

# Climate Change, Energy & Food Supply in a Sustainable World

## What Does the Future Hold?

active at:



Andreas Pfennig  
Products, Environment, and Processes (PEPs)  
Department of Chemical Engineering  
Université de Liège  
[www.chemeng.uliege.be/pfennig](http://www.chemeng.uliege.be/pfennig)  
[andreas.pfennig@uliege.be](mailto:andreas.pfennig@uliege.be)



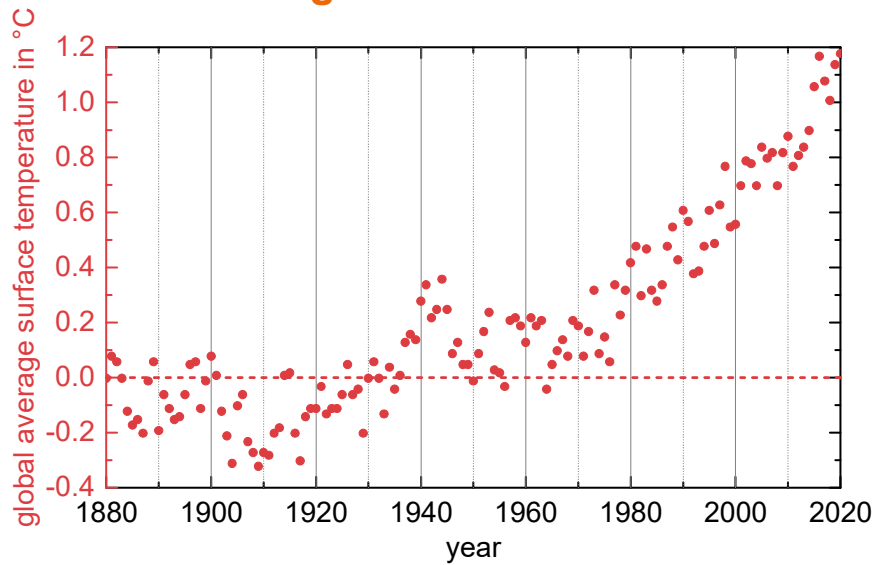


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## climate change in Vietnam



## cause of climate change



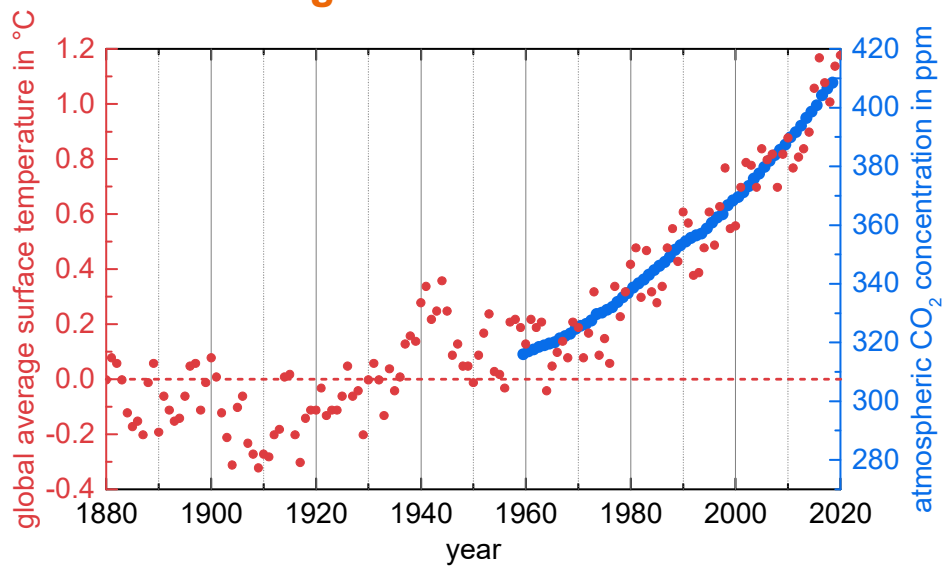
reference period for temperature: 1850 to 1900

5



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## cause of climate change

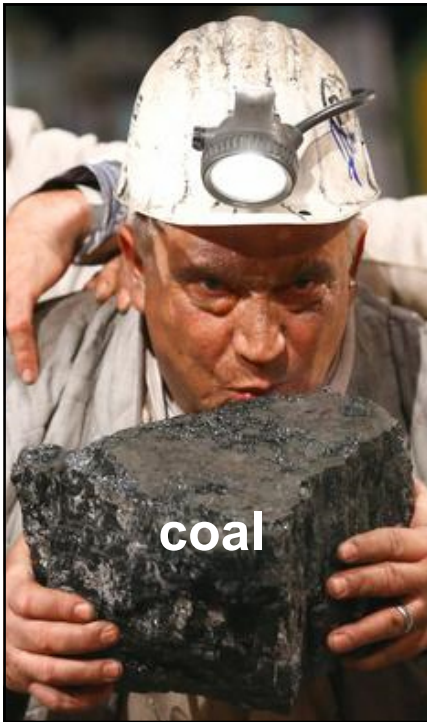


reference period for temperature: 1850 to 1900

6



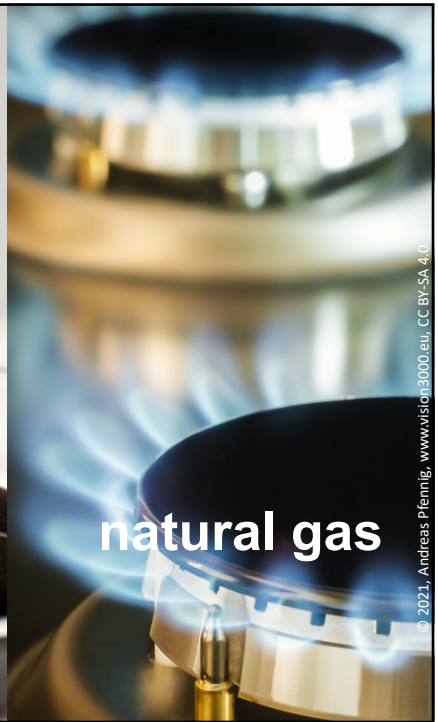
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coal



crude oil



natural gas

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## renewable energies



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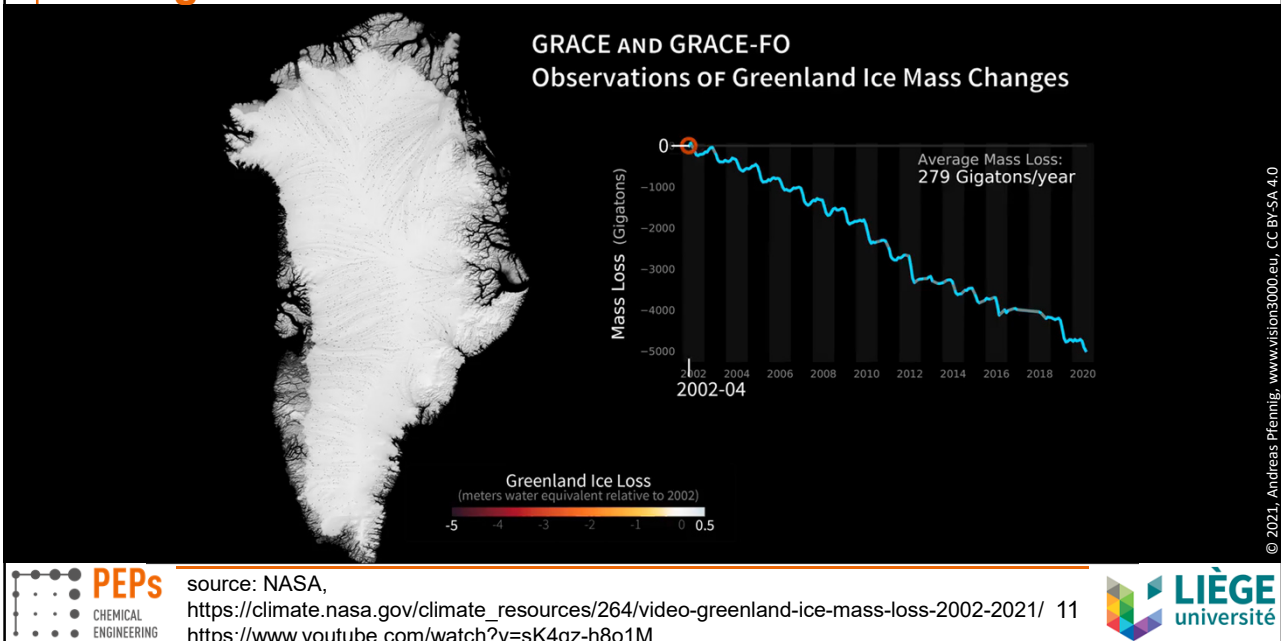
## UN Climate Conference, COP21, 2015, Paris

Article 2.1:

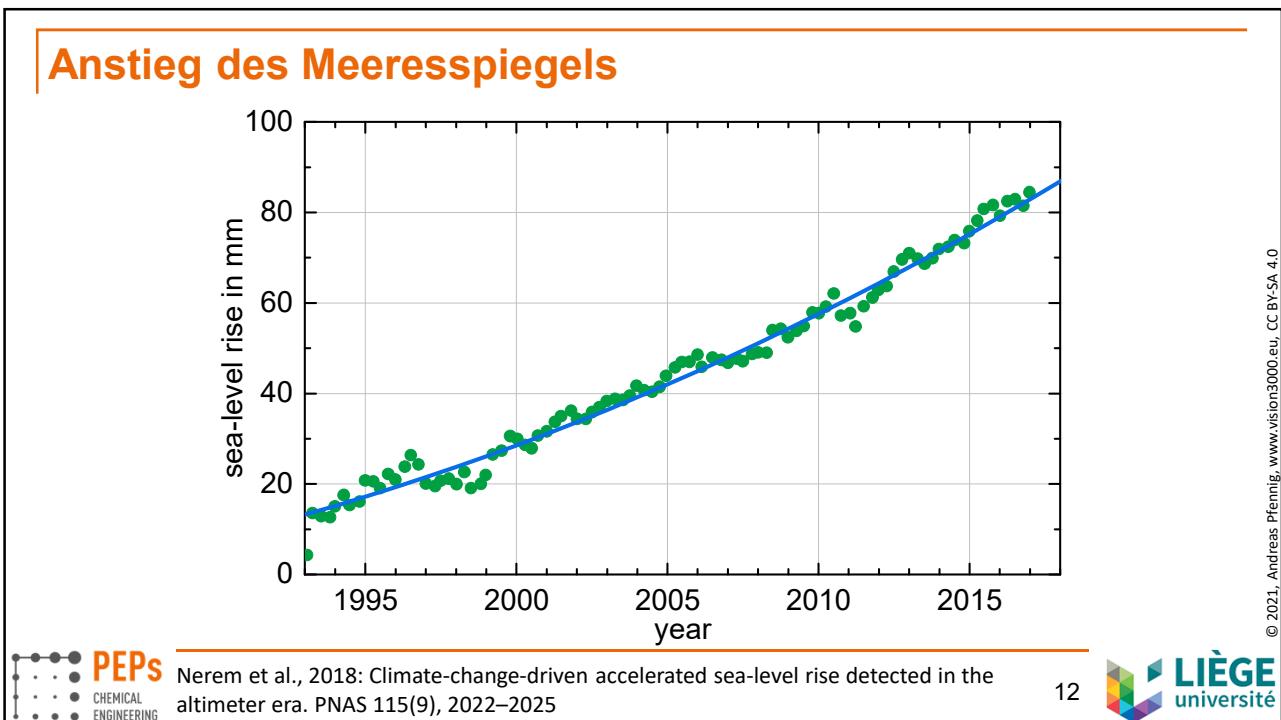
This Agreement ... aims to strengthen the global response to the threat of climate change ... by:

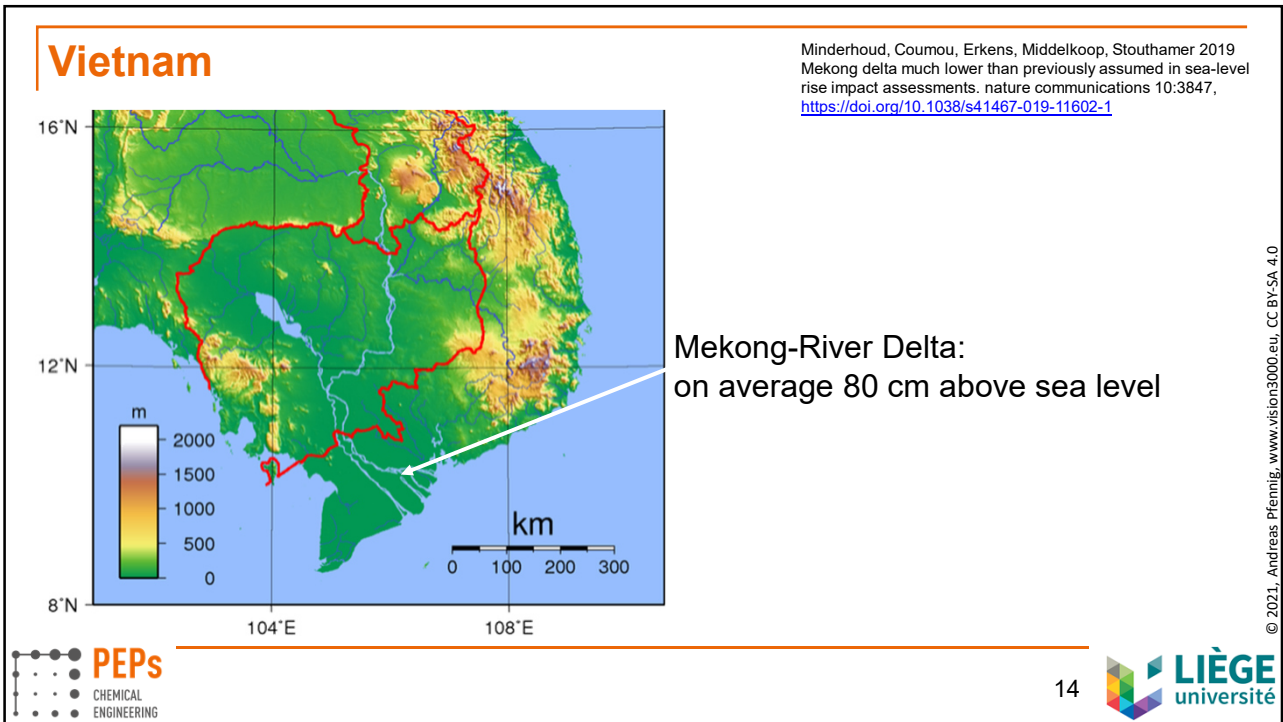
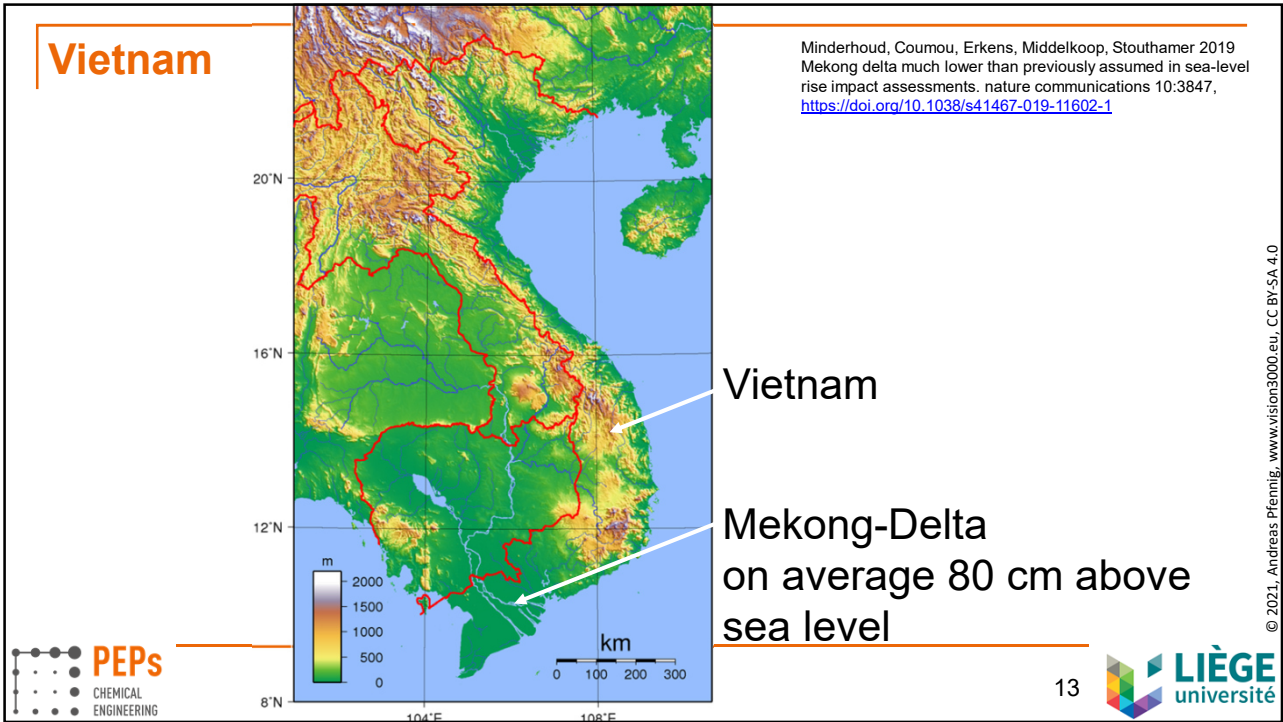
Holding the increase in the global average temperature to **well below 2 °C** above pre-industrial levels and to **pursue efforts to limit** the temperature increase **to 1.5 °C** above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change...

## melting of Greenland ice

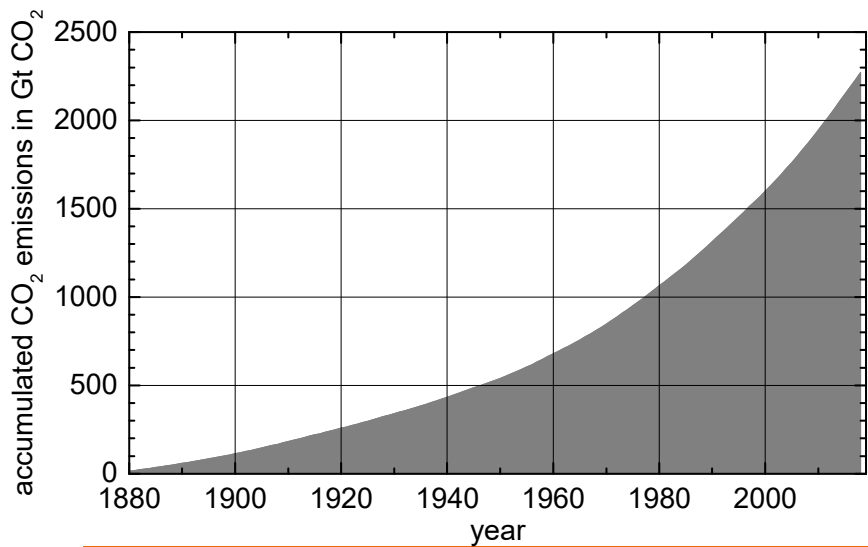


## Anstieg des Meeresspiegels



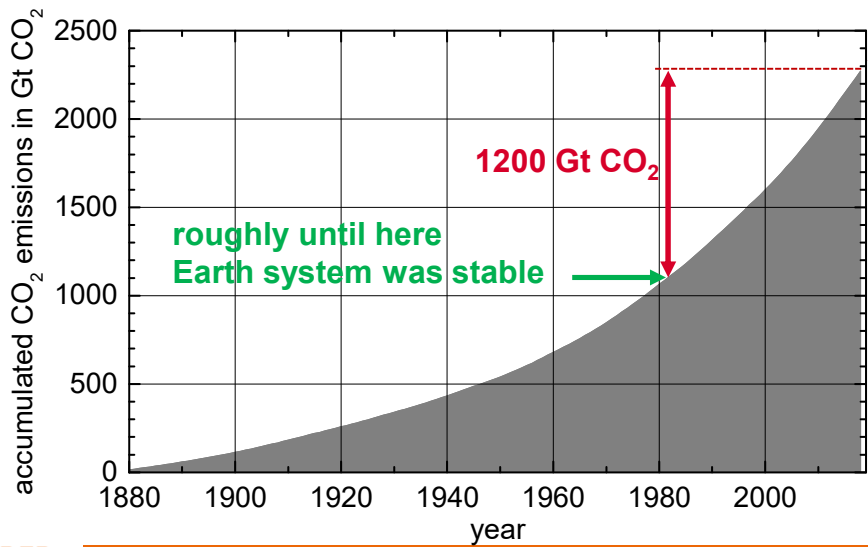


## total emitted CO<sub>2</sub> since industrialization



+ 600 to 800 Gt CO<sub>2</sub>  
until end of  
renewable-energy  
transition

## total emitted CO<sub>2</sub> since industrialization



roughly until here  
Earth system was stable

1200 Gt CO<sub>2</sub>

+ 600 to 800 Gt CO<sub>2</sub>  
until end of  
renewable-energy  
transition



## stabilizing Earth system

- afforestation, rewetting of peatlands
- humus formation in the soil, sustainable agriculture

## stabilizing Earth system

- afforestation, rewetting of peatlands
- humus formation in the soil, sustainable agriculture
  - ⇒ simple
  - ⇒ cheap, 0 to 100 US-\$ per t CO<sub>2</sub>
  - ⇒ maximum about 650 Gt CO<sub>2</sub>
  - ⇒ requires fertile land

## stabilizing Earth system

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

## 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)
  - ⇒ costly
  - ⇒ expensive: 250 US-\$ per t CO<sub>2</sub>

compensation of CO<sub>2</sub> emissions from Weisweiler power plant:  
absorber 128 m x 7 000 m  
> 4.5 billion US-\$ per year ≈ 6 times revenue from electricity

## stabilizing Earth system

- afforestation, rewetting of peatlands
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- 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<sub>2</sub>
  - ⇒ requires fertile land

## 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)
- etc.

## stabilizing Earth system

- DACCS is expensive:  
Where do we get the money?
- BECCS needs a lot of fertile land:  
Where do we get the land?

## stabilizing Earth system

- DACCS is expensive:  
Where do we get the money?  
per person in developed countries:  $\approx 1500$  US-\$ per year  
4-member family: 6000 US-\$ per year  $\approx 2$  monthly income
- BECCS needs a lot of fertile land:  
Where do we get the land?

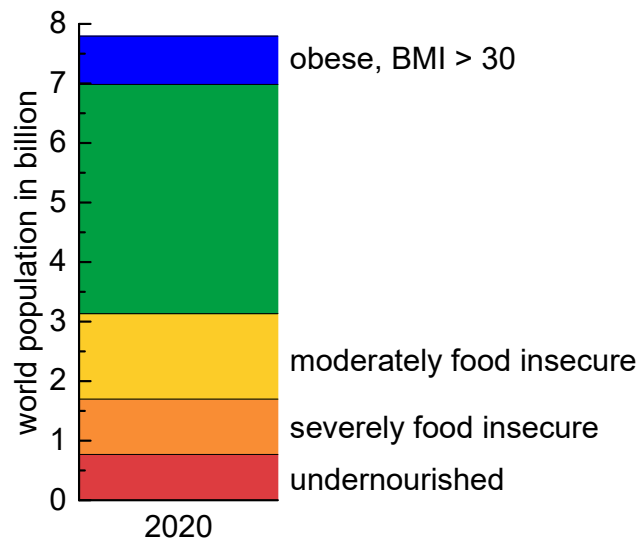
## stabilizing Earth system

- ~~DACCS ist teuer:  
Woher bekommen wir das Geld?  
per person in developed countries:  $\approx 1500$  US-\$ per year  
4-member family: 6000 US-\$ per year  $\approx 2$  monthly income~~
- BECCS needs a lot of fertile land:  
Where do we get the land?

## challenge: world hunger



## nutritional status of world population

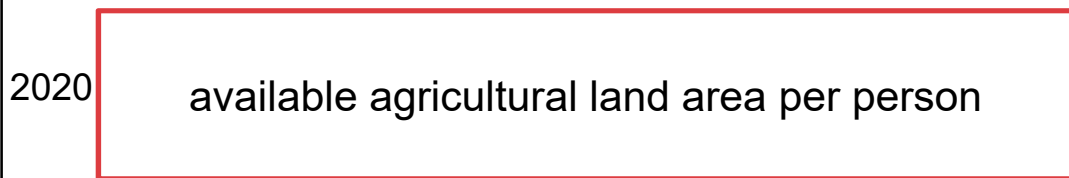


## fire clearing of rainforest in Brasil



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## utilization of land area per person



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## plant-based food



## biofuels



## bio-based materials



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## utilization of land area per person

2020



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## feed



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## pasture



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## utilization of land area per person

2020



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

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## utilization of land area per person

2050



2020



## utilization of land area per person

2050



2020



## afforestation to remove CO<sub>2</sub> from the atmosphere



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## BECCS: bio-energy with carbon capture and storage



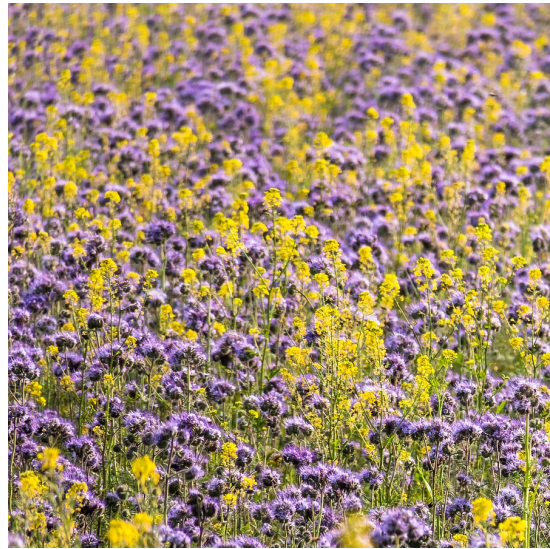
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## sustainable agriculture



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## flower strips & fallow land to save biodiversity



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## utilization of land area per person



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## animal-based food



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## animal-based food: 95 % of land area wasted



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## animal-based food

2 kcal feed + kcal from pasture  $\Rightarrow$  1 kcal animal-based food

thus:  $\gg$  50 % wasted

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## conclusions

- **95 % waste**: land area for **animal-based food**
- **>> 50 % waste**: kcal for **animal-based food**
- in the future we need the land area to reach sustainability
  - ⇒ **we cannot afford wasting** any kcal & land area:
  - ⇒ **be vegan!**
- just saving food waste contributes little to get us sustainable
- **applies today**: burning rainforest, people starving

## behavior vs. technology

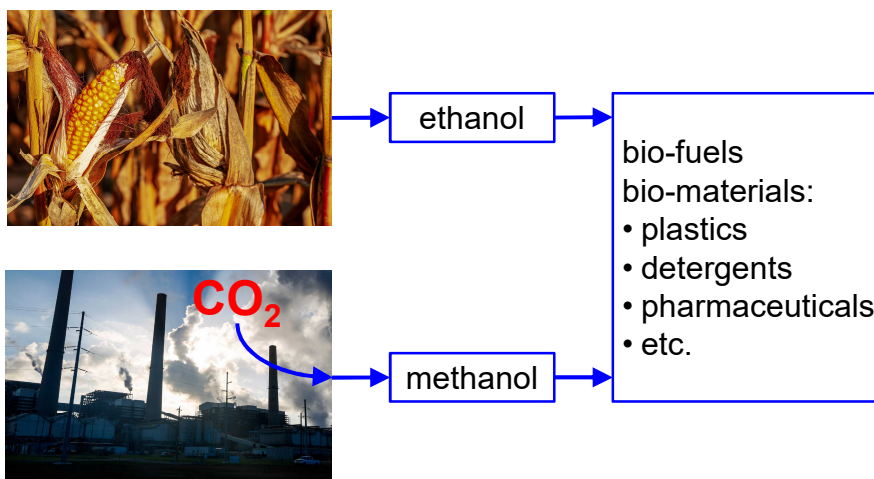
- **with behavior change**  
(maximum 2 children, plant-based nutrition):  
**available technology allows sustainable well-being for everybody**
- **without behavior change**:
  - **technology forced to maximum progress &**
  - **more people undernourished or**
  - **more deforestation**

## behavior vs. technology

- with behavior change  
(maximum 2 children, plant-based nutrition):  
available technology **vorhandene** allows sustainable well-being for everybody
- without behavior change:
  - technology forced to maximum progress &
  - more people undernourished or
  - more deforestation

⇒ behavior change required!

## bio or CO<sub>2</sub> economy?



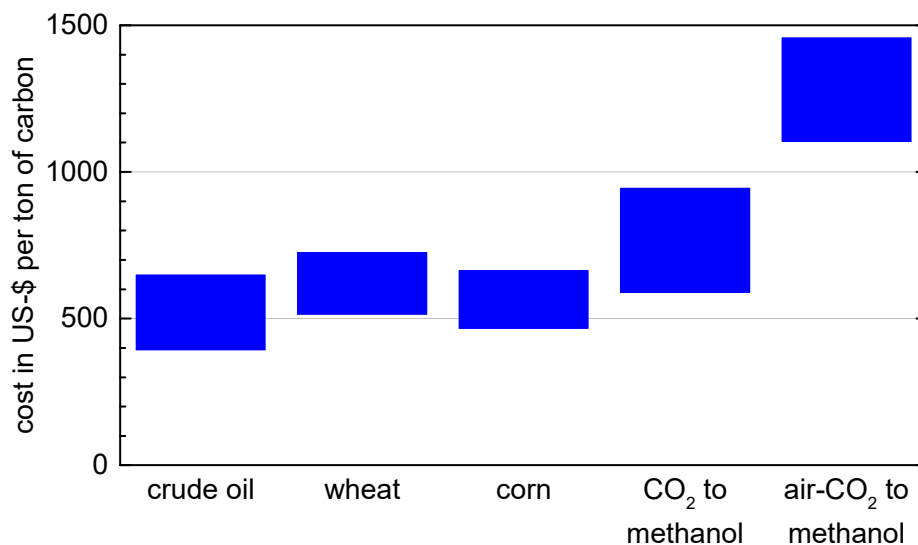
## George-Olah Plant, Iceland: CO<sub>2</sub> to 4000 t MeOH per year



## bio- vs. CO<sub>2</sub>-economy

- **bio-economy:**
  - existing technology, comparable to food processes
  - requires agricultural land area
  - energy requirements comparably small
  - drop-in possible for downstream processes
  - proteins available to nutrition
  - large side and recycle streams
- **CO<sub>2</sub>-economy:**
  - no agricultural land area required
  - requires a lot of energy
  - not yet installed on world scale (economically feasible?)
  - drop-in possible for downstream processes
  - after net-decarbonization CO<sub>2</sub> mostly from air

## comparing cost for bio and CO<sub>2</sub> economy



## conclusions bio- vs. CO<sub>2</sub>-economy

- CO<sub>2</sub> economy foreseeable significantly more expensive than bio-economy and today not yet sufficiently established on large scale.

### 3 generations of biomass

1. edible: oil palm, sugar cane, corn, wheat, etc.
2. inedible but on fertile land: wood, miscanthus, jatropha, etc.
3. waste of food production: straw, dung, etc.

### options for bio-based chemicals 2050

gen	feedstock	products	area in m <sup>2</sup> /cap
first generation	sugar beet	sugar or ethanol + CO <sub>2</sub>	●
		ethanol	●
	sugar cane	sugar or ethanol + CO <sub>2</sub>	●
		ethanol	●
	corn	sugar or ethanol + CO <sub>2</sub>	●
		ethanol	●
	wheat	sugar or ethanol + CO <sub>2</sub>	●
ethanol		●	
oil palm	plant oil	●	
rape seed	plant oil	●	
second	miscanthus/reeds	sugar or ethanol + CO <sub>2</sub>	●
		ethanol	●
	wood	sugar or ethanol + CO <sub>2</sub>	●
third	corn straw	sugar or ethanol + CO <sub>2</sub>	●
		ethanol	●
	wheat straw	sugar or ethanol + CO <sub>2</sub>	●
		ethanol	●

ranges:  
maximum national to  
world average productivity  
projected for 2050

color:  
■ technically realized  
■ partly pilot-plant

← arable land  
2050 →

## conclusions climate, energy, food, land area

- realize the renewable-energy transition as quickly as possible
  - save energy where large quantities can be saved
  - we inevitably have to capture CO<sub>2</sub> from the atmosphere: biobased
  - preferred: bioeconomy instead of CO<sub>2</sub> economy
  - preferred: first generation biomass
  - we have to avoid animal-based food
- 
- political measures **and** industrial change **and** change in land use and management **and** behavior change
  - get involved!

## next activity in HCMC

Ho Chi Minh City  
Vietnam

In front of townhall  
At 12.00-13.00 (noon to 1pm)  
Sat, 13 Aug 2022  
Demonstration  
Weekly

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Report results!

Contact info!

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## the next global action



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active at:

Andreas Pfennig  
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Department of Chemical Engineering  
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[www.chemeng.uliege.be/pfennig](http://www.chemeng.uliege.be/pfennig)  
[andreas.pfennig@uliege.be](mailto:andreas.pfennig@uliege.be)

