The International Symposium for Green Solutions, ISGS 2022
Industrial University of Ho Chi Minh City, Vietnam, Nov. 25, 2022

Sustainable Bioeconomy or CO_2-Economy: What Does the Future Hold?

Andreas Pfennig
Products, Environment, and Processes (PEPs)
Department of Chemical Engineering
Université de Liège
www.chemeng.uliege.be/pfennig
www.vision3000.eu
andreas.pfennig@uliege.be

aktiv bei:

Copyright, Citation, Contact

- **Contact:** In case you would like to contact me or are interested in a presentation on this topic, please contact me via: andreas.pfennig@uliege.be

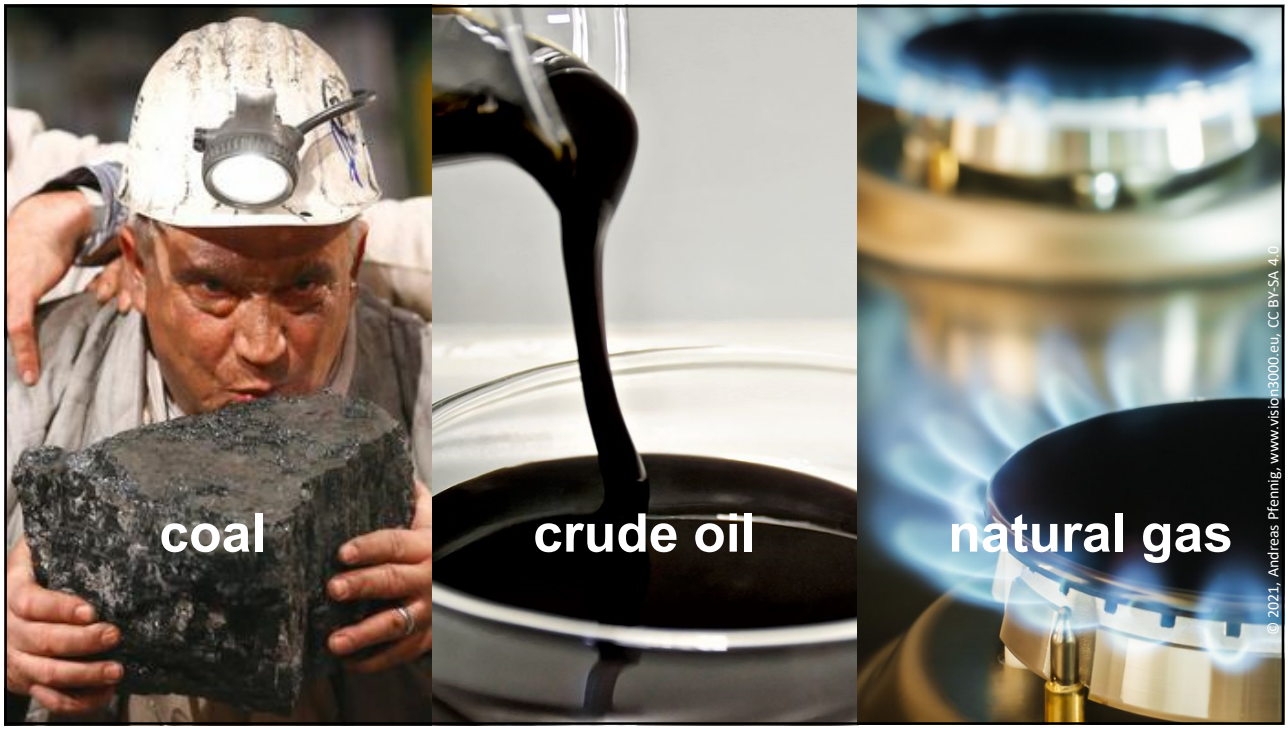
further resources

Sustainability and Future Human Development
www.youtube.com playlist

www.vision3000.eu
incl. scenario explorer

A. Pfennig:
Sustainable Bio- or CO_2 Economy:
Chances, Risks, and Systems Perspective
ChemBioEng Reviews 2019, 6(3)
doi.org/10.1002/cben.201900006

2019
Books on Demand
Norderstedt, 15€

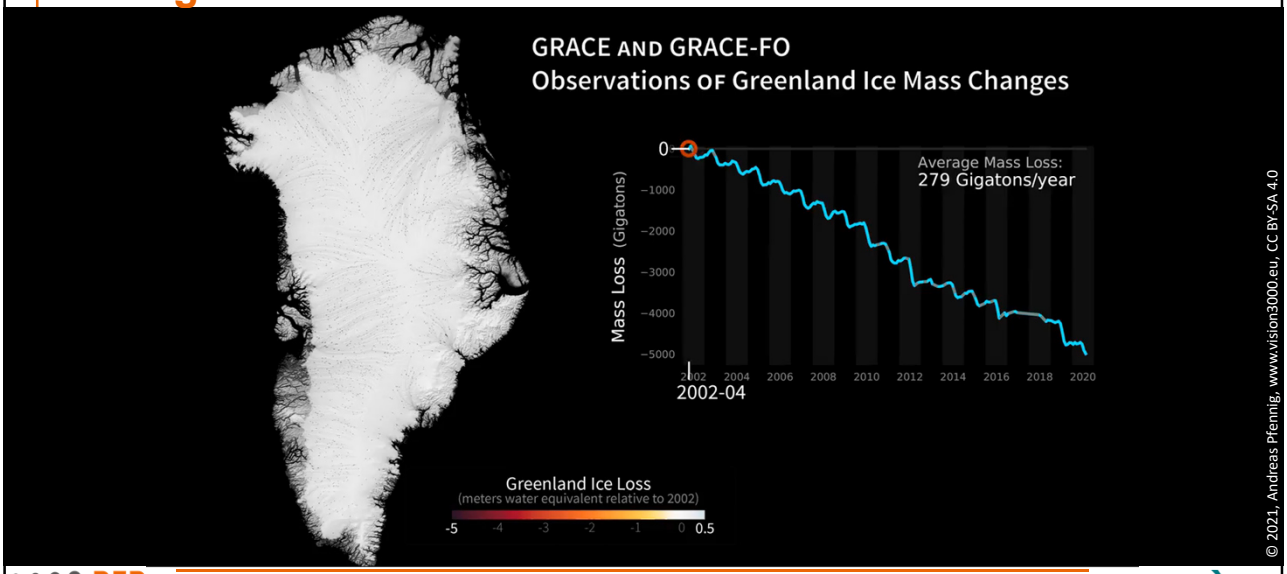


renewable energies



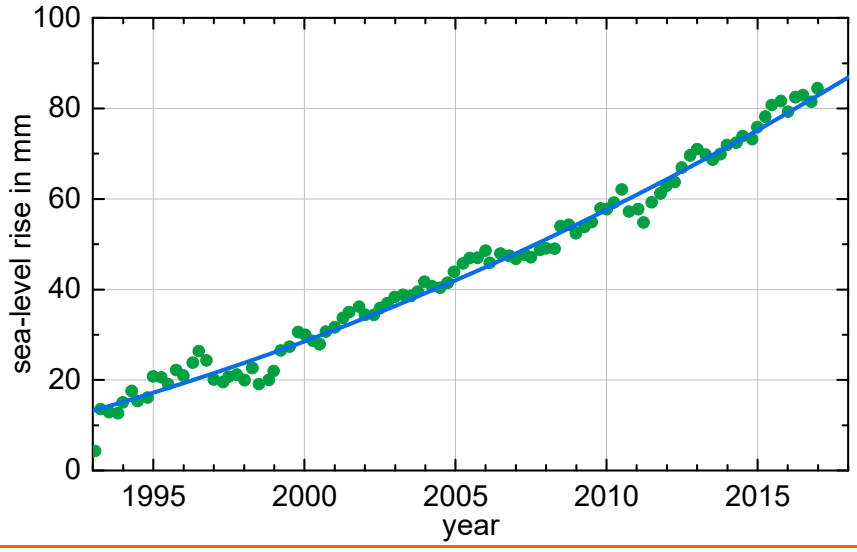


melting of Greenland ice



source: NASA,
https://climate.nasa.gov/climate_resources/264/video-greenland-ice-mass-loss-2002-2021/
https://www.youtube.com/watch?v=sK4qz-h8o1M

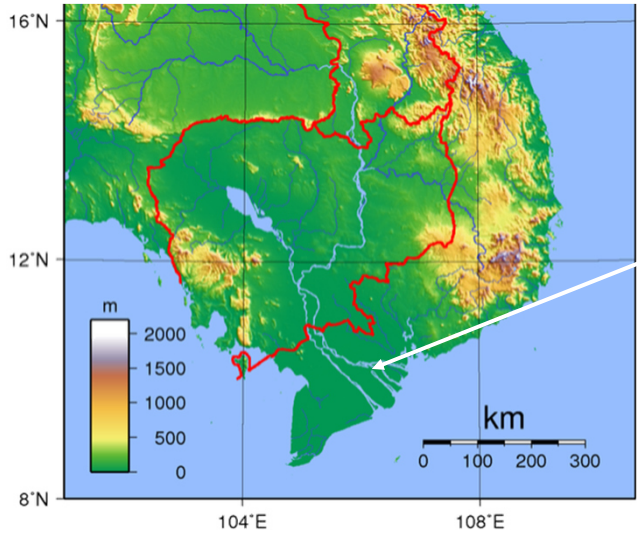
sea-level rise



Nerem et al., 2018: Climate-change-driven accelerated sea-level rise detected in the altimeter era. PNAS 115(9), 2022–2025

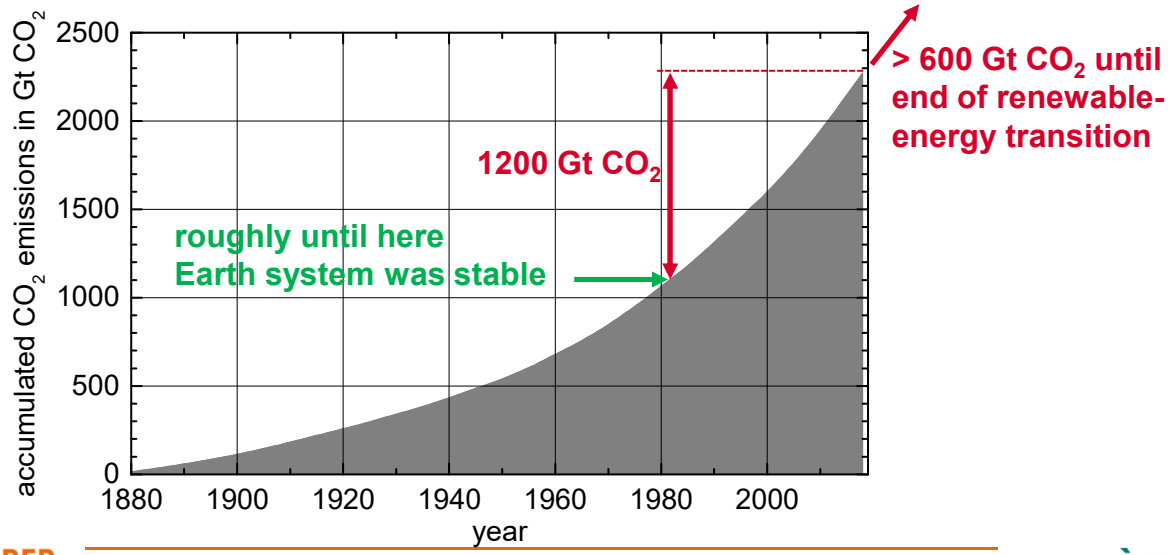
Vietnam

Minderhoud, Coumou, Erkens, Middelkoop, Stouthamer 2019
Mekong delta much lower than previously assumed in sea-level rise impact assessments. nature communications 10:3847,
https://doi.org/10.1038/s41467-019-11602-1



Mekong-River Delta:
on average 80 cm above sea level

total emitted CO_2 since industrialization

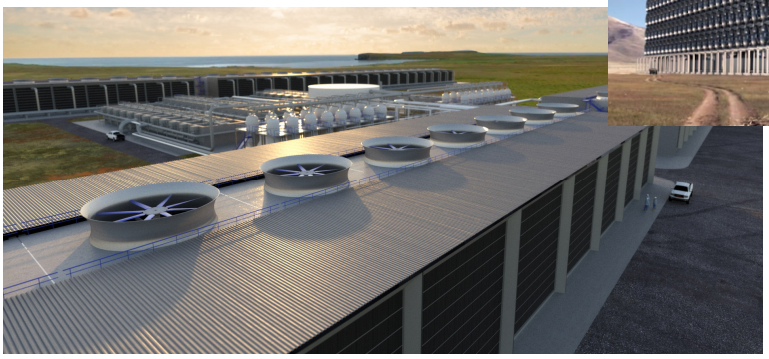


stabilizing Earth system

- afforestation, rewetting of peatlands
- humus formation in the soil, sustainable agriculture
  - ⇨ relatively cheap, < 100 US-$ per t CO_2
  - ⇨ easy, directly available
  - ⇨ can only capture around 1/3 of the CO_2 required

Fuss, S. et al. 2018. Negative emissions - Part 2: Costs, potentials and side effects. Environ. Res. Lett. 13:063002

DACCS/U direct air carbon capture & storage/utilization



https://carbonengineering.com
https://www.climeworks.com
https://globalthermostat.com
etc.

stabilizing Earth system

- afforestation, rewetting of peatlands
- humus formation in the soil, sustainable agriculture
- DACCS (direct air carbon capture and storage)
  - ⇨ not yet proven on large scale
  - ⇨ expensive: 250 US-$ per t CO_2

per person in developed countries: ≈ 1500 US-$ per year
4-member family: 6000 US-$ per year ≈ 2 x monthly income

Fuss, S. et al. 2018. Negative emissions - Part 2: Costs, potentials and side effects. Environ. Res. Lett. 13:063002 & own evaluations

stabilizing Earth system

- afforestation, rewetting of peatlands
- humus formation in the soil, sustainable agriculture
- DACCS (direct air carbon capture and storage)
- BECCS (bioenergy with carbon capture and storage)

BECCS (bio-energy with carbon capture and storage)

stabilizing Earth system

- afforestation, rewetting of peatlands
- humus formation in the soil, sustainable agriculture
- DACCS (direct air carbon capture and storage)
- BECCS (bioenergy with carbon capture and storage)
  - ⇨ cheap, revenue from bioenergy, < 100 US-$ per t CO_2
  - ⇨ requires fertile land

Fuss, S. et al. 2018. Negative emissions - Part 2: Costs, potentials and side effects. Environ. Res. Lett. 13:063002

sorting the options

atmospheric CO_2

CO_2 from point source

biomass

sorting the options

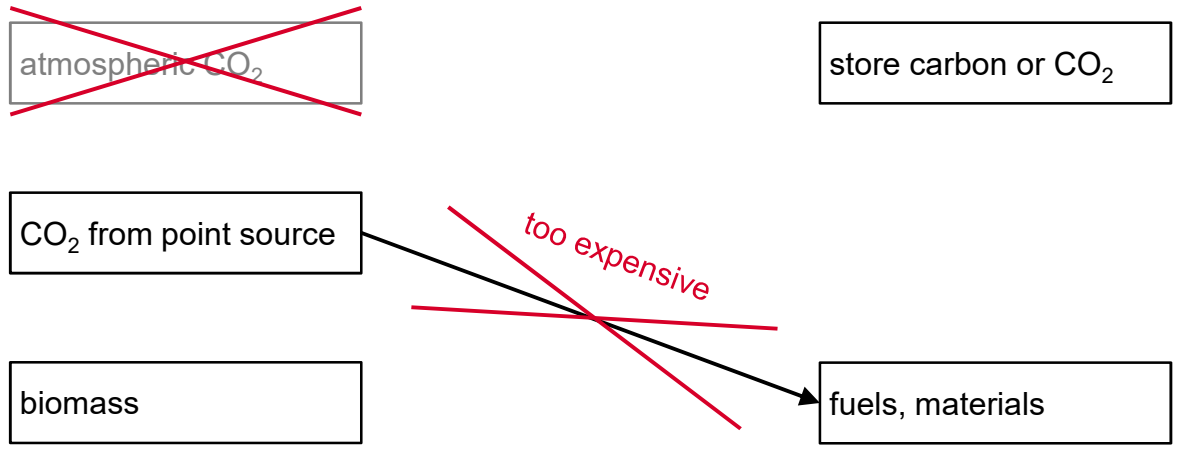
too expensive

~~atmospheric CO_2~~

CO_2 from point source

biomass

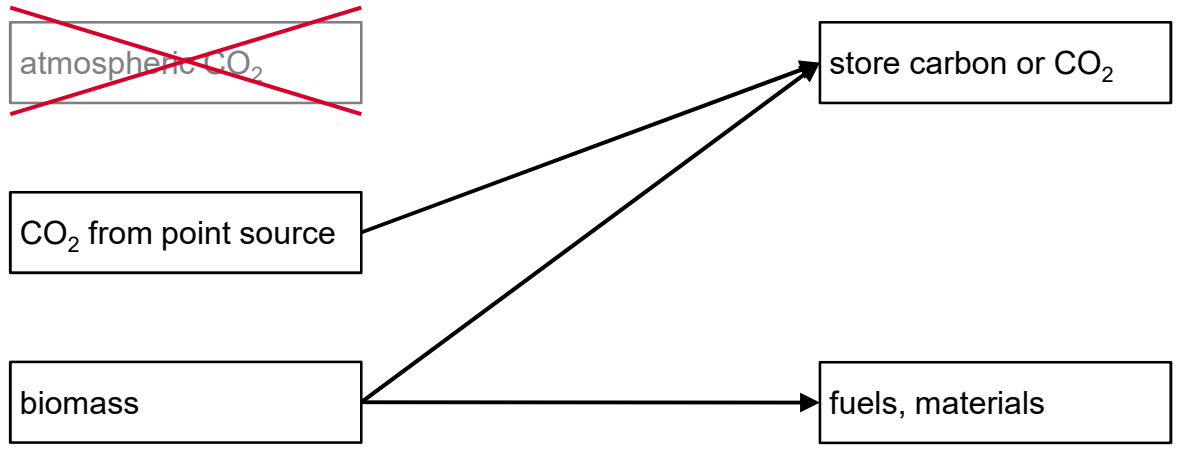
sorting the options



PEPs CHEMICAL ENGINEERING

LIÈGE université

sorting the options



PEPs CHEMICAL ENGINEERING

LIÈGE université

which biomass

1. generation: edible: palm oil, sugar cane, corn, wheat, etc.

2. generation: inedible but on fertile land: wood, miscanthus, etc.

3. generation: waste of food production: straw, dung, etc.

which biomass

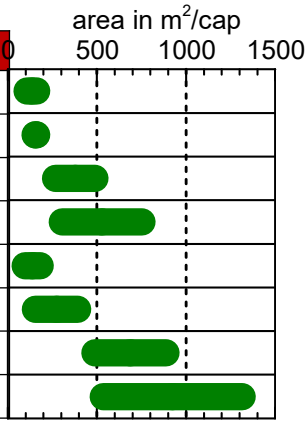
1. generation

2. generation

3. generation: humus formation, possibly some bioenergy
rest too distributed and complex processes

land-area demand 2050, ethanol as biomaterials feedstock

generation	feedstock
1. generation	sugar beet
	sugar cane
	corn
	wheat
2. generation	miscanthus/reeds
	wood
3. generation	corn straw
	wheat straw



ranges shown:
maximum national to world average productivity of big producers projected for 2050

Pfennig, A. 2019. Sustainable Bio- or CO_2 economy: Chances, Risks, and Systems Perspective. ChemBioEng Rev. 6(3):90-104

which biomass

1. generation	biomaterials, biofuels simple processes, ‚pure' feed components synergies with food production
2. generation	rarely used no benefit in land area more complex processes
3. generation:	humus formation, possibly some bioenergy rest too distributed and complex processes

challenge: world hunger

animal-based food

source: http://www.fao.org/faostat/en/ & own evaluations

animal-based food: 95 % of land area wasted

source: http://www.fao.org/faostat/en/ & own evaluations

conclusions climate, energy, food, land area

- realize the renewable-energy transition as quickly as possible
- we inevitably have to capture CO_2 from the atmosphere
- only biobased capturing is economically feasible
- preferred: first generation biomass
- we have to avoid animal-based food

The International Symposium for Green Solutions, ISGS 2022
Industrial University of Ho Chi Minh City, Vietnam, Nov. 25, 2022

Sustainable Bioeconomy or CO_2-Economy: What Does the Future Hold?

Andreas Pfennig
Products, Environment, and Processes (PEPs)
Department of Chemical Engineering
Université de Liège
www.chemeng.uliege.be/pfennig
www.vision3000.eu
andreas.pfennig@uliege.be

aktiv bei: