SDU
LIFE CYCLE ENGINEERING

Why go circular?

- the circular economy og biogas
- tackling scarce resources and climate change

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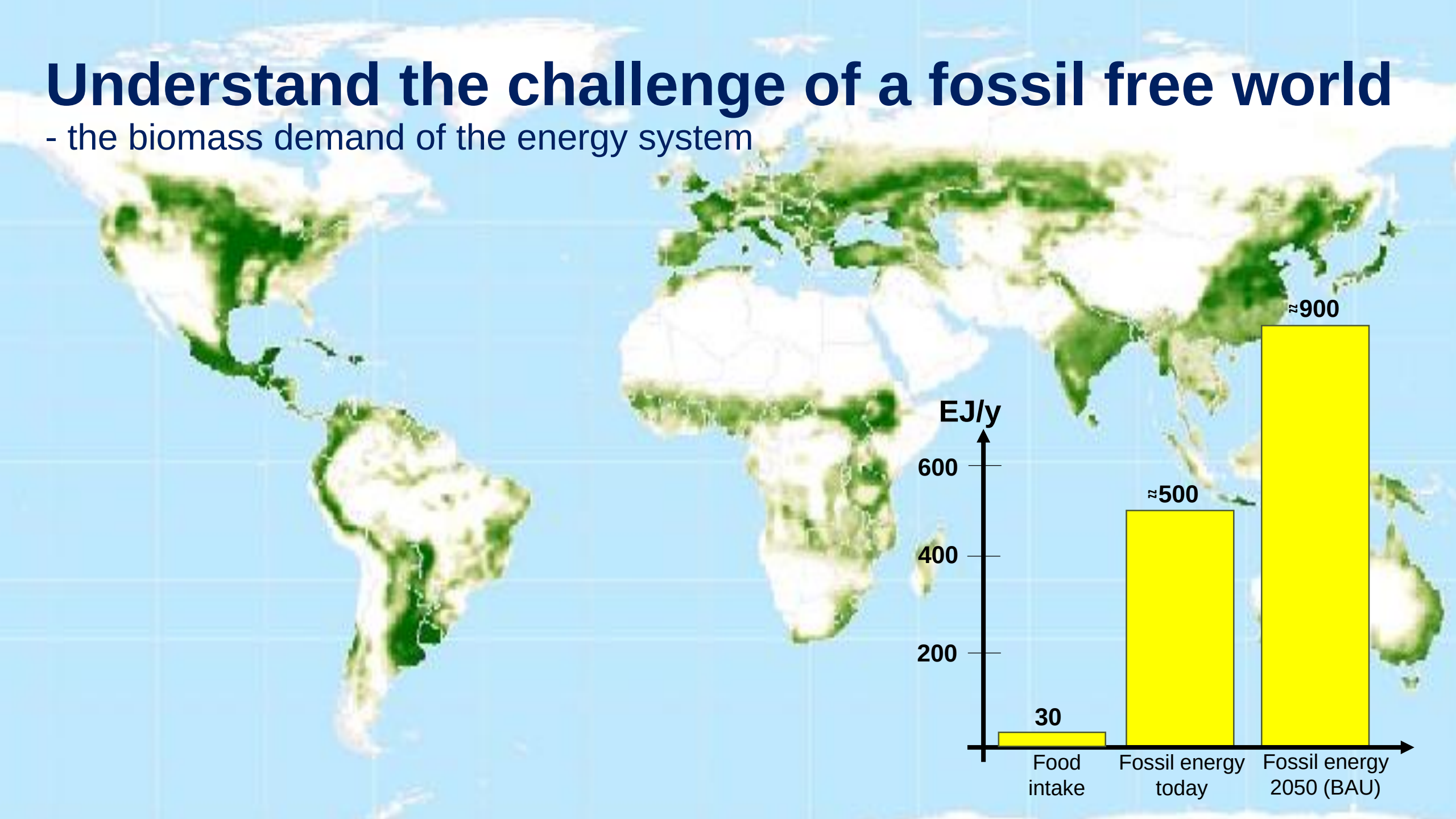
Nordic Biogas Conference
Oslo, 9th of April 2019

Understand the challenge of a fossil free world

- the biomass demand of the energy system



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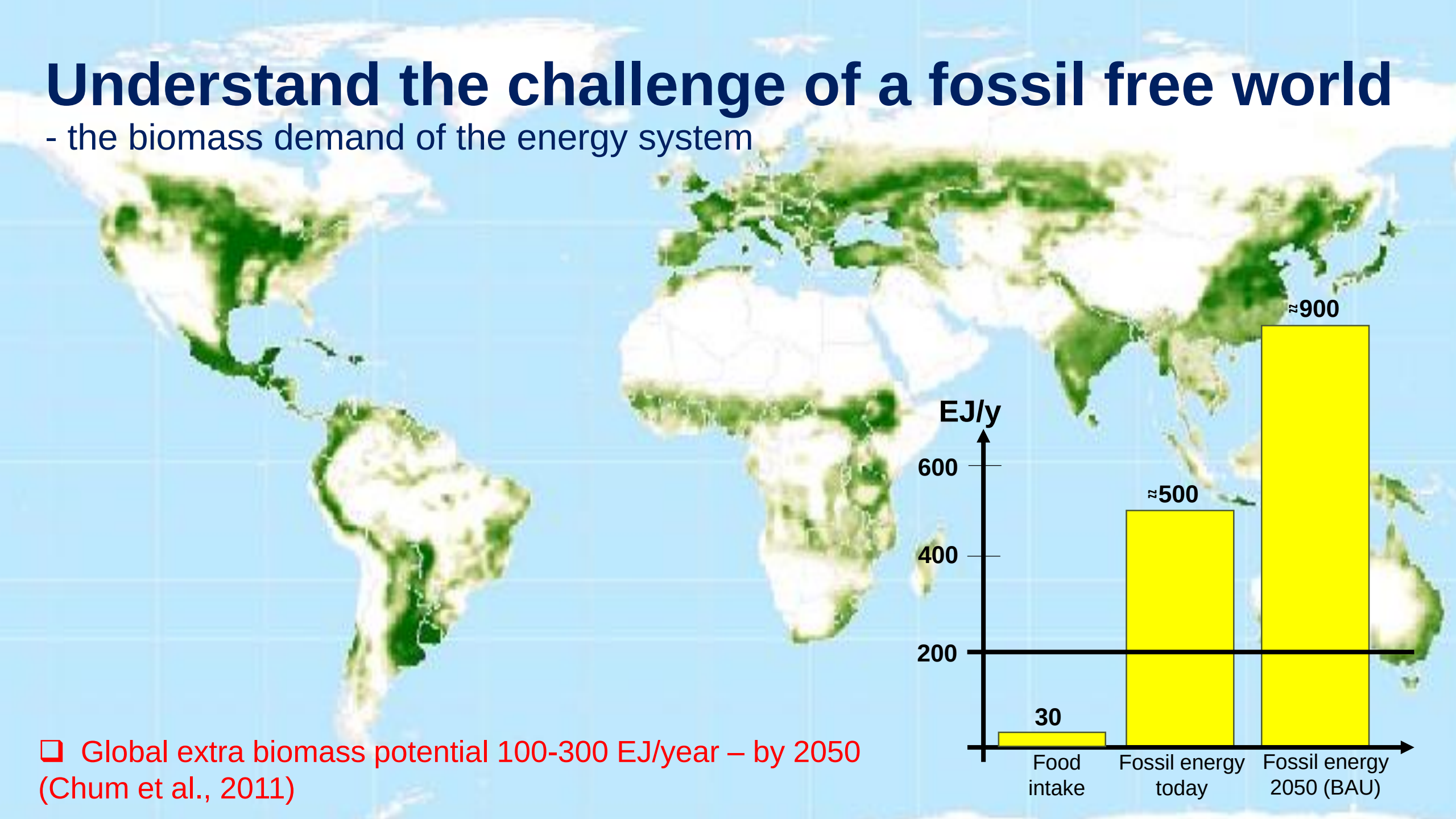

❑ Global extra biomass potential 100-300 EJ/year – by 2050 (Chum et al., 2011)

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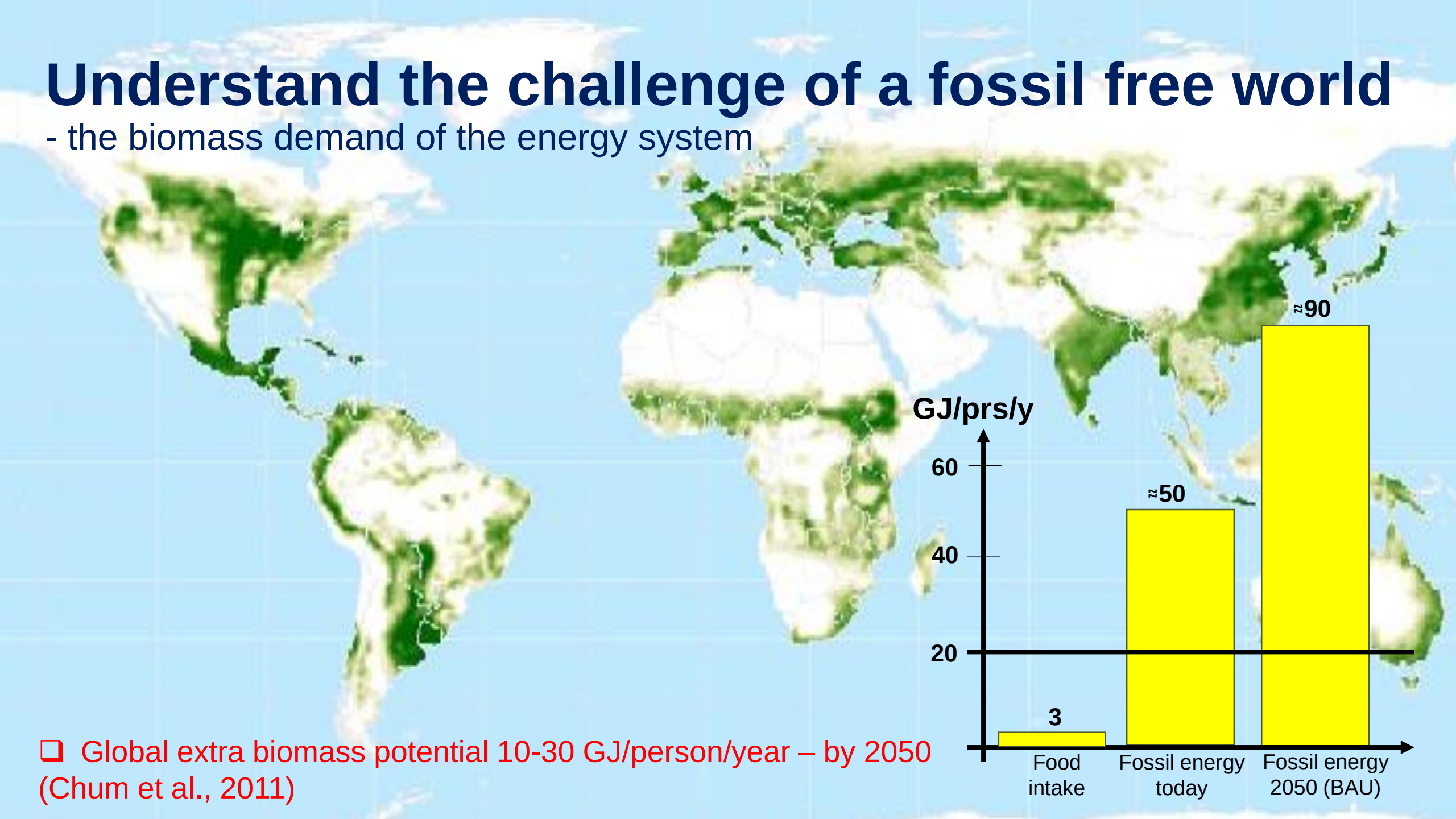

❑ Global extra biomass potential 10-30 GJ/person/year – by 2050 (Chum et al., 2011)

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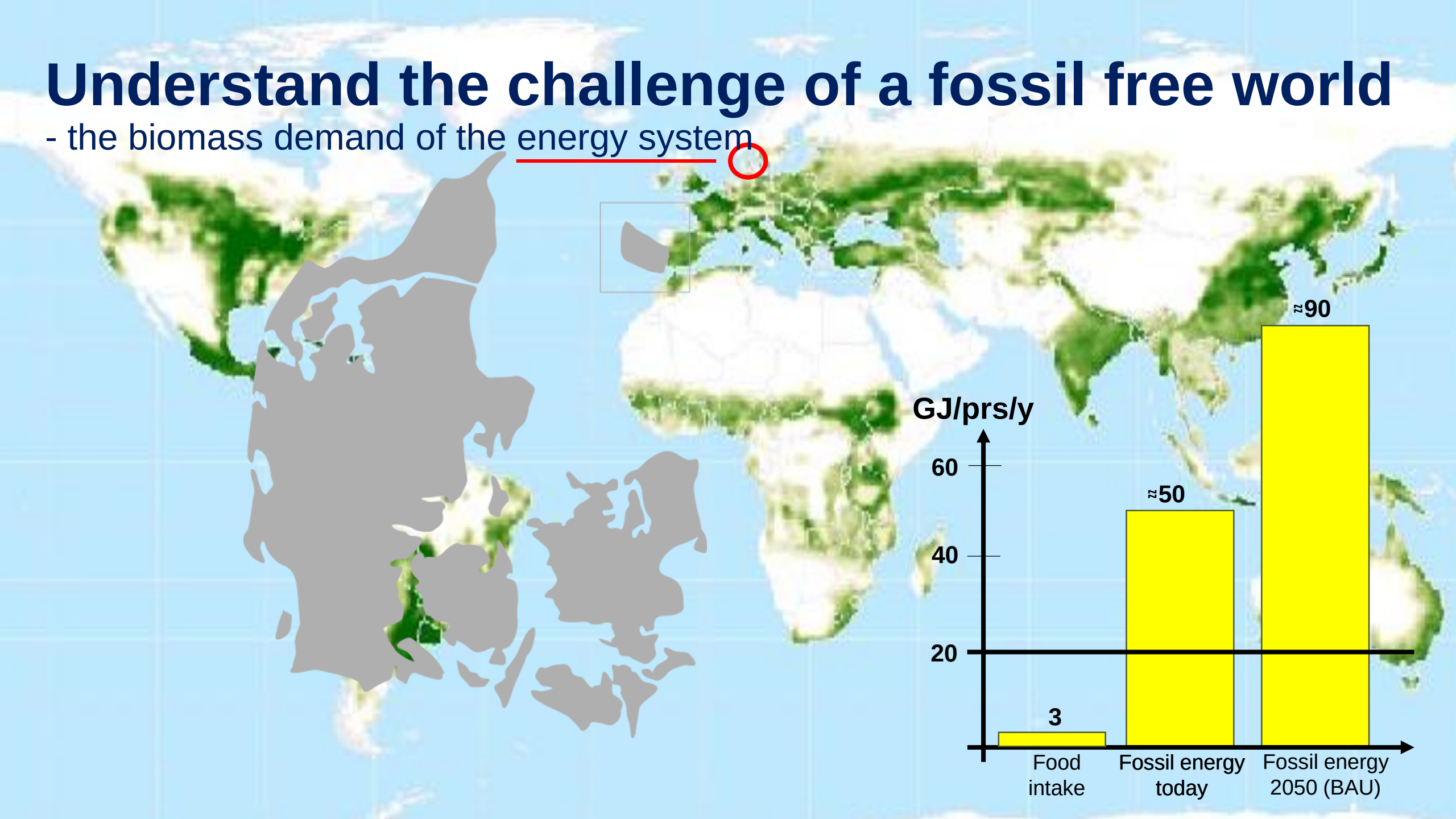
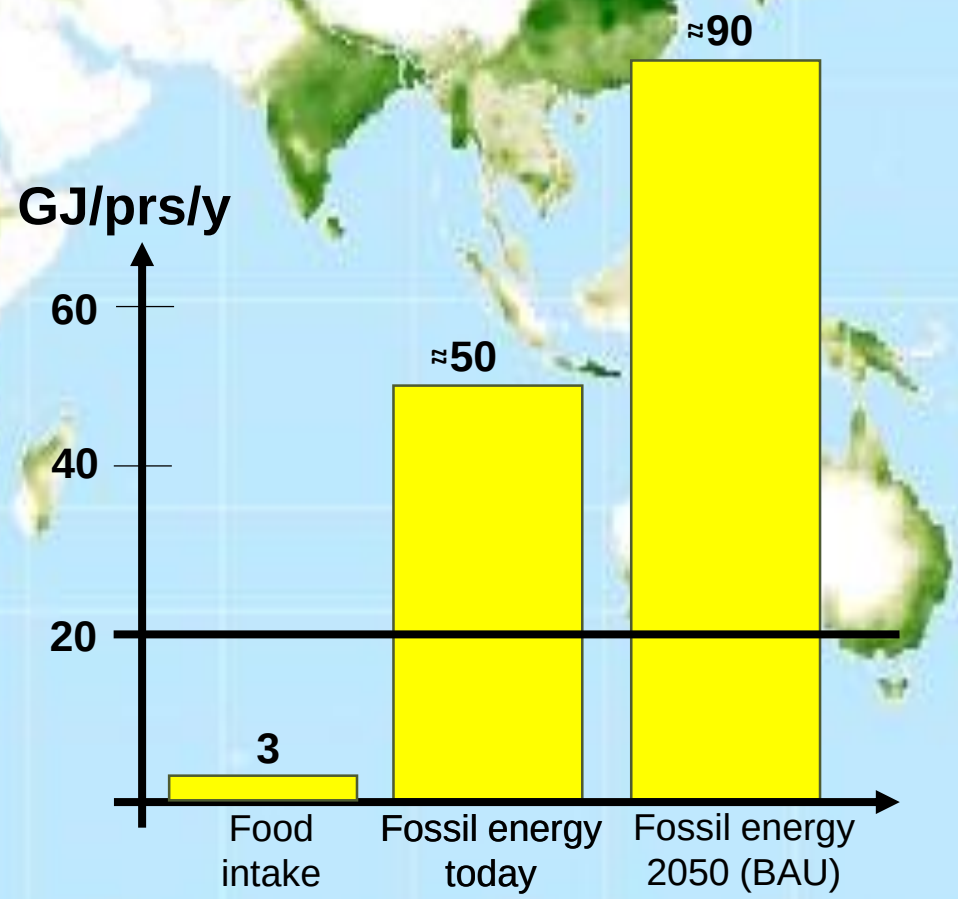
- the biomass demand of the energy system



Understand the challenge of a fossil free world

- the biomass demand of the energy system

Study title (original title)	Reference
IDAs energiplan 2030	IDA (2006)
IDAs klimaplan 2030	IDA (2009)
IDAs Energi Vision 2050	IDA (2015)
Grøn energi – vejen mod et dansk energisystem uden fossile brændsler	The Climate Commission (2010)
Coherent Energy and Environmental System Analysis (CEESA)	AAU et al. (2011)
Energiscenarier mod 2020, 2035 og 2050	Danish Energy Agency (2014)
Carbon Footprint of bioenergy pathways for the future Danish energy system	SDU and COWI (2014)
Energi 2050 – et udviklingsspor for energisystemet	Energinet (2010)
Energikoncept 2030	Energinet (2015)
Systemperspektiv 2035	Energinet (2018)

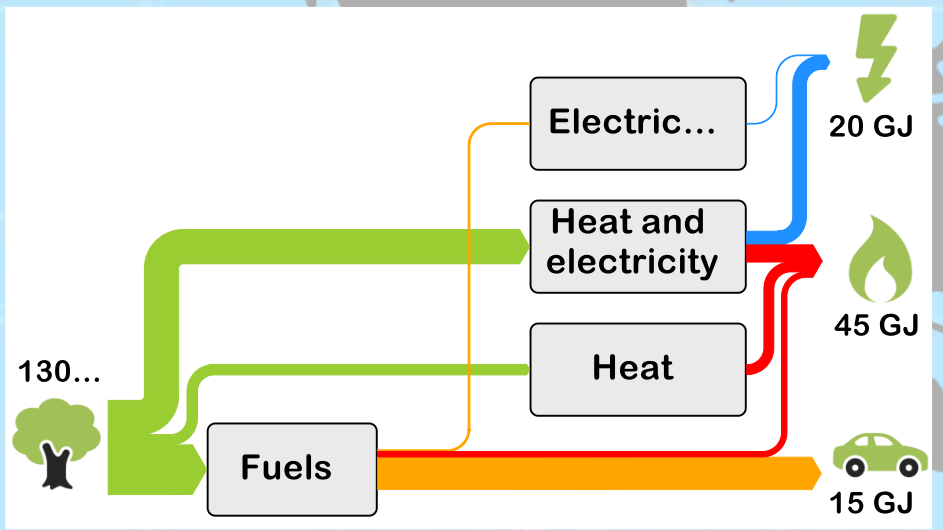


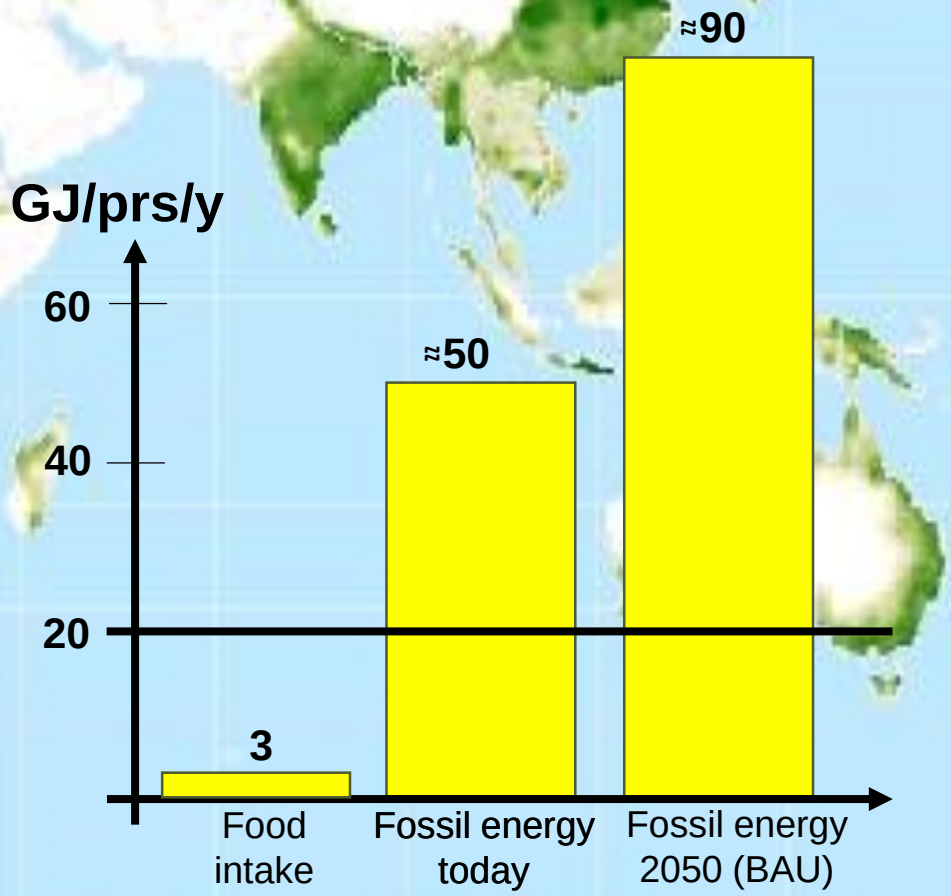
Understand the challenge of a fossil free world

- the biomass demand of the energy system

130 GJ/prs/y – bio-energy scenario

Pure bioenergy





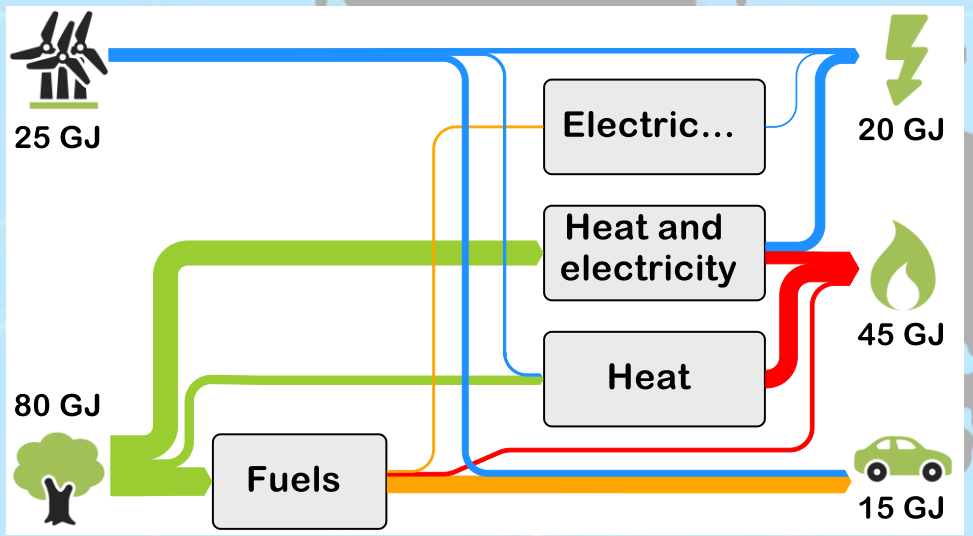
Understand the challenge of a fossil free world

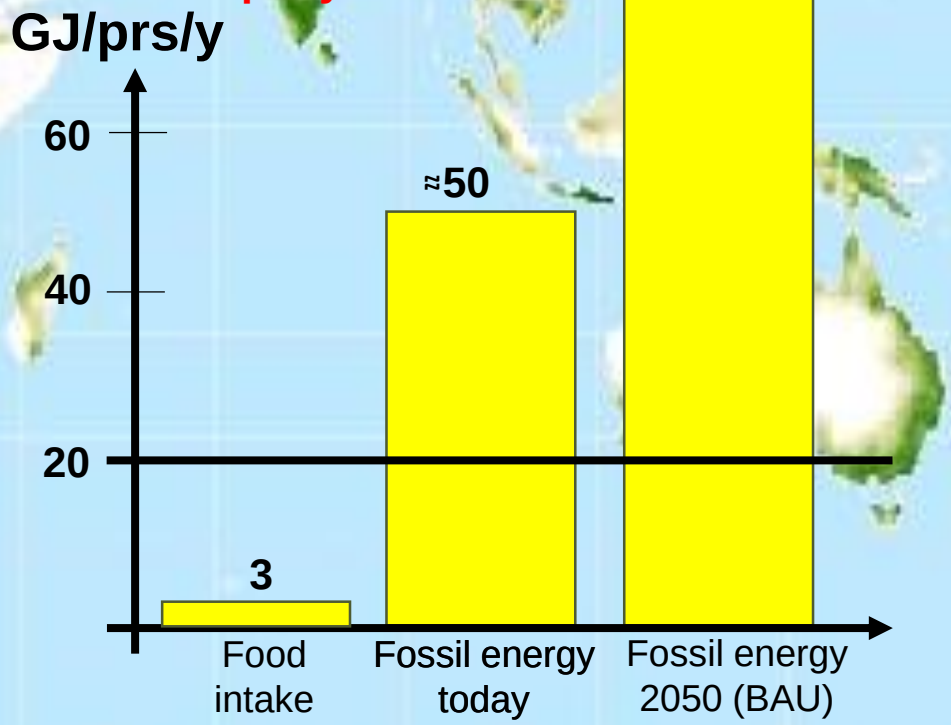
- the biomass demand of the energy system

130 GJ/prs/y – bio-energy scenario

80 GJ/prs/y – electrification scenario

Electrification





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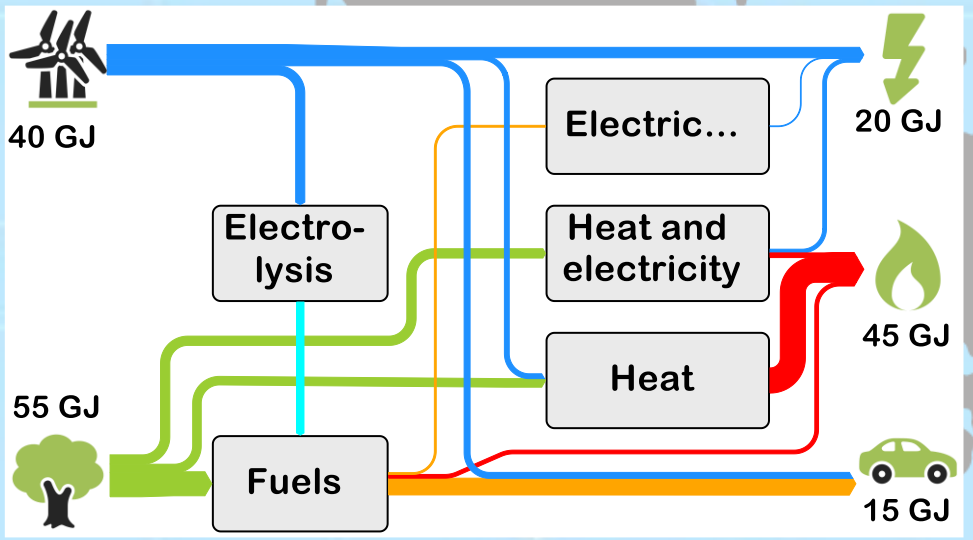
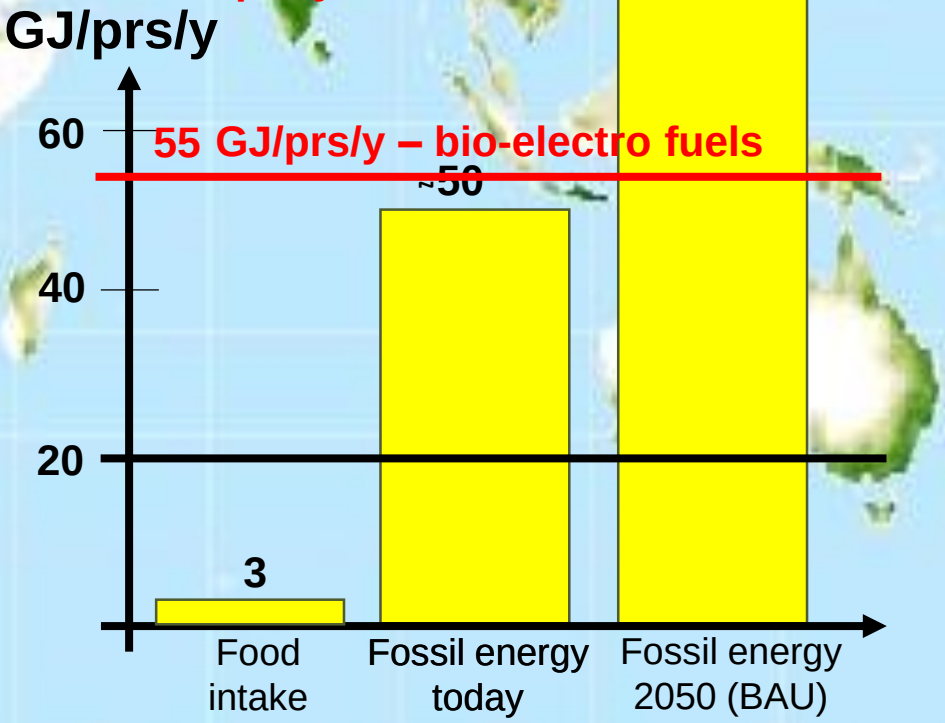
- the biomass demand of the energy system

120 GJ/prs/y – bio-energy scenario

80 GJ/prs/y – electrification scenario

55 GJ/prs/y – bio-electro fuels





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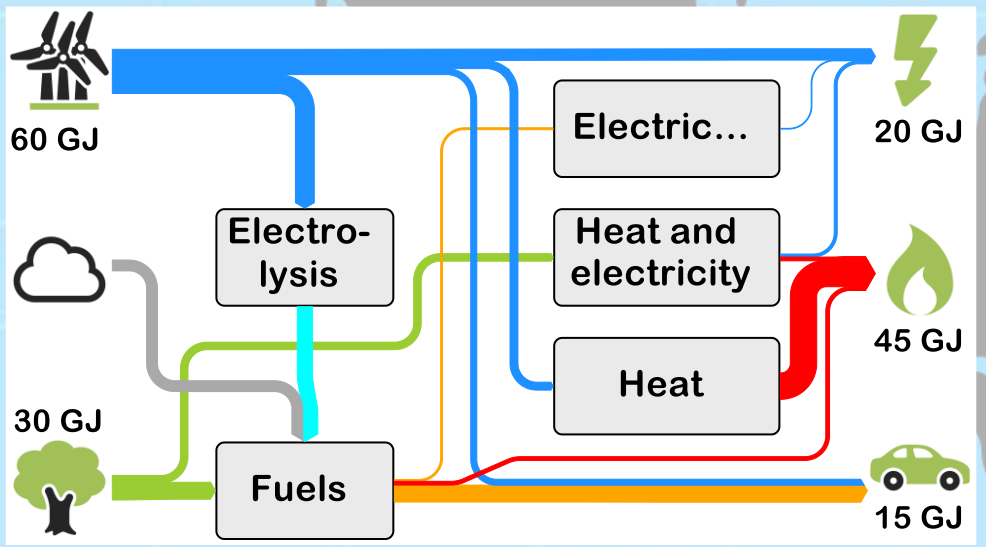
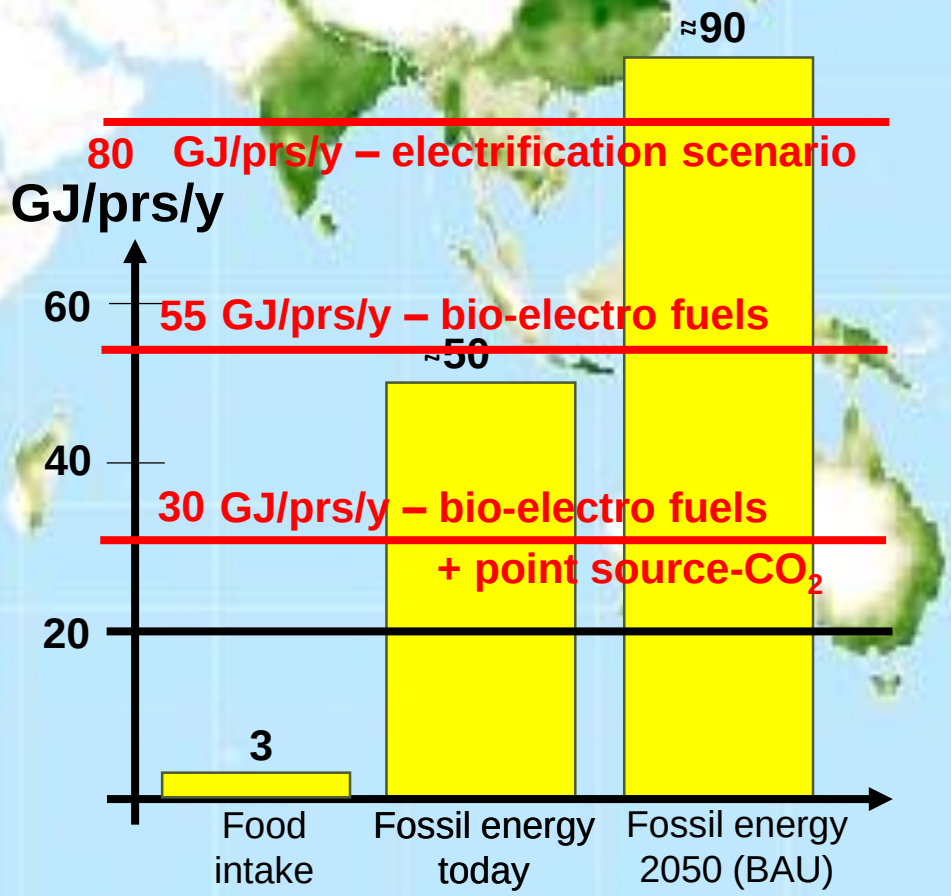
Bio-electrofuels + point source CO_2





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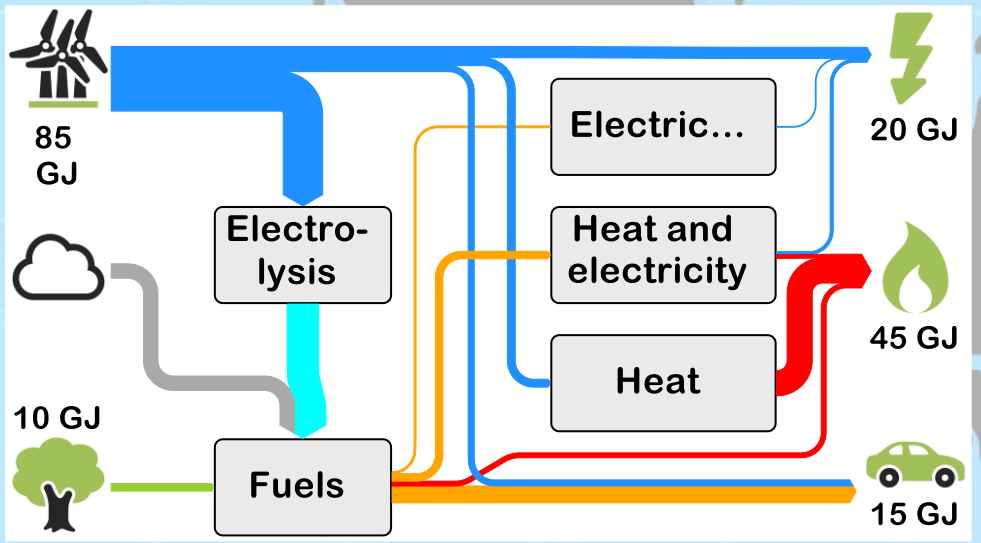
Biogas-electrofuels incl. DAC



120 GJ/prs/y – bio-energy scenario

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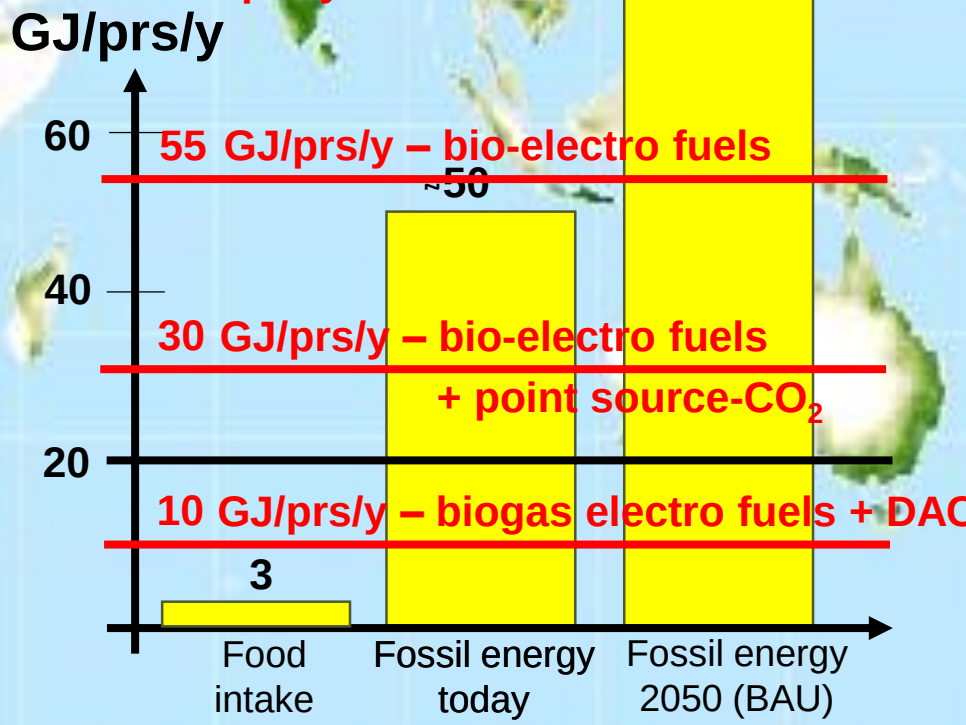

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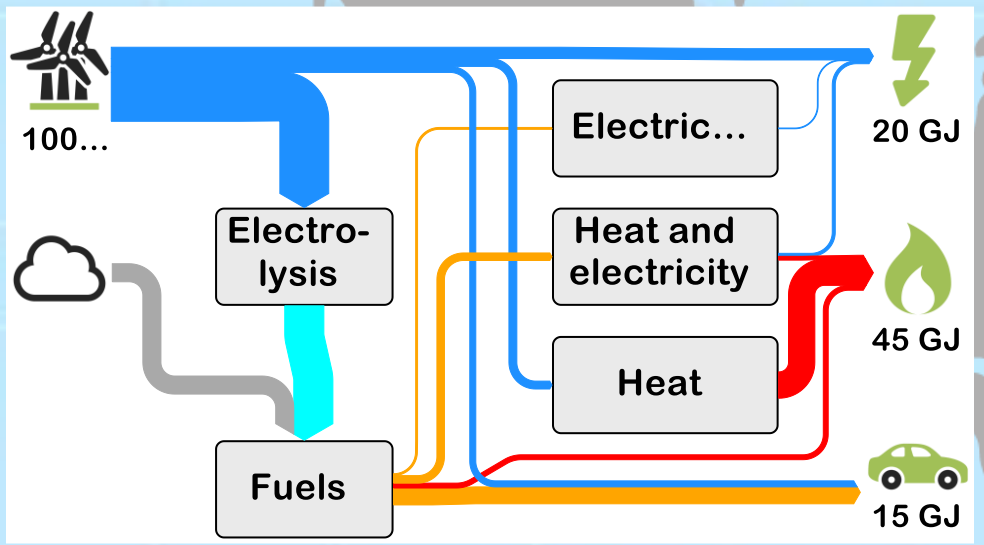
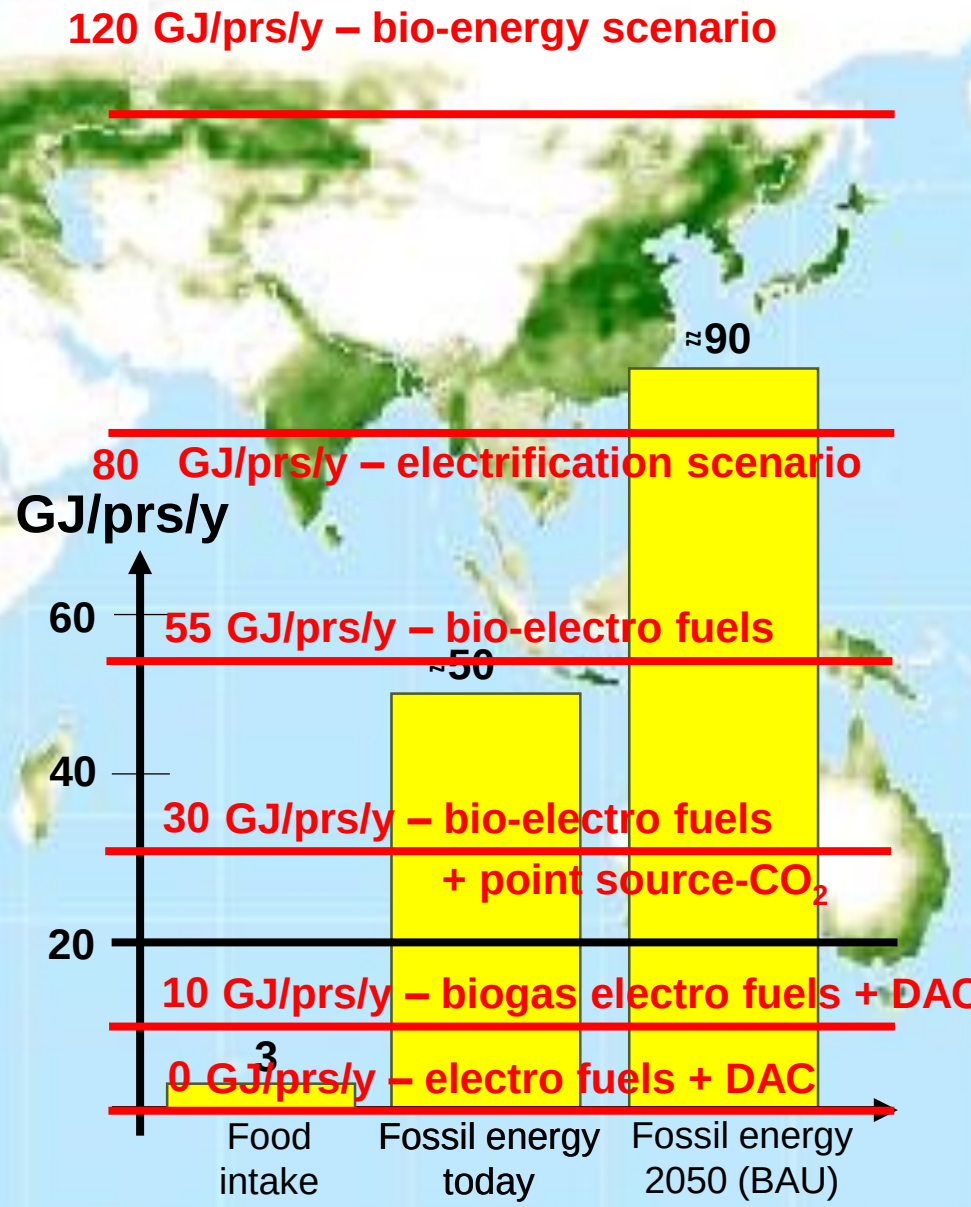
Pure electrofuels





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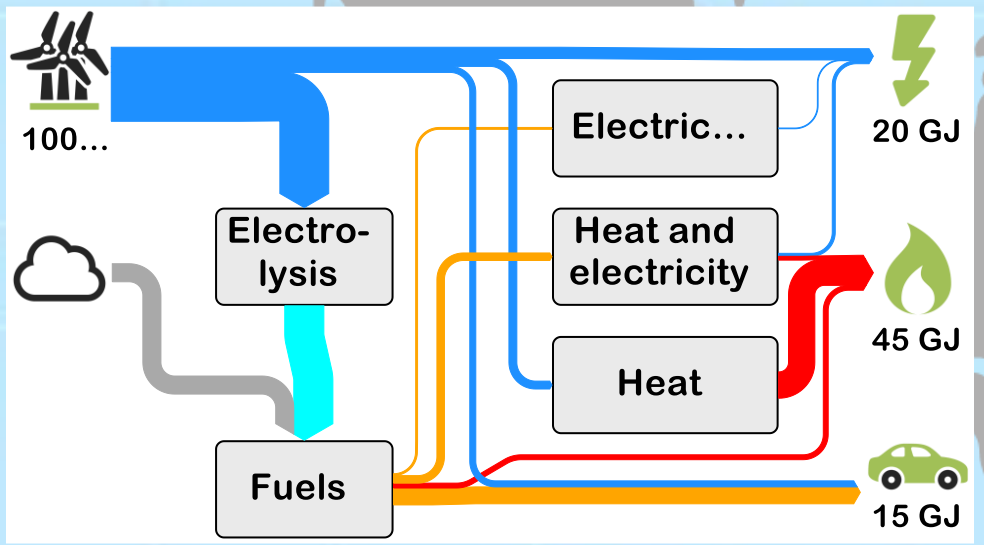
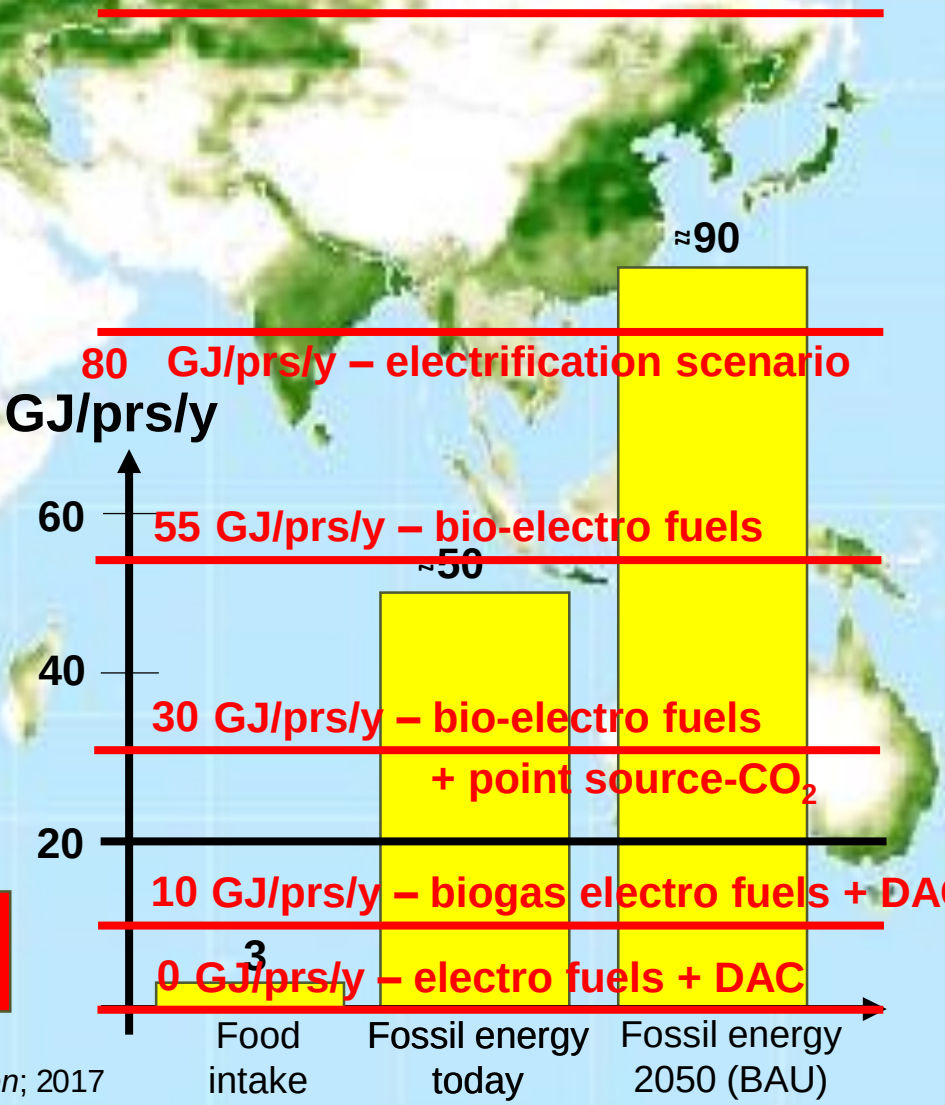


Plastic 2016:
0,335 Gtons/y

Plastic 2050: 1,2
Gtons/y*



* Ellen MacArthur Foundation. *The New Plastics Economy - Rethinking the Future of Plastics & Catalysing Action*; 2017

Understand the challenge of a fossil free world

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120 GJ/prs/y – bio-energy scenario

80 GJ/prs/y – electrification scenario

GJ/prs/y

60

40

20

15

3

~90

~50

55 GJ/prs/y – bio-electro fuels

30 GJ/prs/y – bio-electro fuels + point source-CO_2

10 GJ/prs/y – biogas electro fuels + DAC

0 GJ/prs/y – electro fuels + DAC

Food intake

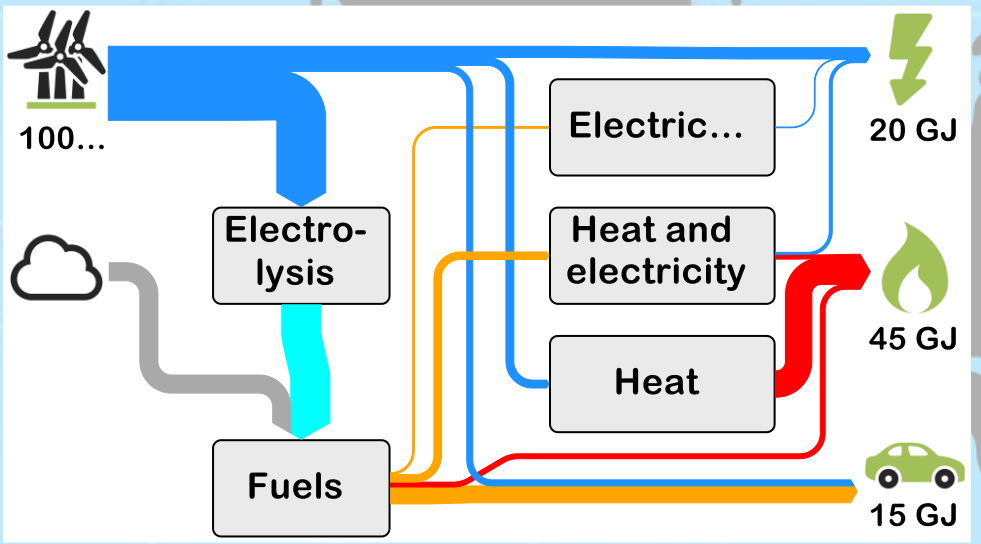
Fossil energy today

Fossil energy 2050 (BAU)

Plastic 2016: 0,335 Gtons/y

Plastic 2050: 1,2 Gtons/y*

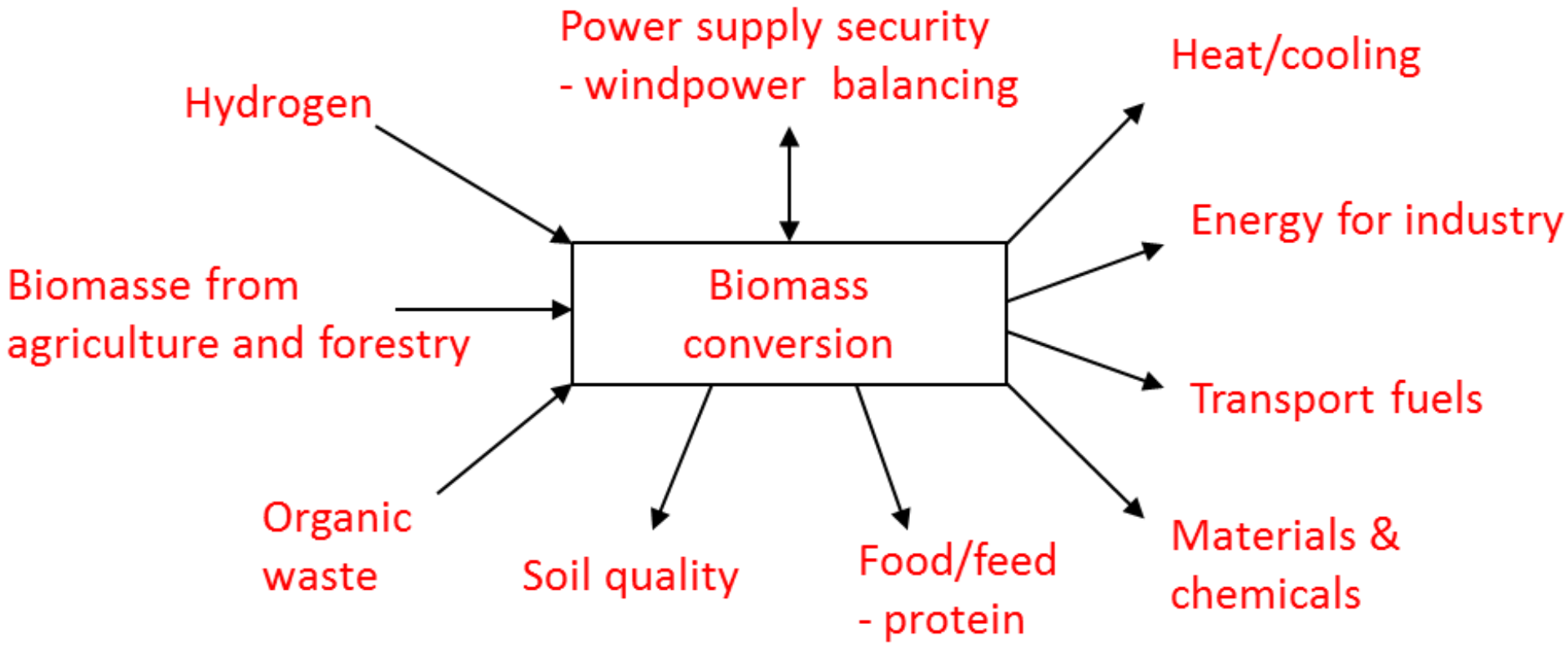
Pure electrofuels



Global biomass potential, International Energy Agency (2017)

Understand the role of bioenergy

- in the future fossil free energy system



Biomass and bioenergy is the keystone of the construction – stabilizing the energy system

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General sustainability criteria for any bioenergy

Money: cost, image value, front runner value
Technique: Area efficiency, biomass efficiency or carbon efficiency of hydrocarbon supply
Robustness, flexibility, readiness, supply security, sufficiency, …
Environment: carbon footprint, biodiversity, soil quality

Biogas and CO_2 as the feedstock for future hydrocarbons

Manure
Straw
Organic waste

Wind/solar power

Biogas production

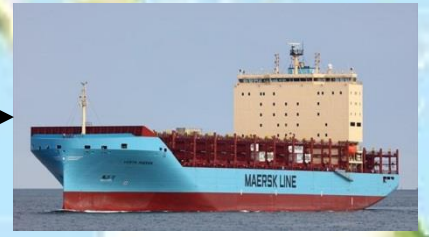
Electrolysis

H_2

Methanation

CO_2

Fuels/HC production



Biogas and CO_2 as the feedstock for future hydrocarbons

Flight ticket Copenhagen-New York and return
< 270 Euro extra or only 20 % extra

Manure
Straw
Organic waste

Wind/solar power

Biogas production

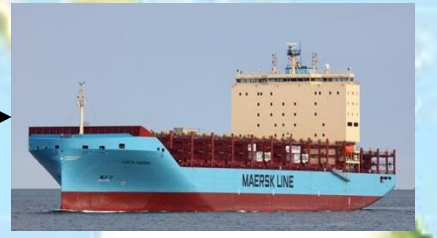
Electrolysis

H_2

Methanation

Fuels/HC production

CO_2



StarWars LEGO package at 100 Euro:
700 g plastic at 2 Euro/kg
=> plastic feedstock cost ≈ 1 %

Cost increase of a 100 % renewable energy system
≈ 0,5 % of GDP

≈ 20 Euro/person/month

≈ a netflix subscription

≈ a cup of coffee at Starbucks per week

- Including fuels and plastic from CO_2 and hydrogen

Overview of existing Gas-to-Liquid plants

Navn	Placering	Kapacitet	Investering	Investering pr. b/d
Lake Charles	Louisiana, USA	1.100 b/d	135 mio. USD	123.000 USD pr. b/d
Bintulu	Malaysia	14.000 b/d	1 mia. USD	68.000 USD pr. b/d
Escravos	Nigeria	33.000 b/d	10 mia. USD	303.000 USD pr. b/d
Oryx	Qatar	34.000 b/d	1.2 mia. USD	35.000 USD pr. b/d
OLTIN YO'L	Uzbekistan	37.000 b/d	3.2 mia. USD	86.000 USD pr. b/d
Mossel Bay	Sydafrika	45.000 b/d	???	???
Pearl	Qatar	260.000 b/d	18-19 mia. USD	71.000 USD pr. b/d

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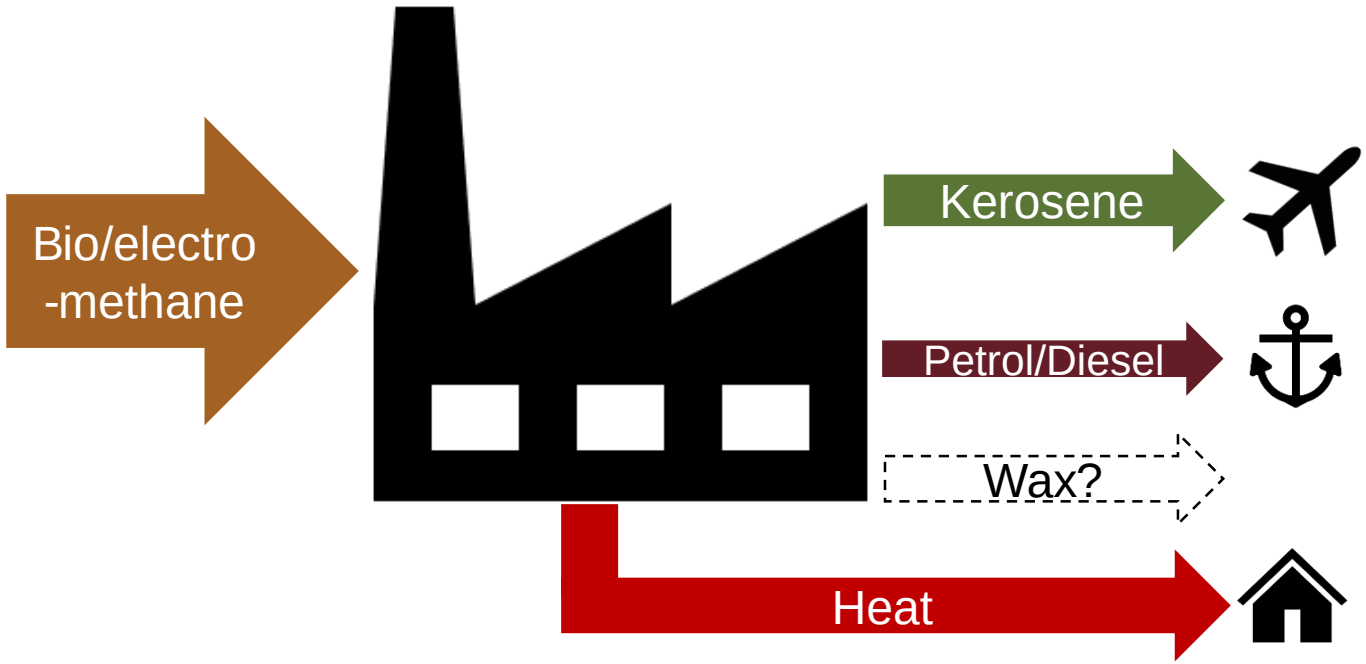
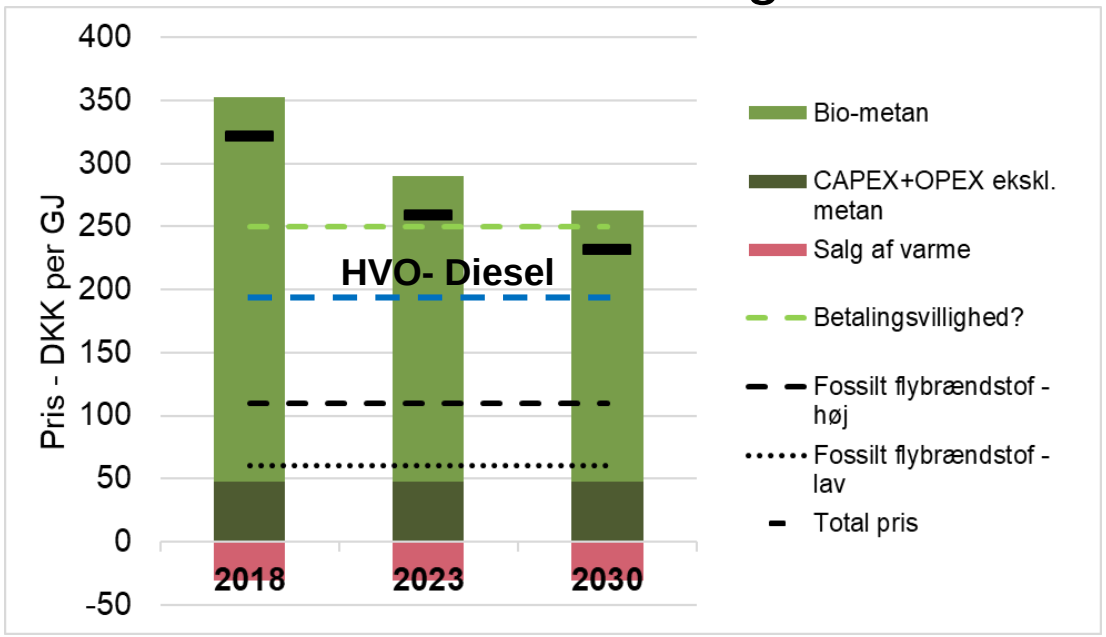
What is the cost of bio/electro-methane based liquid fuels?





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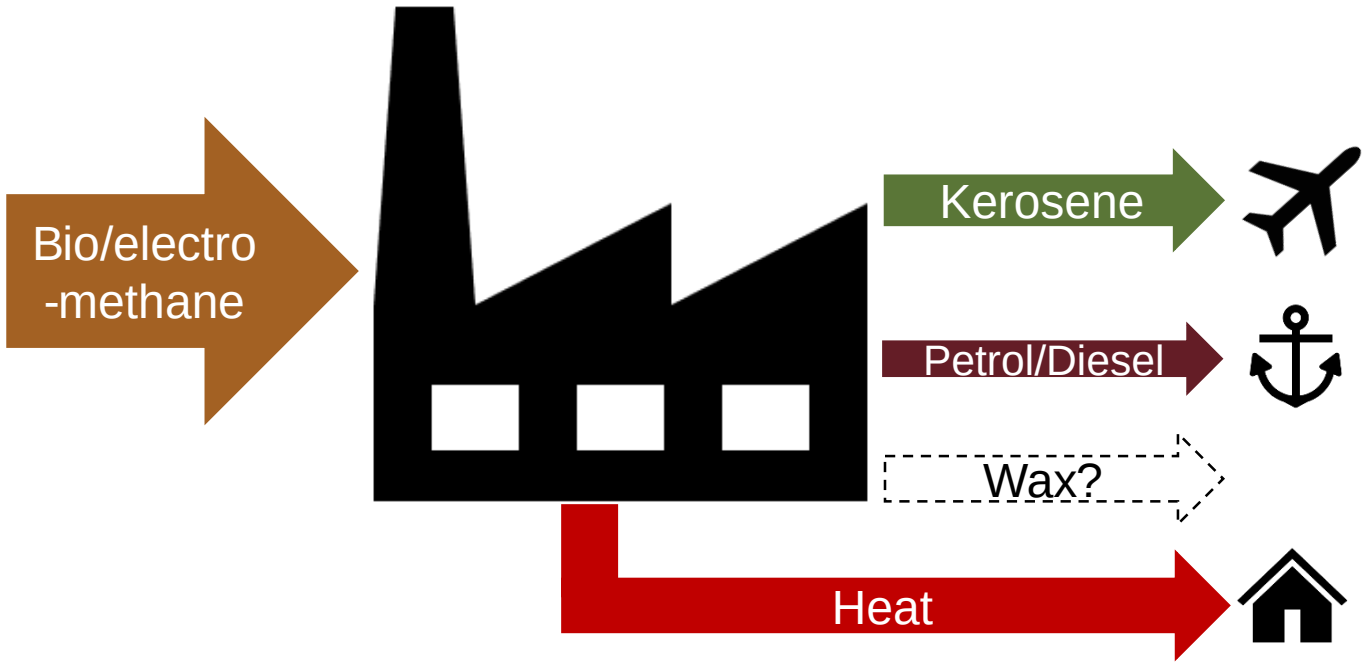

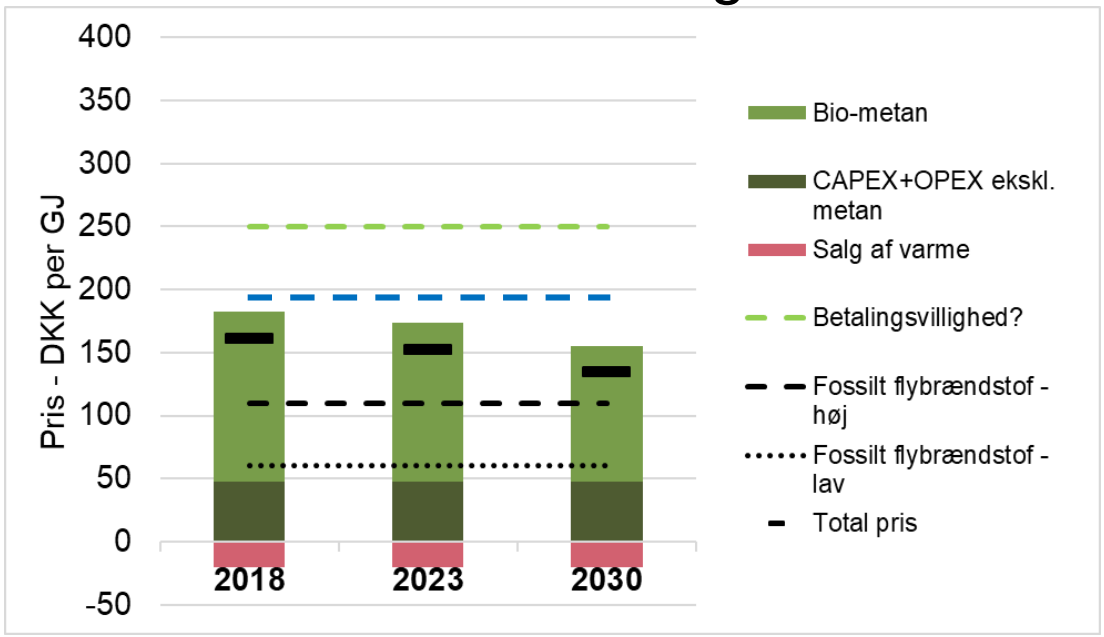

Discussion

In Denmark

- Four governments in a row have had the policy for our country to be fossil free in 2050
- We understand that we need hydrocarbons – and that the transport sector is the key challenge and key bottleneck in designing a renewable energy system
- We know that biogas by far is the cheapest supply of non-fossil hydrocarbons
- We know that we need to store our windpower and have back-up power supply when the wind is not blowing, and we know that bio-methane from biogas is by far the cheapest way to secure this back-up
- We know that we need to integrate hydrogen into the system in order to reduce our dependency on biomass to a sustainable level, and we know that the methanation of CO2 in biogas is by far the most feasible way, and that this methanation of CO2 with hydrogen is by far the cheapest way to store windpower
- We know that overall, biogas as a keystone in the energy system is by far the best way to create synergy and integrate the needs of agriculture, the transport sector, the heat sector and the electricity sector
- And we know that the transition to renewable energy really costs almost nothing in a private economic perspective

But even so…

- Our Ministry of Finance still seem to compare subsidies for biogas to subsidies for wind- and solar power per kWh of electricity produced – and cut down subsidies for biogas

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Thanks for your attention

Appendices

SDU vision on a bio-methane platform

- for optimal system efficiency and integration of hydrocarbon supply

by Henrik Wenzel, Anders Winther Mortensen, Kasper Dalgas Rasmussen, Lars Yde and Abid Rabbani

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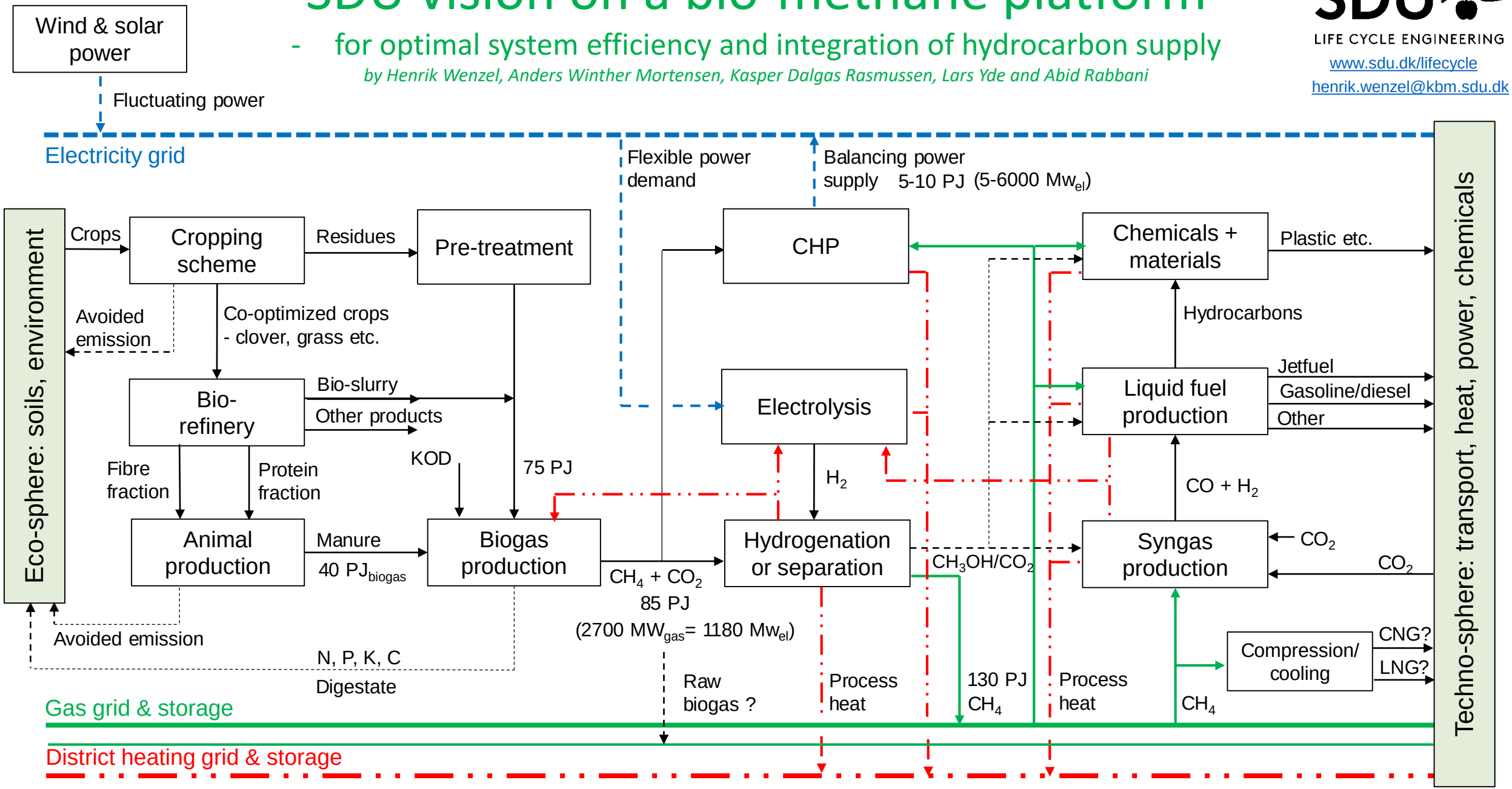

SDU vision on a bio-methane platform

- for optimal system efficiency and integration of hydrocarbon supply

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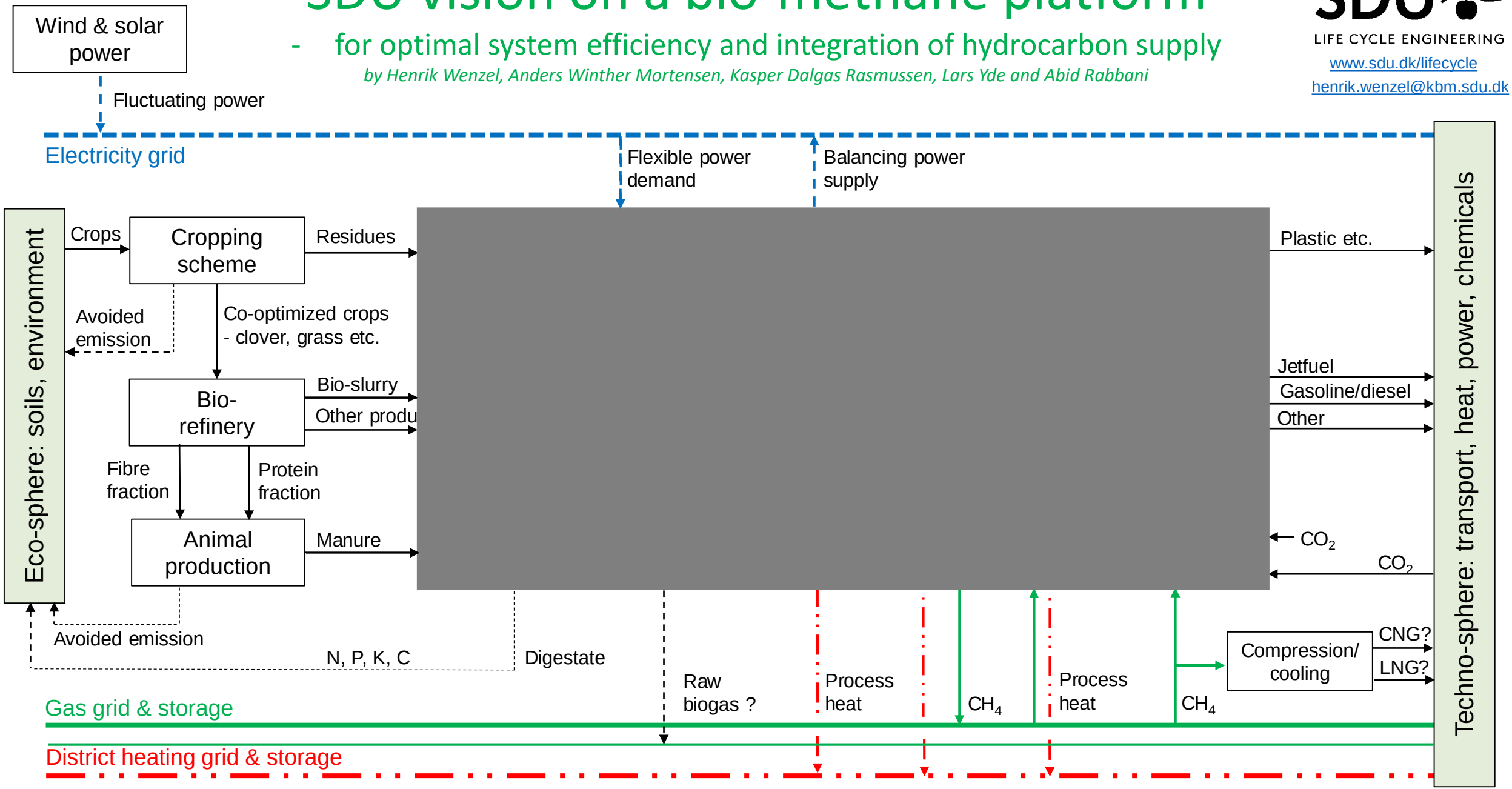

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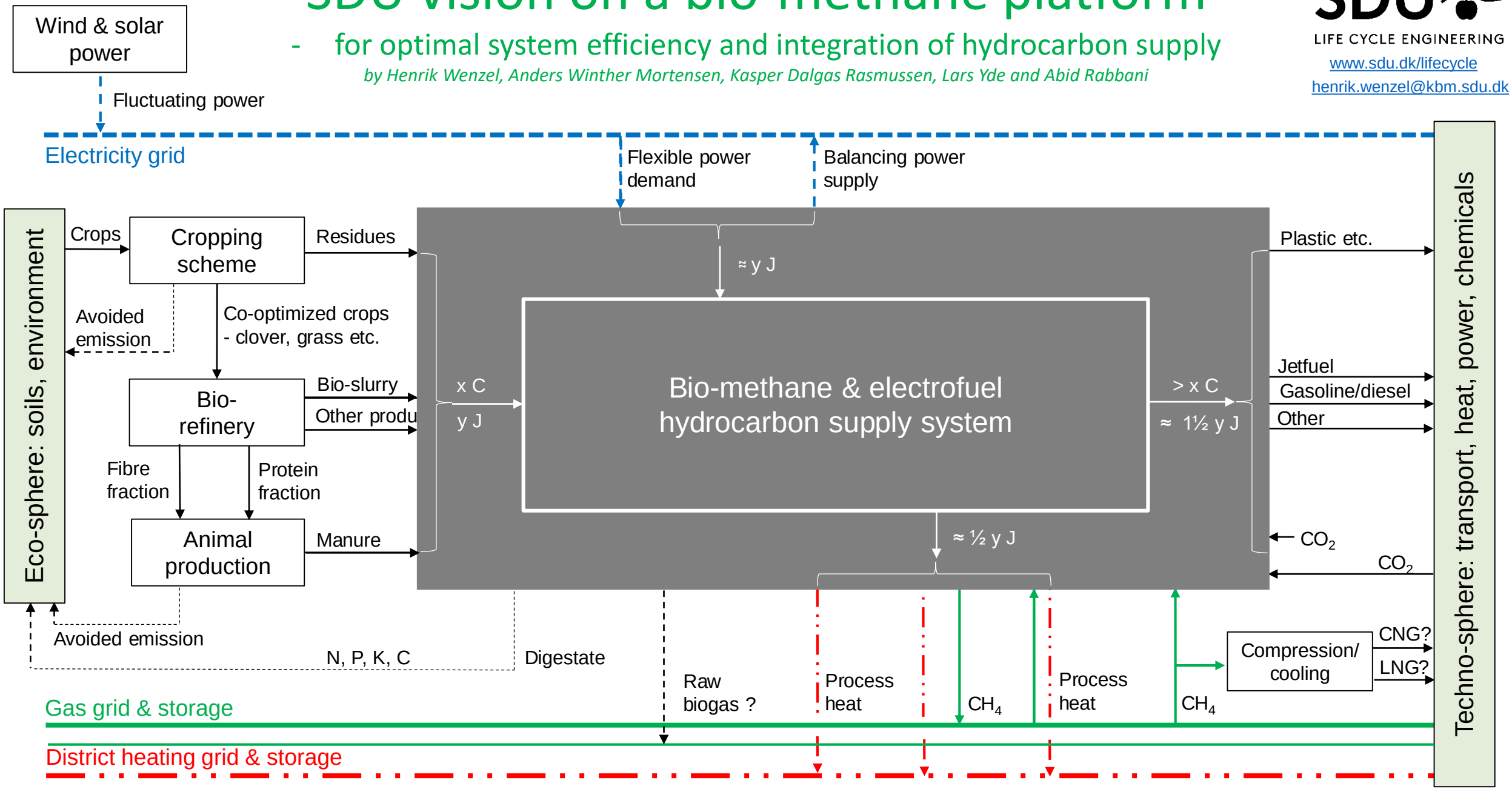

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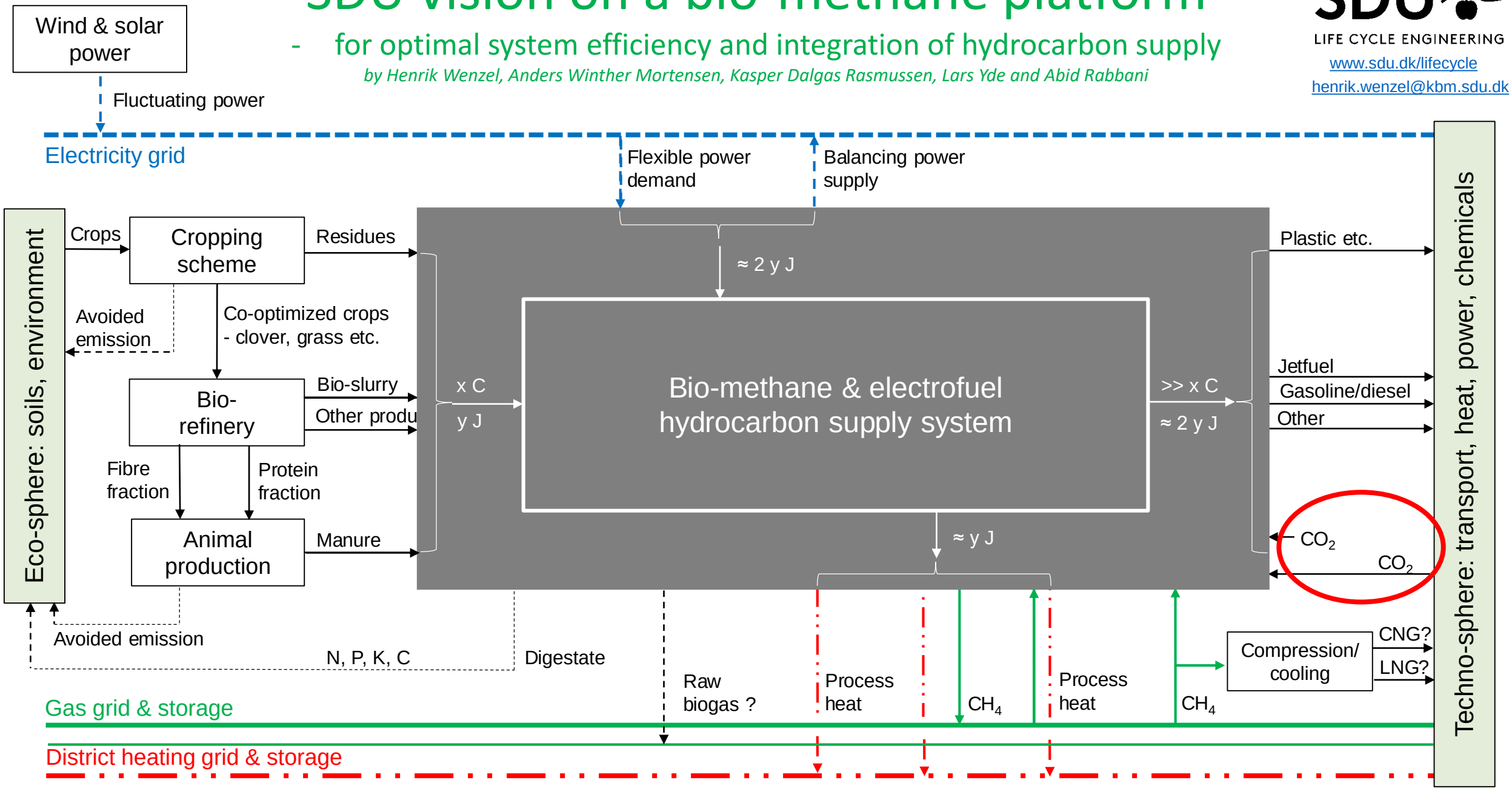

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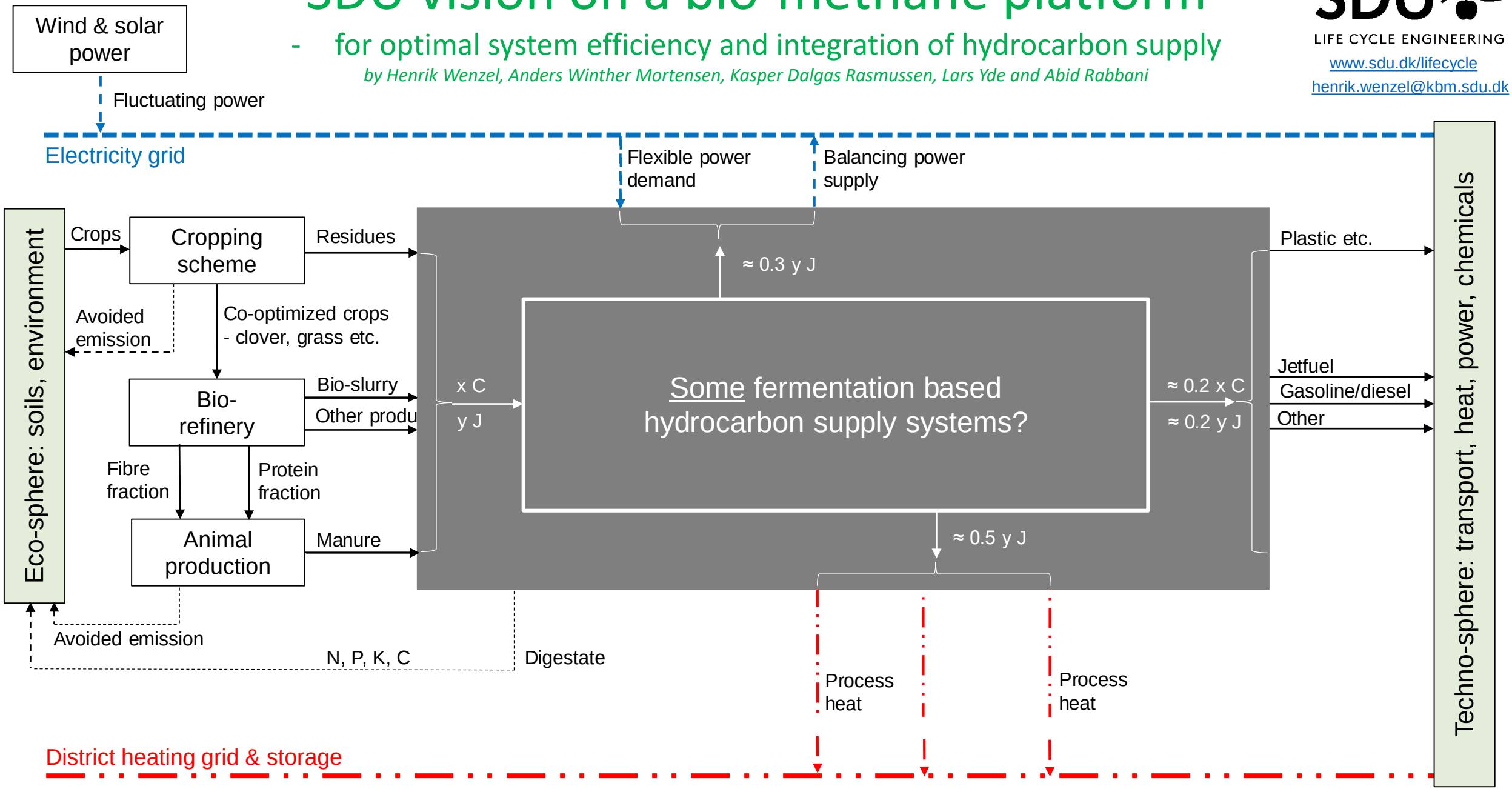

Why Denmark?

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