.0

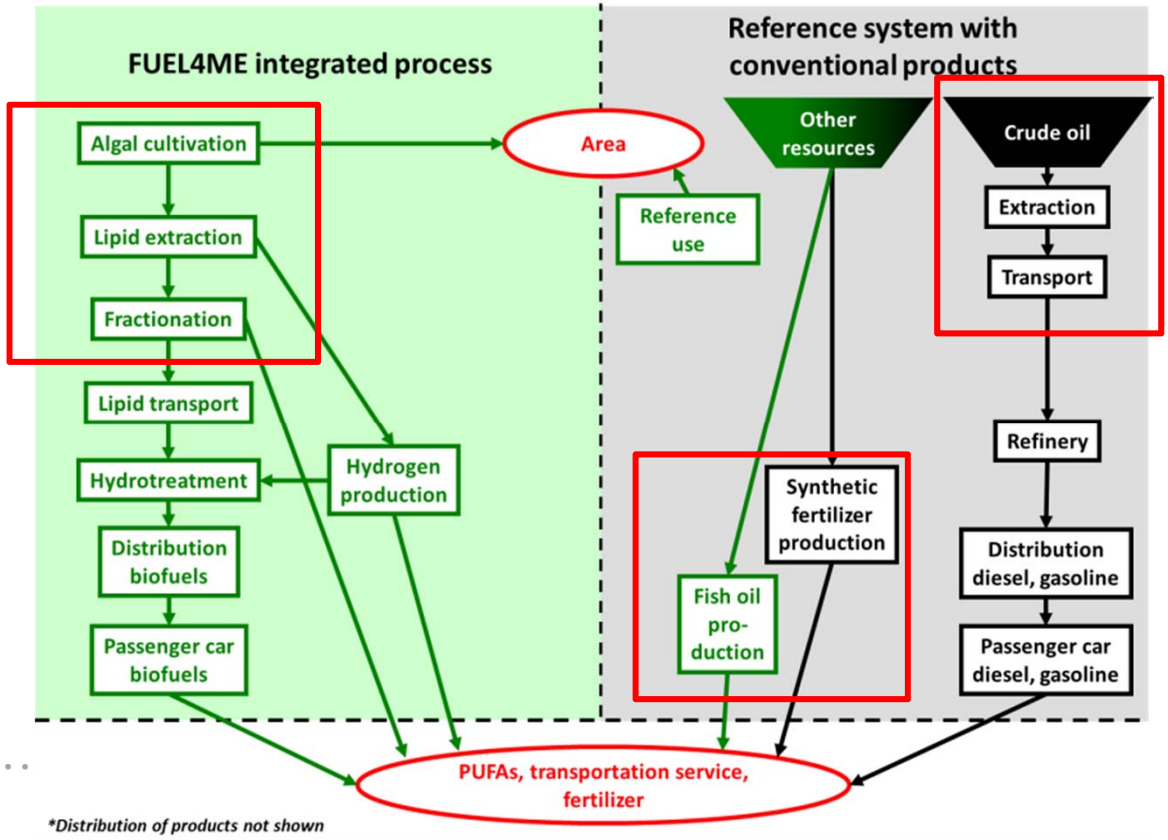
Possible Social „Hot Spots“

Process steps where social issues should be addressed:

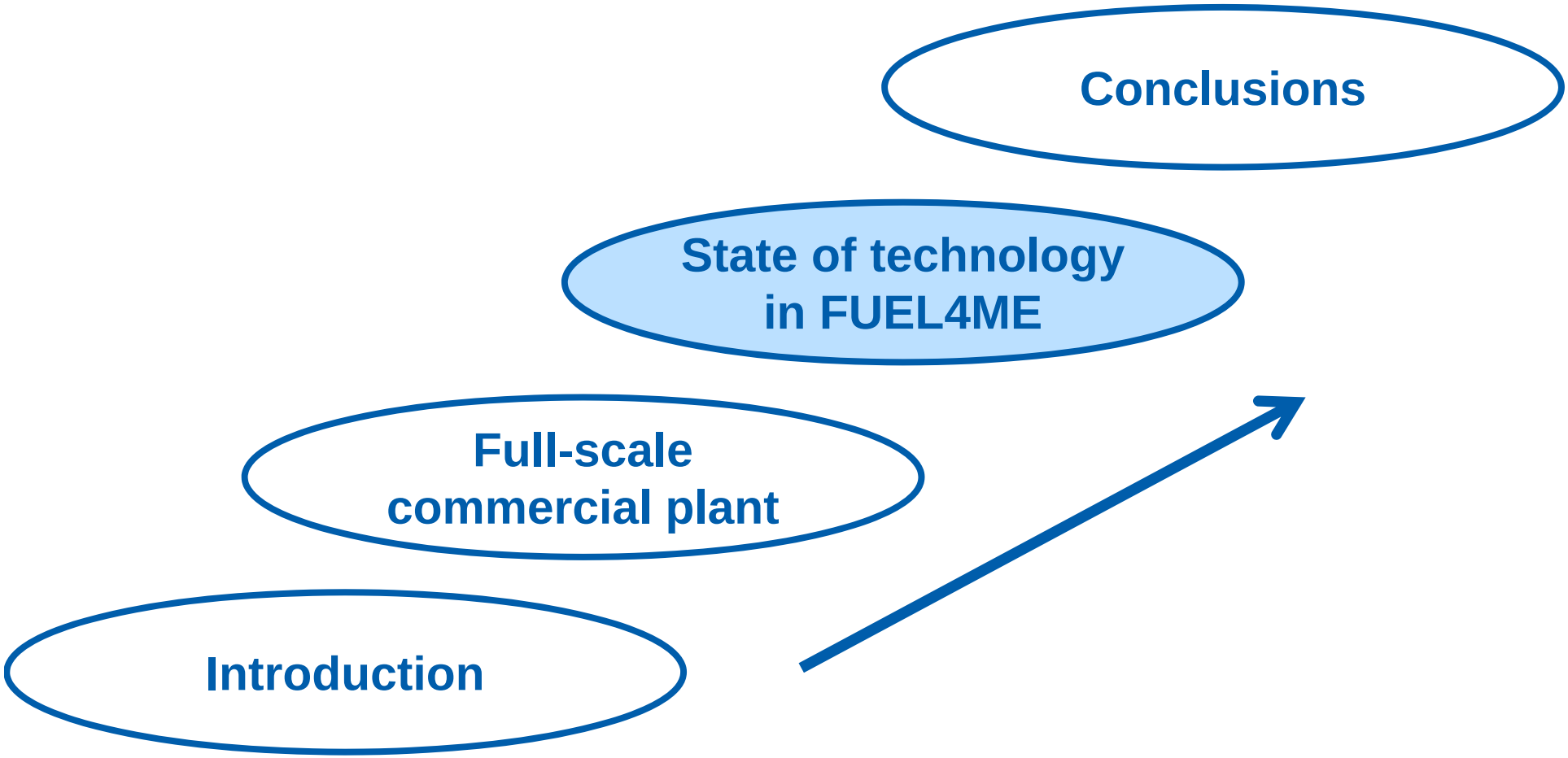
- Cultivation and harvesting
- Lipid extraction and fractionation

“Hot spots”:

- Differences Europe – Outside Europe
- Engagement with local citizens
- Local employment
- Transparency to foster the acceptance



Overview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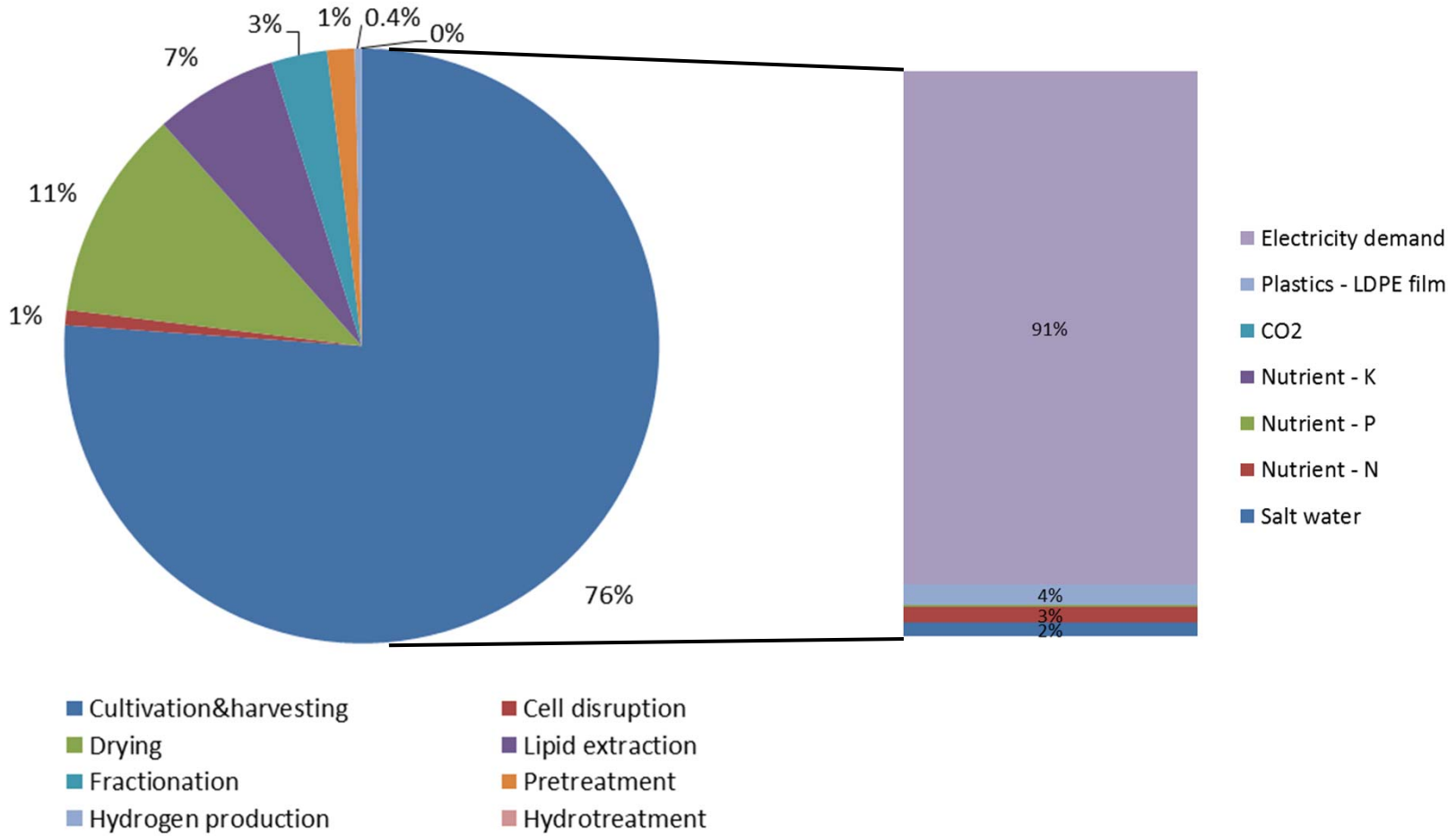
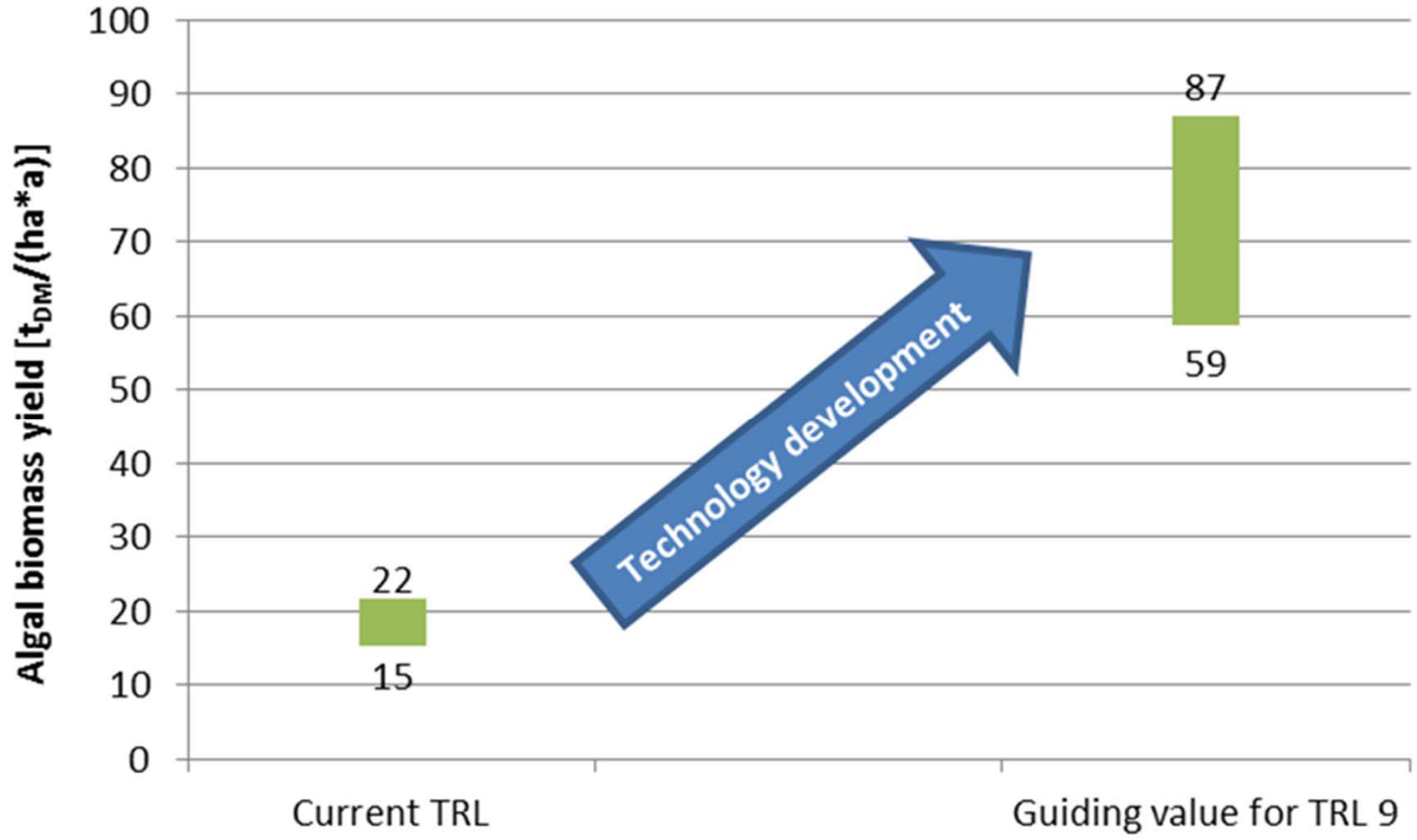
GHG Emissions for FUEL4ME defined Concepts

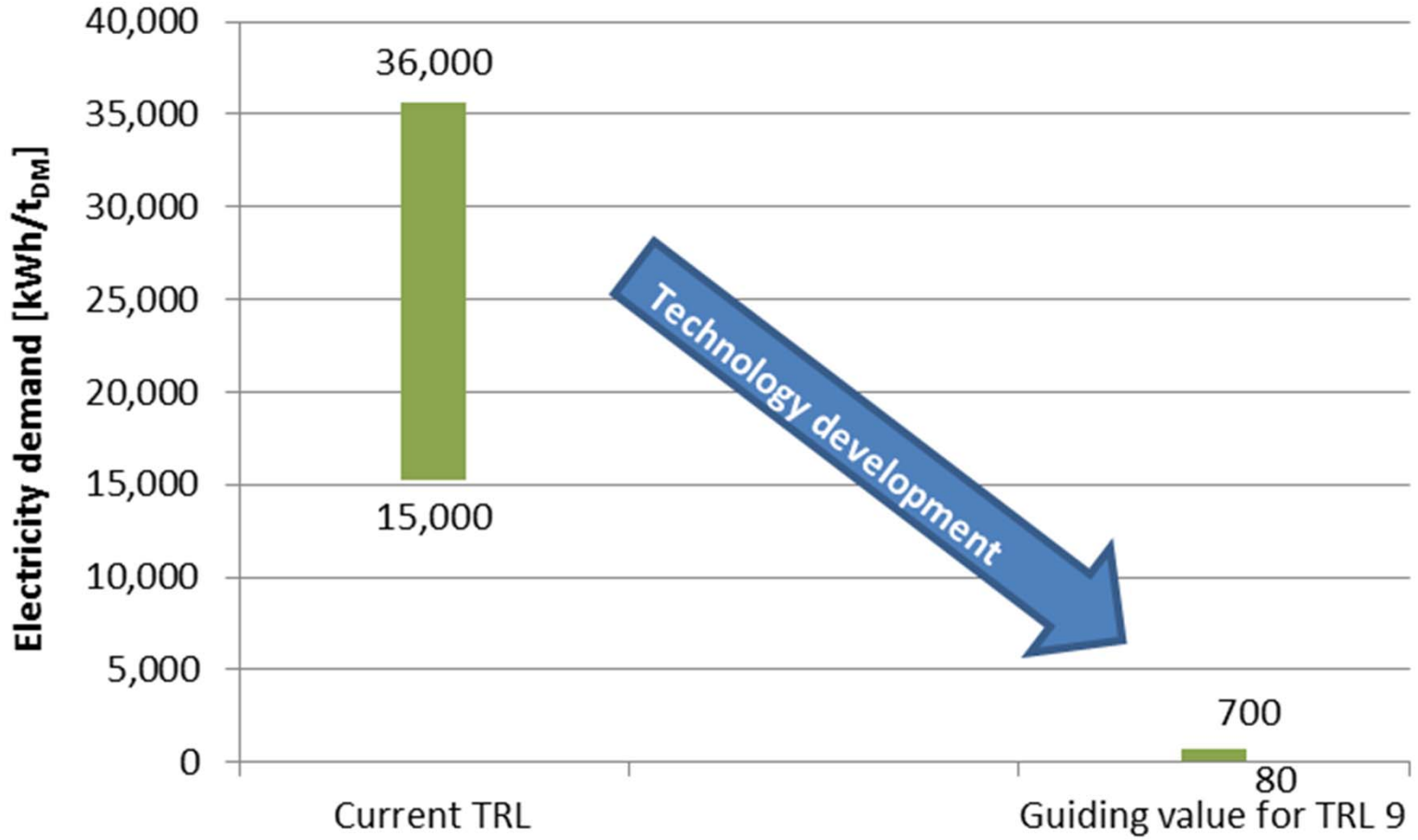


Algal Biomass Yield



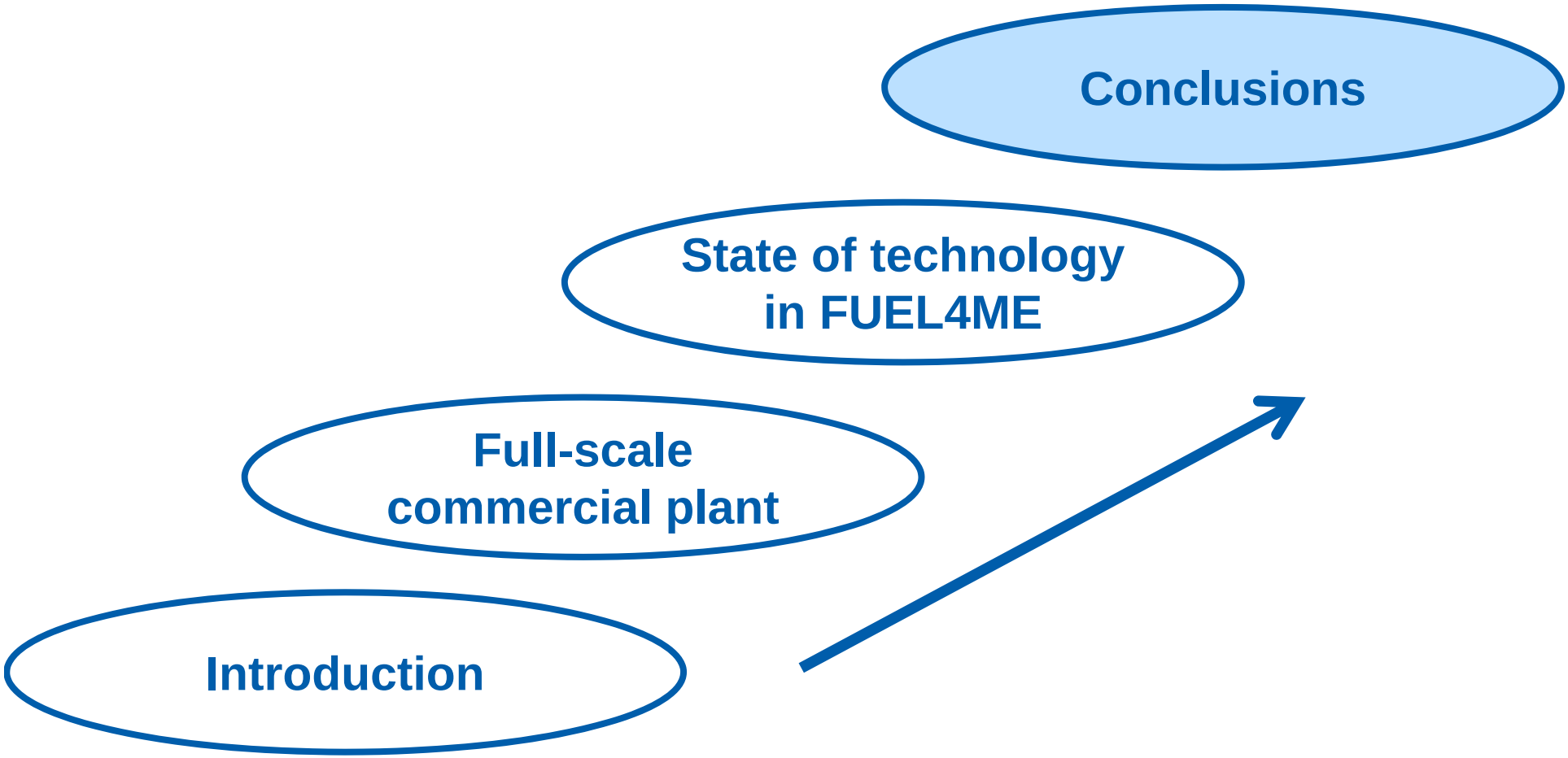
TRL…Technology readiness Level

Electricity Demand



TRL…Technology readiness Level

Overview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Sustainability Indicators of a Full Scale Process

Technical values – cultivation	Average	Value range	Unit
algae oil yield	21	13 - 34	t_oil/(ha*a)
oil content algae	30	21 - 39	%_DM
PUFA content used	2	0 - 5	%_oil
algal biomass yield	71	59 – 87	t_DM/(ha*a)
nutrient recycling	70	60 – 80	%
Technical values - production plant			
production capacities	110	109 – 113	kt/a (algae oil, H_2, PUFA)
algal biomass production	550	370 – 870	kt/a
CO2 demand	280	210 – 390	kt/a
fuel power of CO2-source	180	100 – 340	MW_oil
	140	80 – 270	MW_wood
minimal hydrogen production	12	8 – 17	kg/t_residueDM
Environmental indicators			
cumulated primary energy demand	1.4	1.3 – 1.7	MJ_primaryenergy/MJ_HVO
electricity demand	240	80 – 700	kWh/t_DM
heat demand	320	100 – 1,300	kWh/t_DM
area demand	11,000	5,000 – 23,000	ha
GHG emissions	20	18 – 25	g_CO_2-eq/MJ_HVO
GHG saving	77	71 – 79	%
GHG emissions of cultivation	16	15 – 21	g_CO_2-eq/MJ_HVO
GHG emissions including albedo effect	30	23 - 44	g_CO_2-eq/MJ_HVO
Economic indicators			
annual revenues	110	73 – 170	mio. €/a
annual costs	110	73 – 170	mio. €/a
investment costs	830	120 – 1,400	mio. €
specific investment costs	4,300	500 – 9,200	€/(t_oil&H_2/a)
	1,500	141 – 3,700	€/(t_DM/a)
total specific costs	1,000	700 – 1,400	€/t_oil&H_2
	200	80 – 420	€/t_DM
economic value added of FUEL4ME biorefinery	101	-	mio. €/a
economic value added: counter effects	-104	-101 - -107	mio. €/a
employment of FUEL4ME biorefinery	2,030	-	persons/a
employment: counter effects	-1,820	-1480 - -2000	persons/a

Conclusions

Further **technology development** needed to improve economic and environmental sustainability

Main influences on the sustainability: cultivation and harvesting, electricity demand, source of CO_2, source of water, suitable land

Biorefinery approach: production of biofuels and high valuable co-products, for economic feasibility and environmental sustainability

Guiding values for future full-scale commercial algae oil cultivation are given by possible revenues, GHG & fossil energy reduction

Elements: environmental e.g. GHG emissions, energy demand, economic e.g. production costs, valued added, society e.g. employment, supplier relationships

Sustainability assessment in three dimensions:
environmental, economic, society based on whole value chain

JOANNEUM RESEARCH LIFE

Thanks!

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