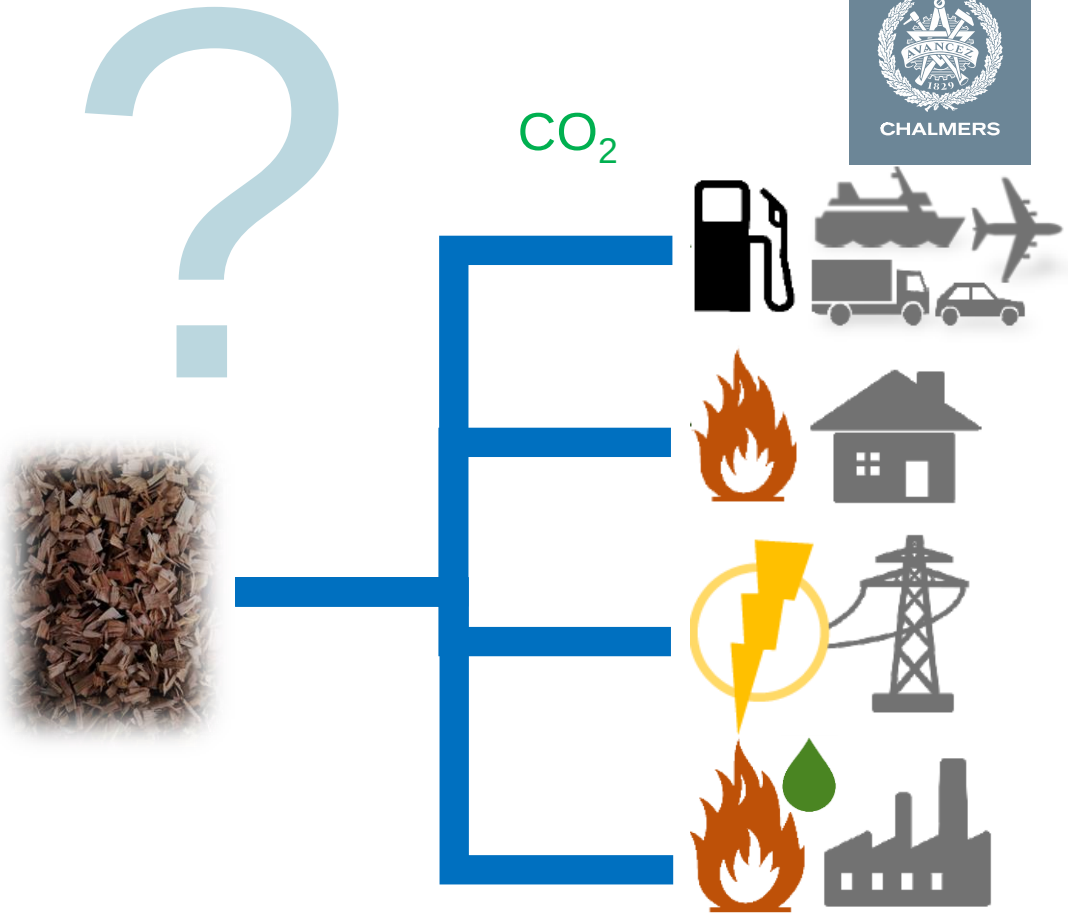
Considerations on the priority of biomass use in future energy systems

Markus Millinger | IEA Bioenergy workshop *Bioenergy in a Net Zero Future*, Lyon, 19 Oct 23

Biomass

- Limited resource with trade-offs
- RED III proposed to exclude forest residues
- Cost-effective use of biomass residues in the energy system?
  - Fuels?
  - Variation management / firm generation?
  - Industry?
  - Negative emissions?



Millinger et.al. 2021:
https://doi.org/10.1039/D0SE01067G

Key take-aways

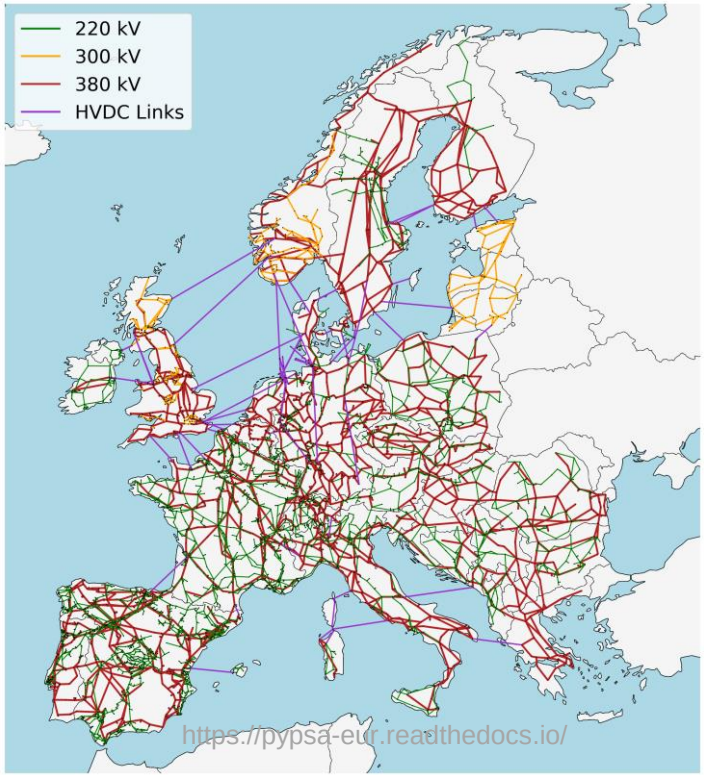
- Removing biomass residues results in **~20%** higher energy system cost
- Main value of biomass is **carbon provision** for further utilisation or negative emissions
- **Not crucial what biomass is used** for if it is connected to carbon capture, which strongly enhances value of biomass
- High CAPEX of carbon capture → **cost-effective in processes with high capacity factors**
- Renewable chemicals and **liquid fuels most challenging** part of the energy system

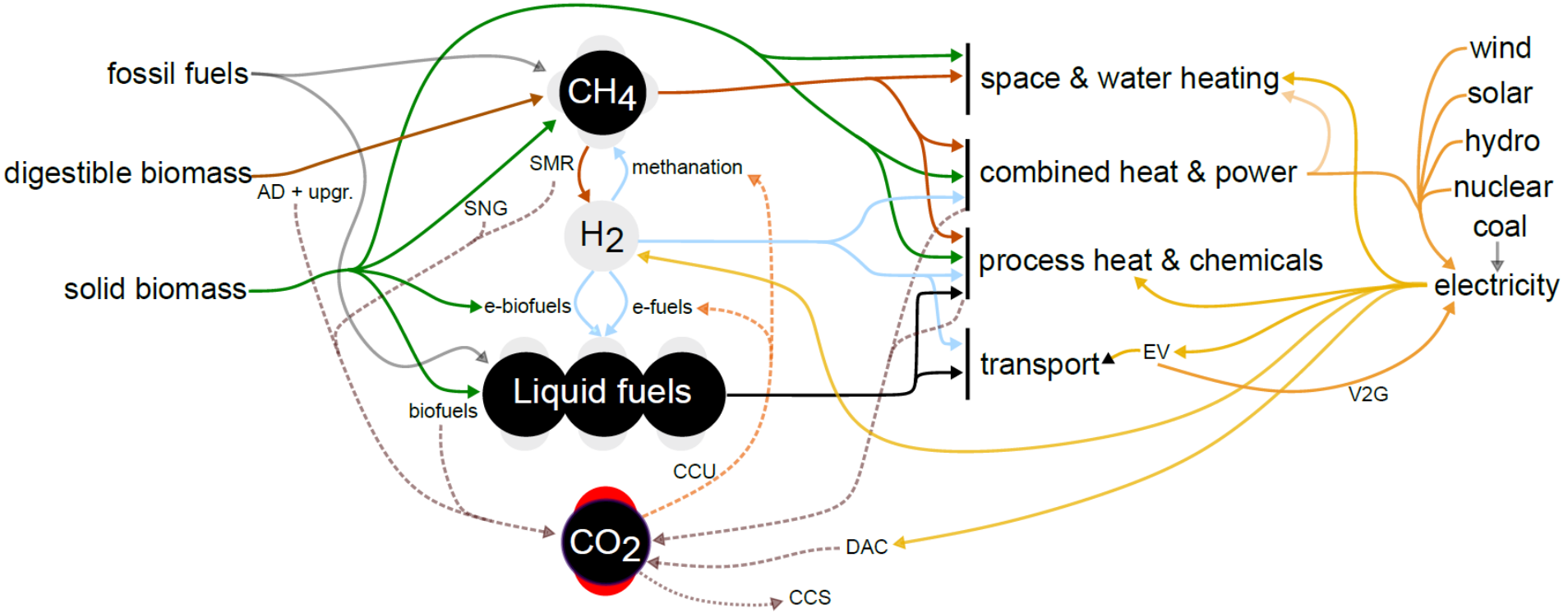
Model

- **PyPSA**-Eur-Sec. Optimisation of capacity and dispatch across all sectors. Open source.
- High spatial and temporal resolution

Set-up:

- Europe in 37 nodes, 5H temporal resolution, **overnight**
- **Net-negative** (-110%) CO_2 emissions vs 1990, with limited carbon storage
- Biomass competes with electricity- and fossil-based options in all sectors

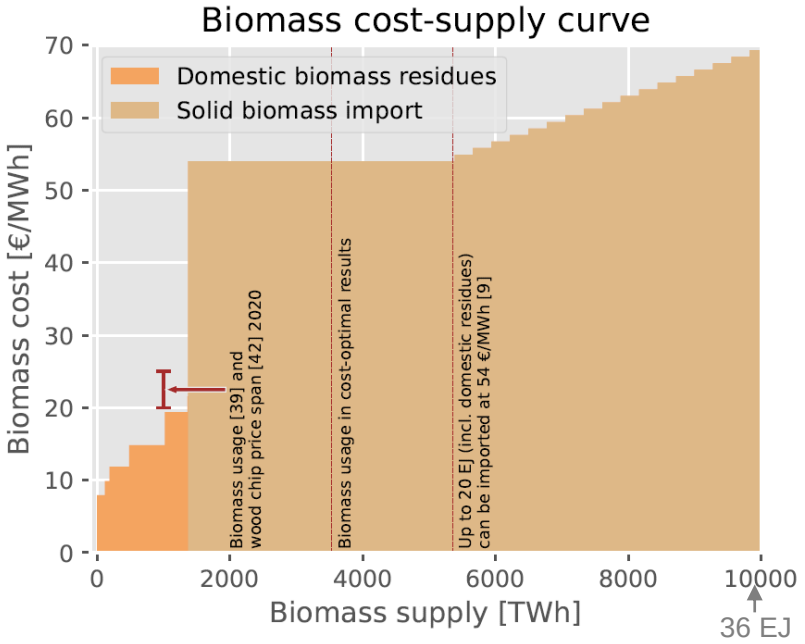




Millinger et.al. (2023):
https://doi.org/10.21203/rs.3.rs-3097648/v1

Biomass

- Domestic residues and more expensive biomass imports
- All biomass processes can choose to add carbon capture (except small-scale heating)
- Carbon capture: energy penalty for added heat demand + substantial infrastructure cost



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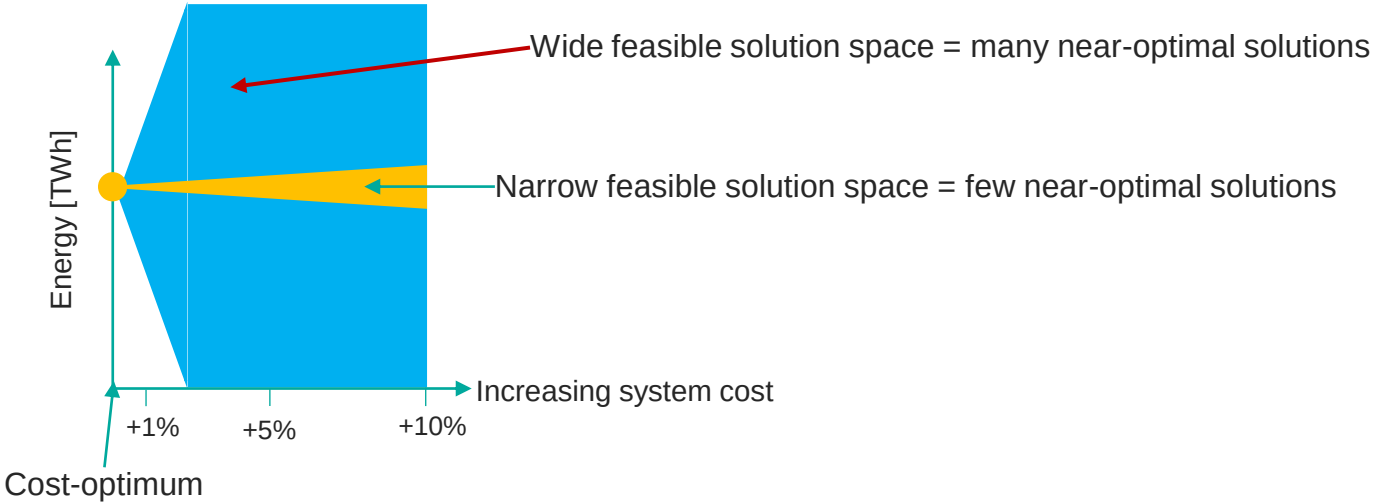
Near-optimal analysis

Analysis of the feasible solution space around cost-optimum:

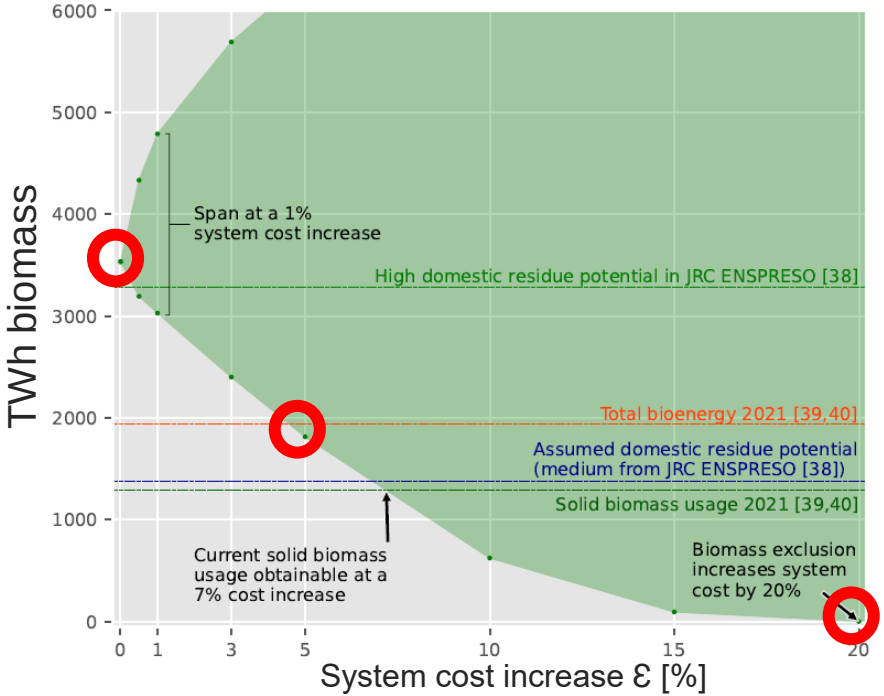
1. Cost-minimised technology mix to achieve an emissions target. **One** optimal solution.
2. Increase allowed system cost by X% and minimise or maximise any option



RESULTS

Biomass in the energy system

- 3500 TWh biomass cost-optimal (29% of primary energy; the rest wind, solar and some hydro)
- Biomass limited to current use corresponds to ~5% higher system cost.
- Can be excluded at ~20% higher system cost (170 B€, or ca total defense spending in EU). Similar to wind power!
- Biomass usage sensitive to biomass upstream emissions if carbon storage is low



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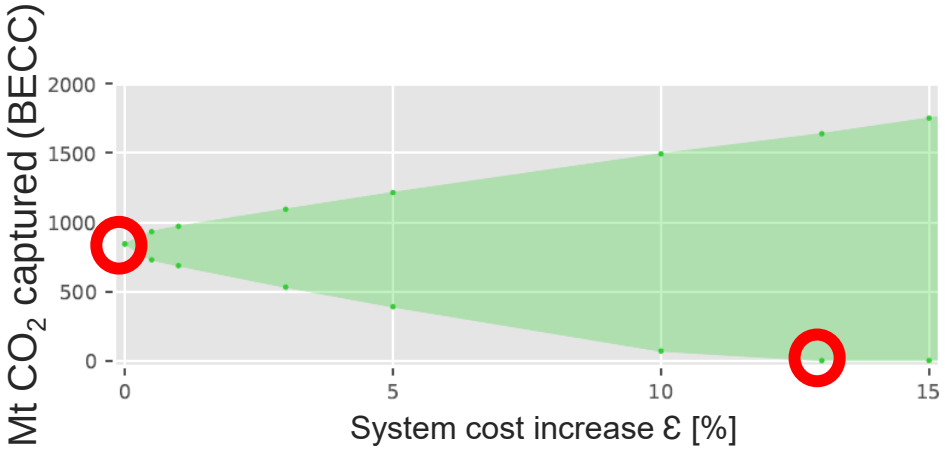
Bioenergy with carbon capture

- Around 900 $MtCO_2$ biogenic capture cost-optimal (21% of total **GHG** emissions in 2021)
- Almost all biomass usage linked to CC
- Can be excluded at a 13% higher system cost
- BECC strongly enhances carbon efficiency and value of biomass
- BECC is competitive to DAC also given very low DAC cost → may inhibit DAC deployment



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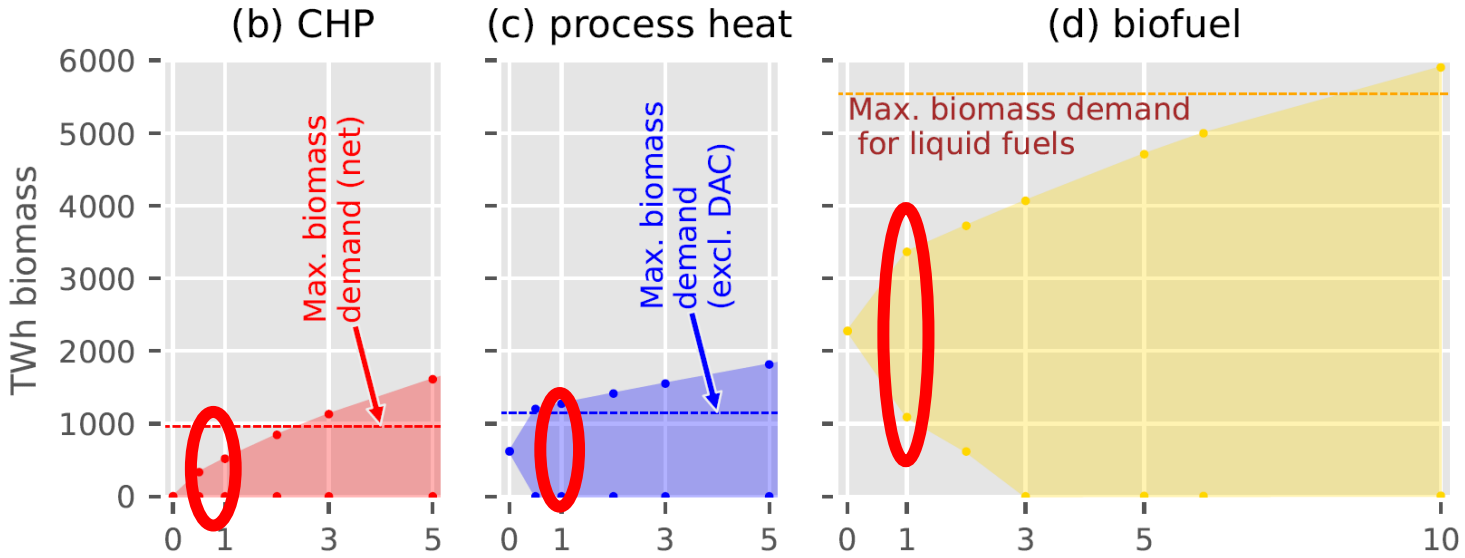
Use of solid biomass



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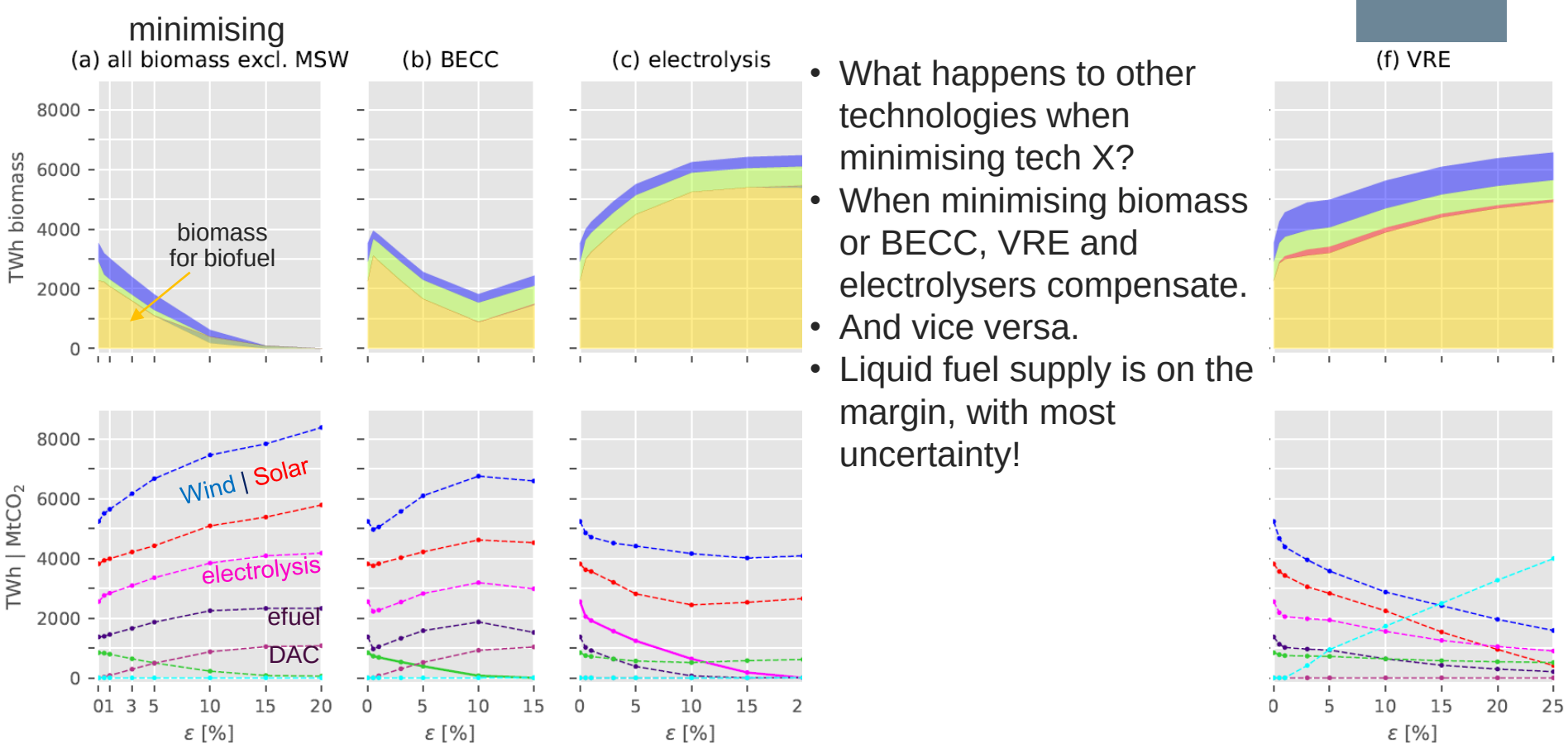

- What happens to other technologies when minimising tech X?
- When minimising biomass or BECC, VRE and electrolysers compensate.
- And vice versa.
- Liquid fuel supply is on the margin, with most uncertainty!

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Conclusions and discussion

- Carbon-neutral biomass provides cost-effective renewable carbon and negative emissions
- Main value is providing carbon, energy only secondary → some freedom in what biomass is used for, as long as it is coupled with carbon capture
- If any of the key technologies deliver less than optimal, liquid fuels are most affected

Read more in the pre-print:

CHALMERS