Prospective LCA of a biorefinery concept for production of bulk and fine chemicals

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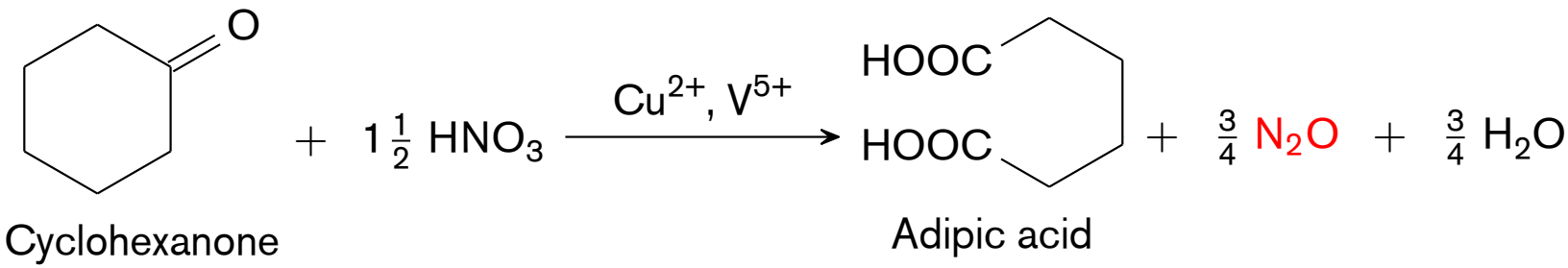
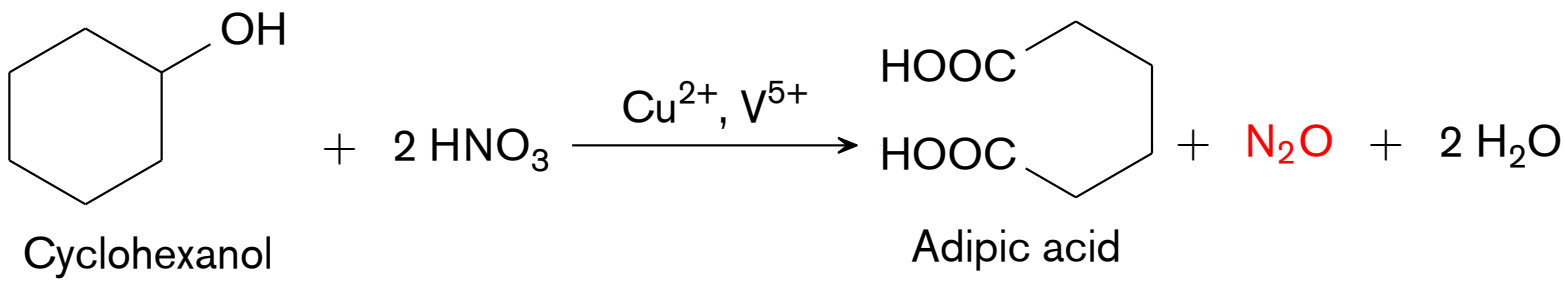
Outline

Fossil-based production of adipic acid

- Traditional production from fossil resources → KA oil[1]

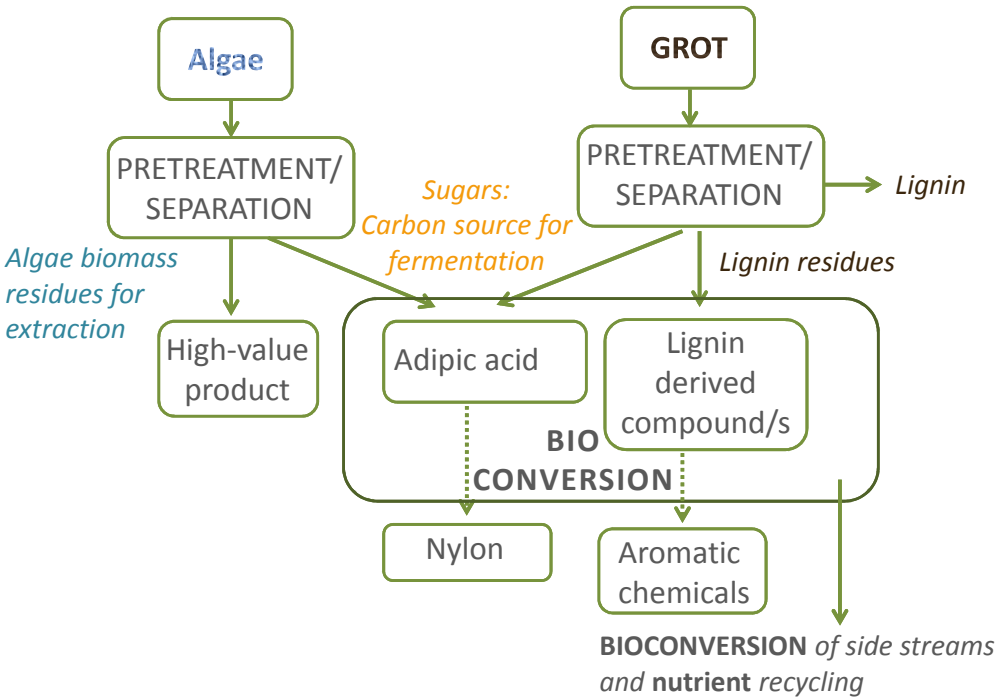




[1] A. Shimizu, K. Tanaka, and M. Fujimori. *Chemosphere - Global Change Science* 2.3-4 (2000), pp. 425–434.

Bio-based production of adipic acid

- Biorefinery concept for the production of bulk and fine chemicals



- Bulk chemical → Adipic acid[2], lignin derivative, lignin as a product
- Fine chemical → Lutein

[2] R. Aryapratama and M. Janssen. *J Clean Prod* 164 (2017), pp. 434–443.

Applying prospective life cycle assessment

- Appropriate methodological choices need to be made[3]
  - Technology alternatives
  - Foreground system
  - Background system

[3] R. Arvidsson et al. *J Ind Ecol* (2018). doi: 10.1111/jiec.12690.

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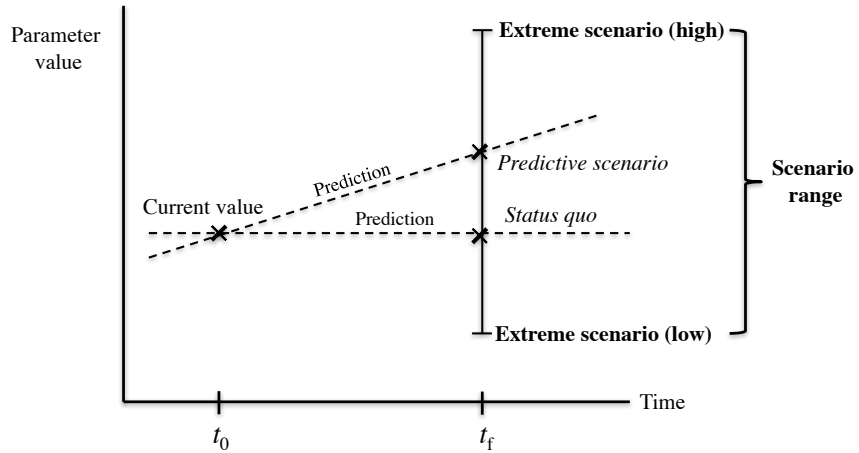

- Predictive scenarios → Based on forecasts or trends
- Scenario ranges → Illustrate potential environmental impact

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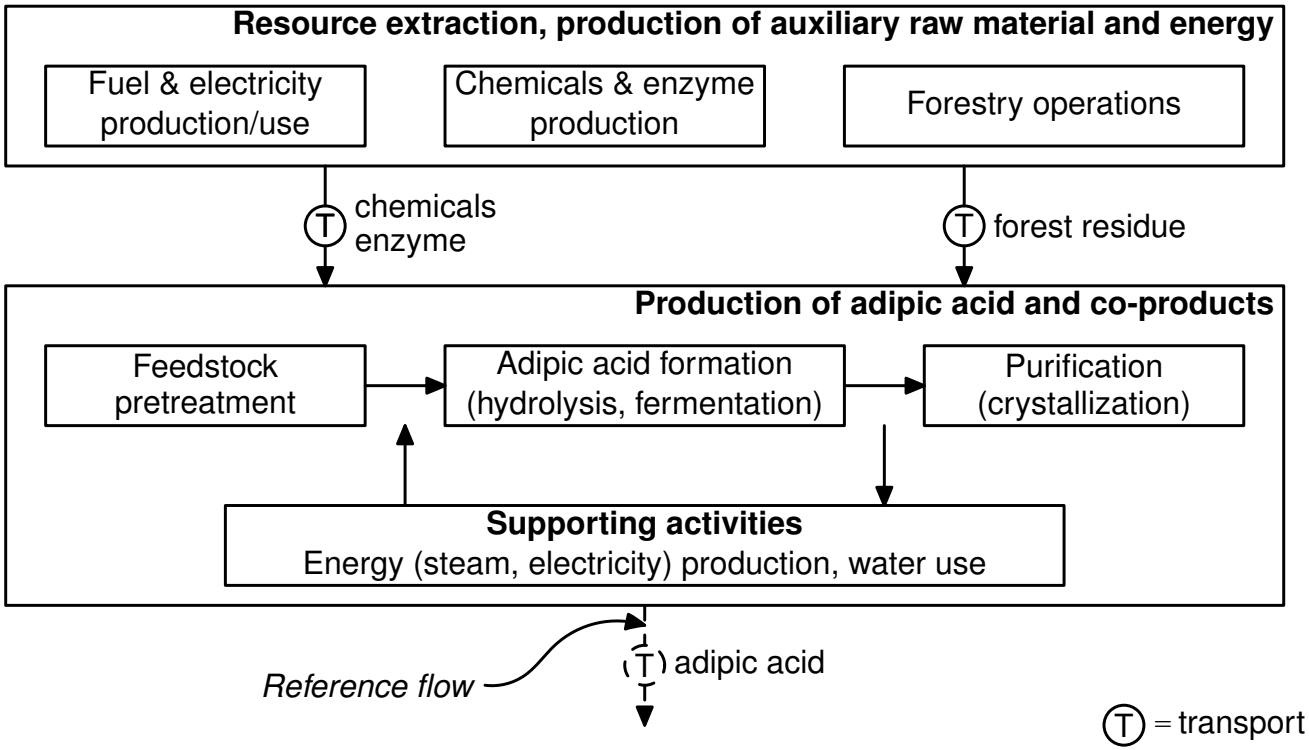
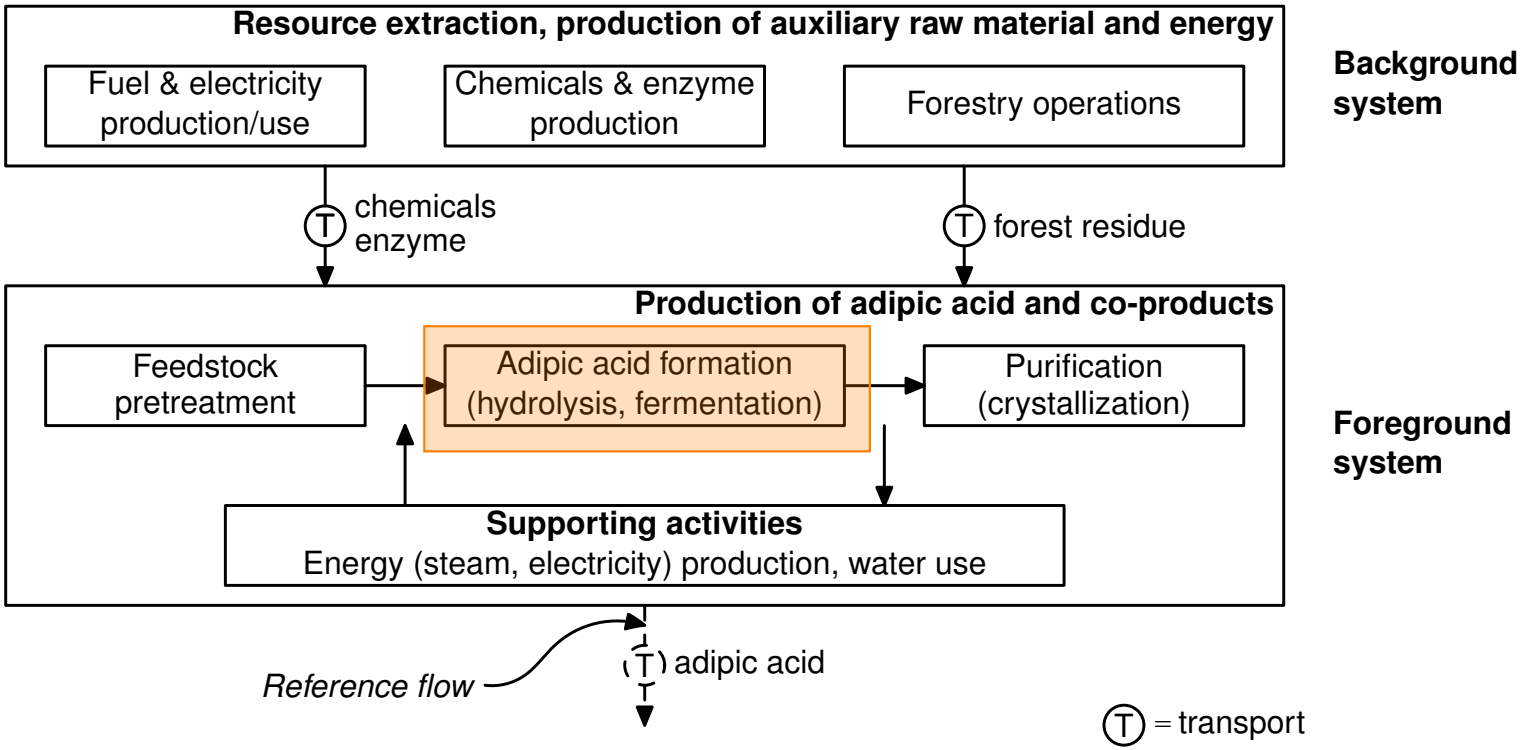
Life cycle assessment



- Goals
  - Guiding technology development
  - Future environmental performance of the concept
- Functional unit $\rightarrow$ 10 000 t of adipic acid produced

Life cycle assessment



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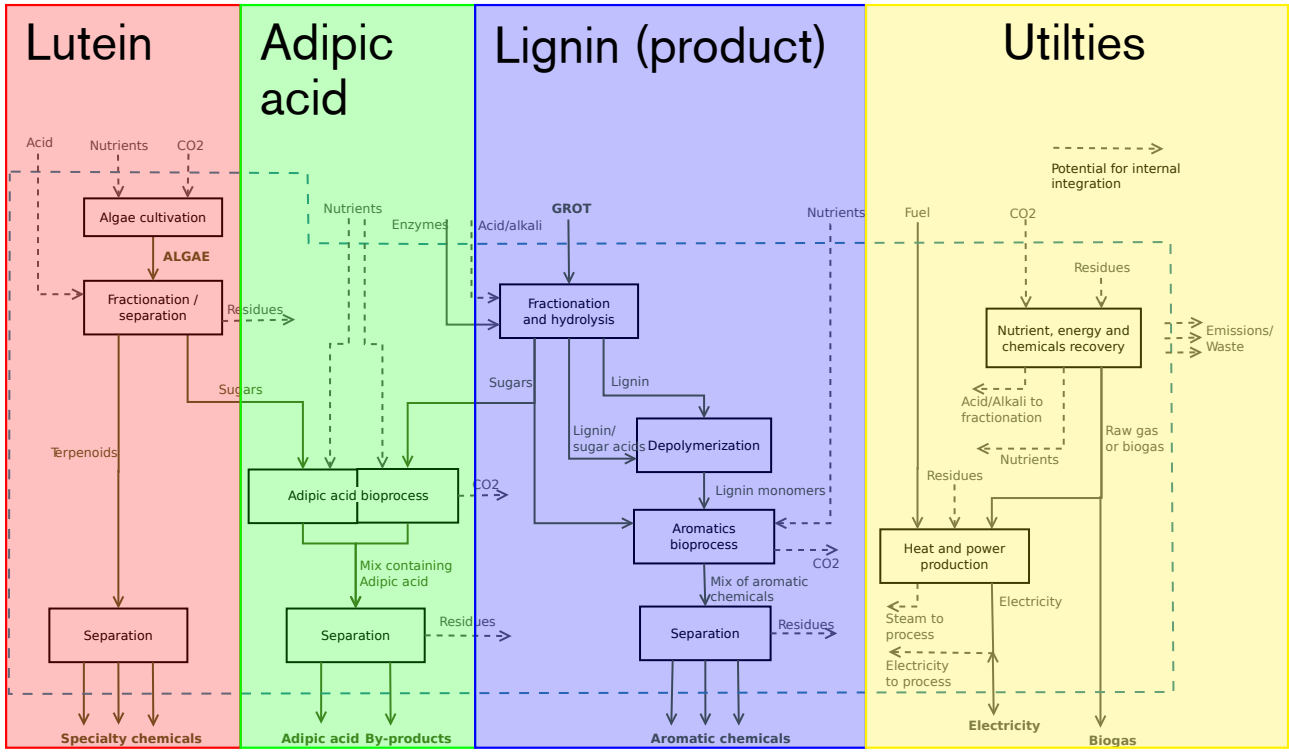
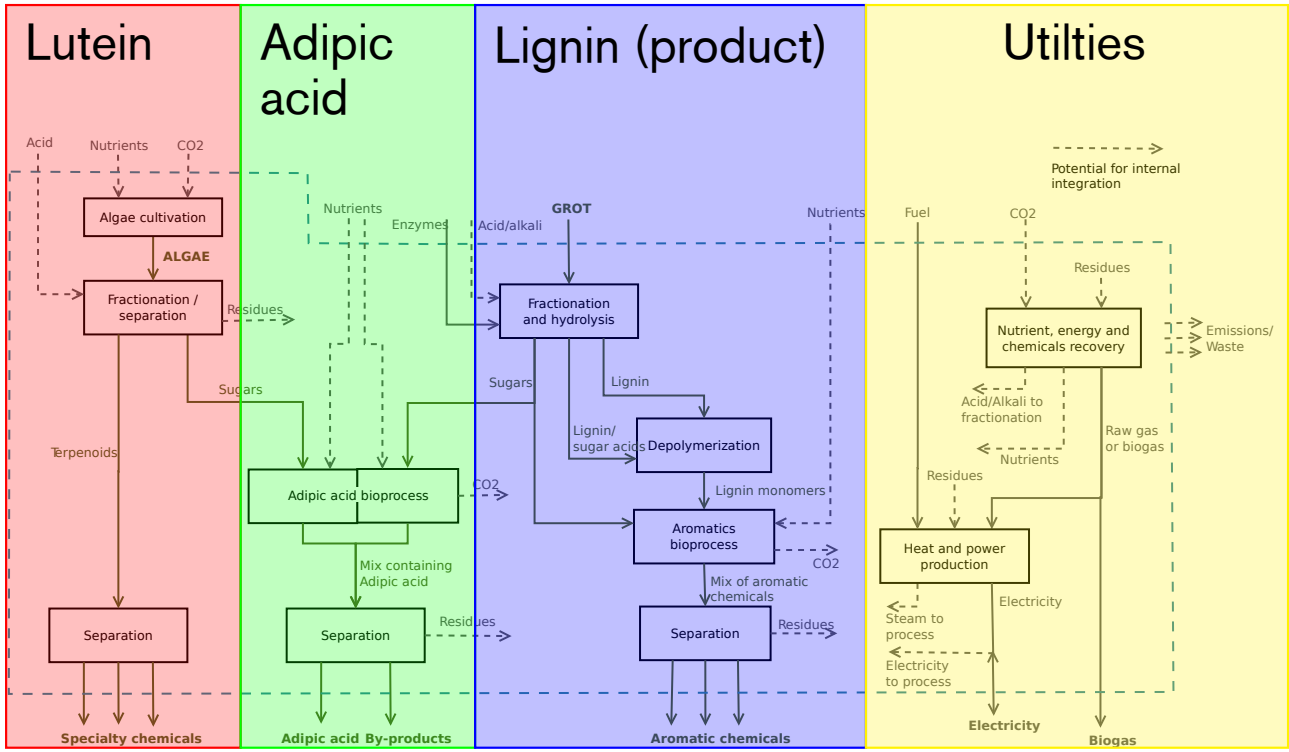
Integrated biorefinery concept

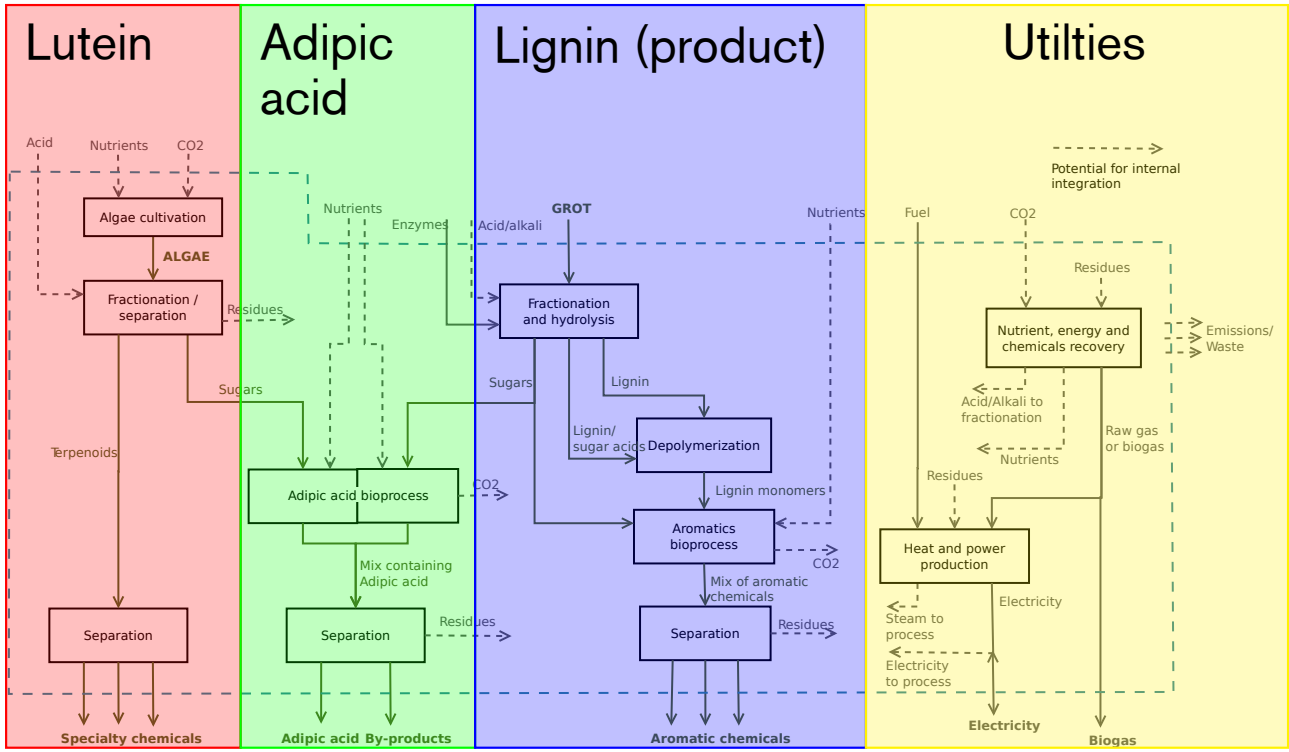


Integrated biorefinery concept



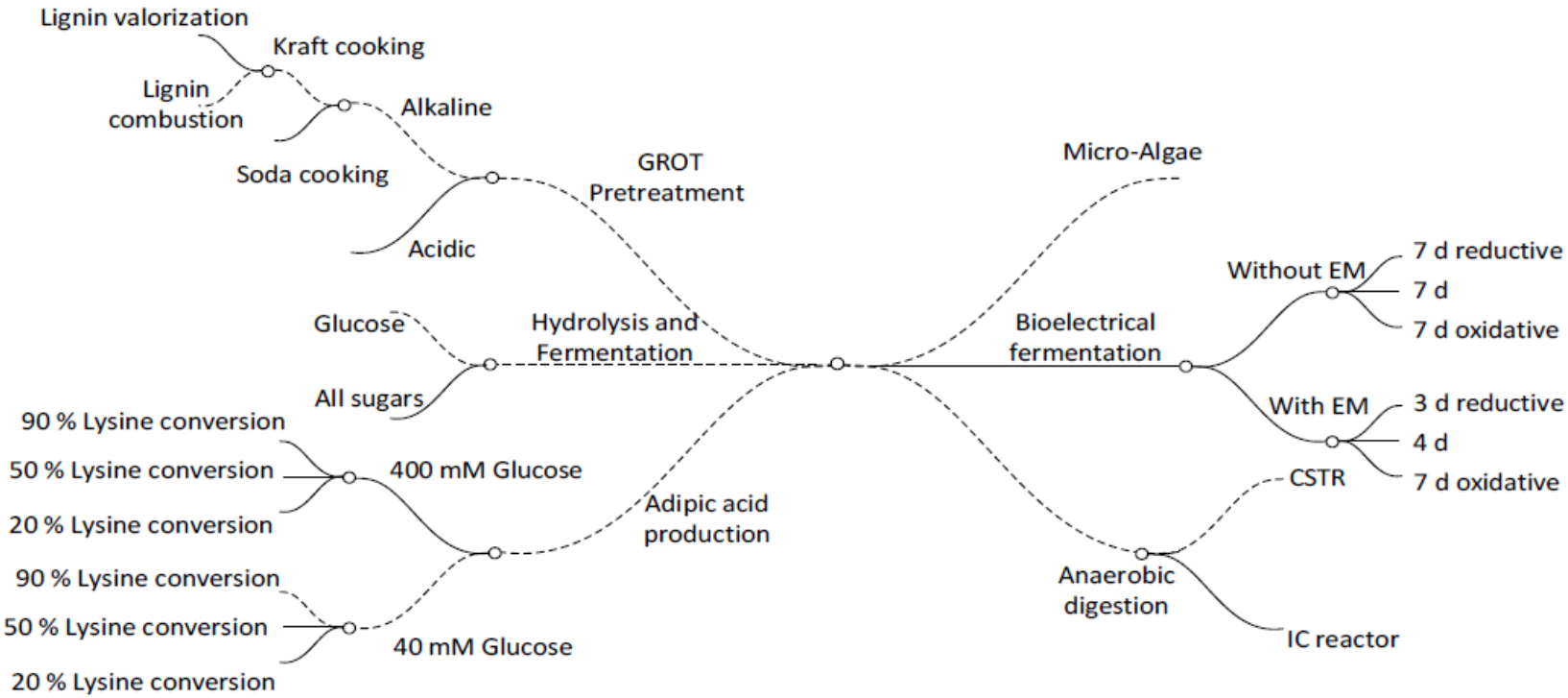
- Alkaline pretreatment (Kraft cooking) with Lignoboost
- Water from anaerobic digestion to conventional WWTP

Integrated biorefinery concept



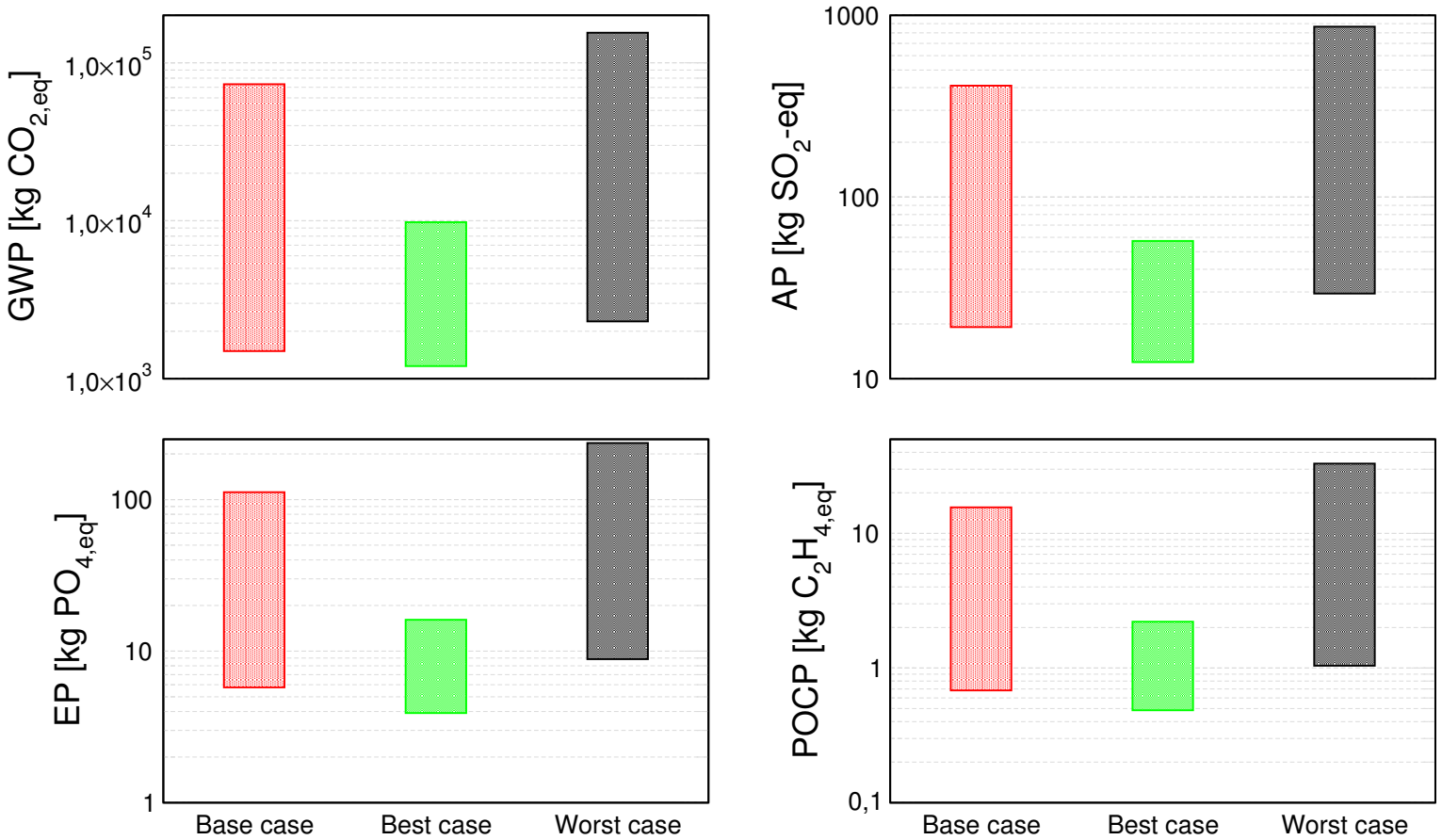
- Alkaline pretreatment (Kraft cooking) with Lignoboost
- Water from anaerobic digestion to conventional WWTP
- Process integration
  - Pretreatment with adipic acid production $\rightarrow CO_2$
  - Adipic acid production with microalgae cultivation $\rightarrow CO_2$, water

Construction of process alternatives



- Twelve alternatives were constructed for the assessment
  - Lysine conversion → 20 %, 50 % and 90 %
  - Sugar concentration → 40 mM and 400 mM
  - Sugar conversion → Only glucose, all sugars

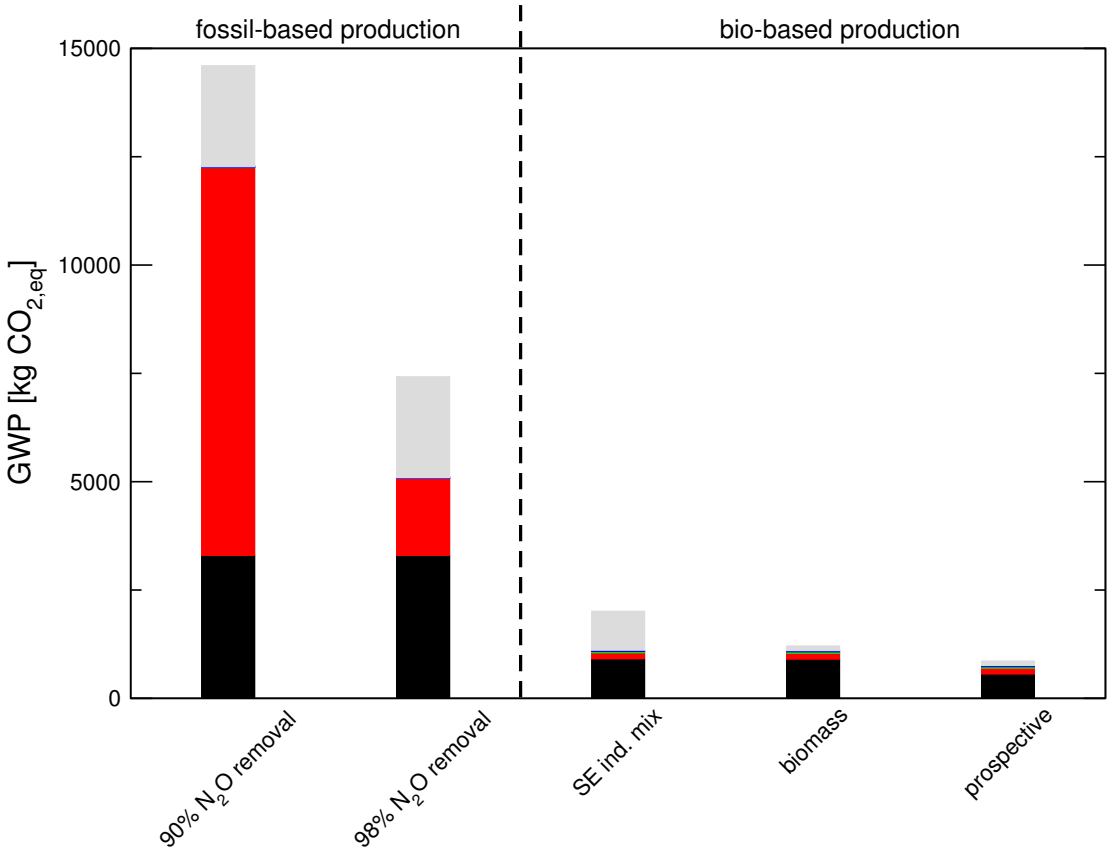
Range of current environmental impacts

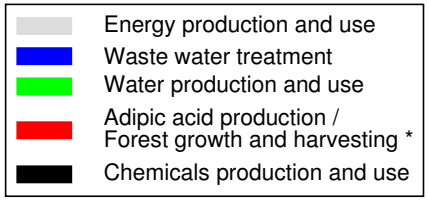


- Variation due to
  - Between alternatives → Foreground system
  - Within alternatives → Heating and cooling demands

Improvements in global warming potential

From fossil-based to bio-based production (minimum heating and cooling demand)





SE ind. mix: Swedish industrial energy mix (**foreground**)
biomass: Only biomass in energy mix (**foreground**)
prospective: Future **background** energy system

* Adipic acid production: fossil-based production
Forest growth and harvesting: bio-based production

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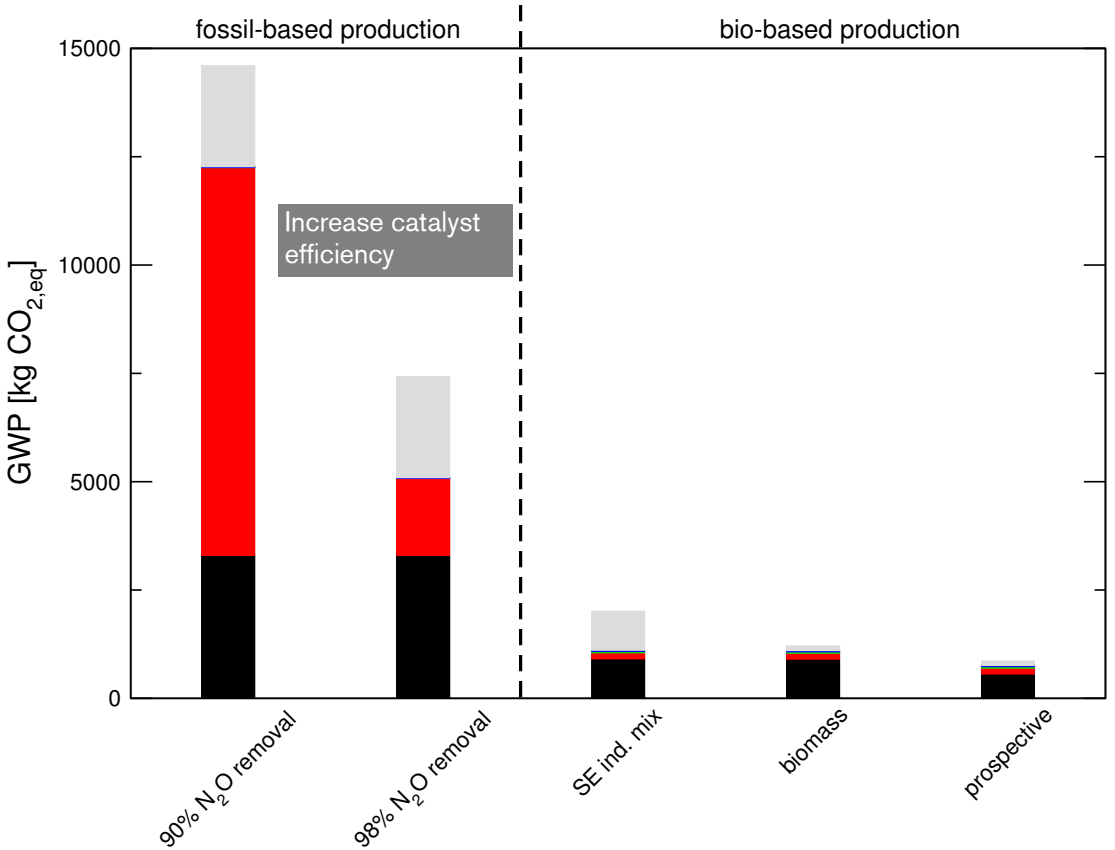

Energy production and use
Waste water treatment
Water production and use
Adipic acid production / Forest growth and harvesting *
Chemicals production and use

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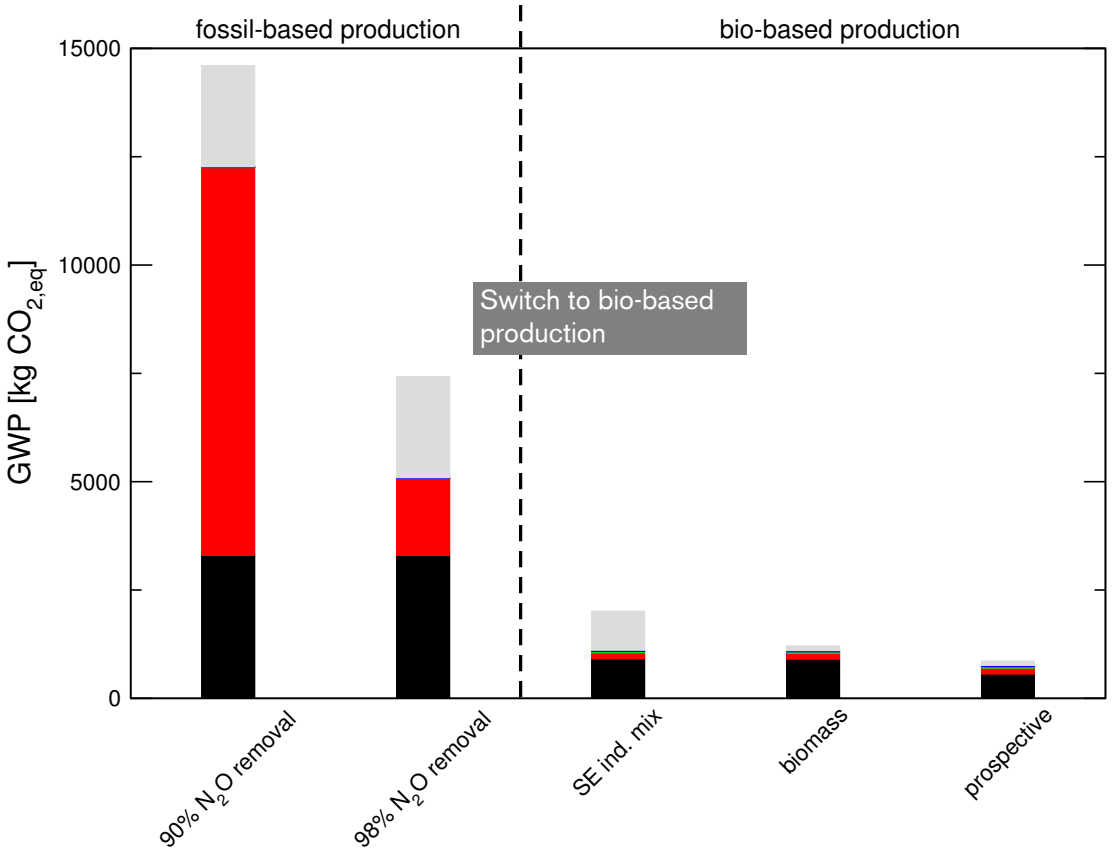

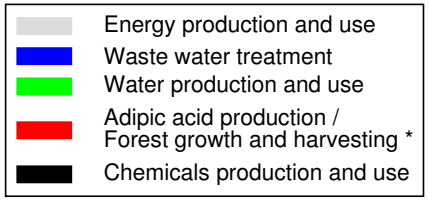

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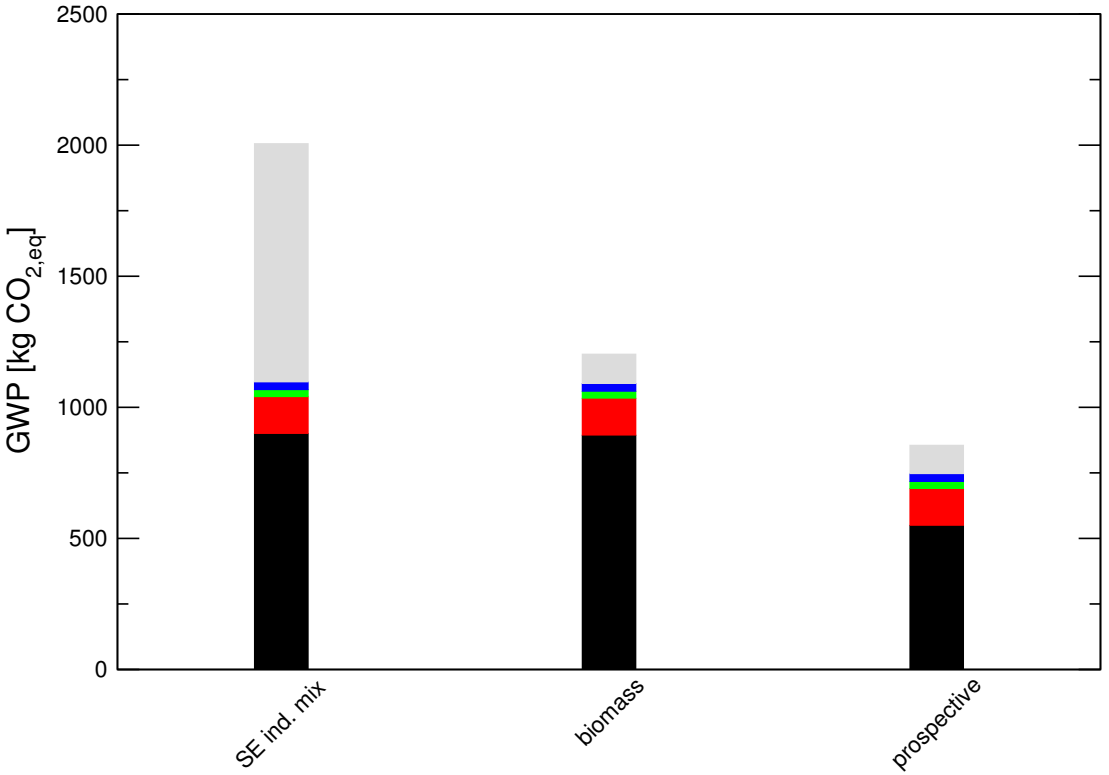

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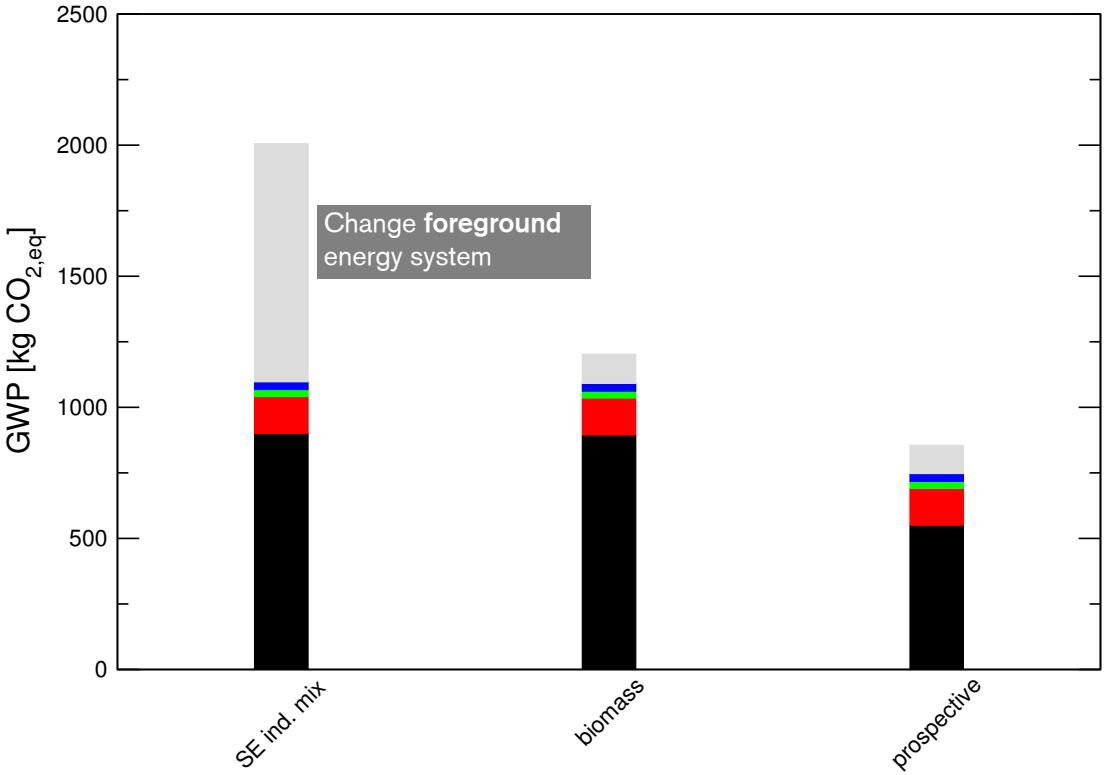

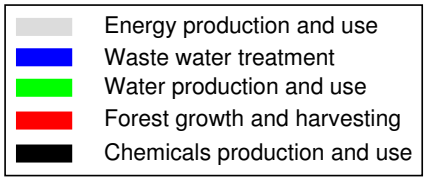

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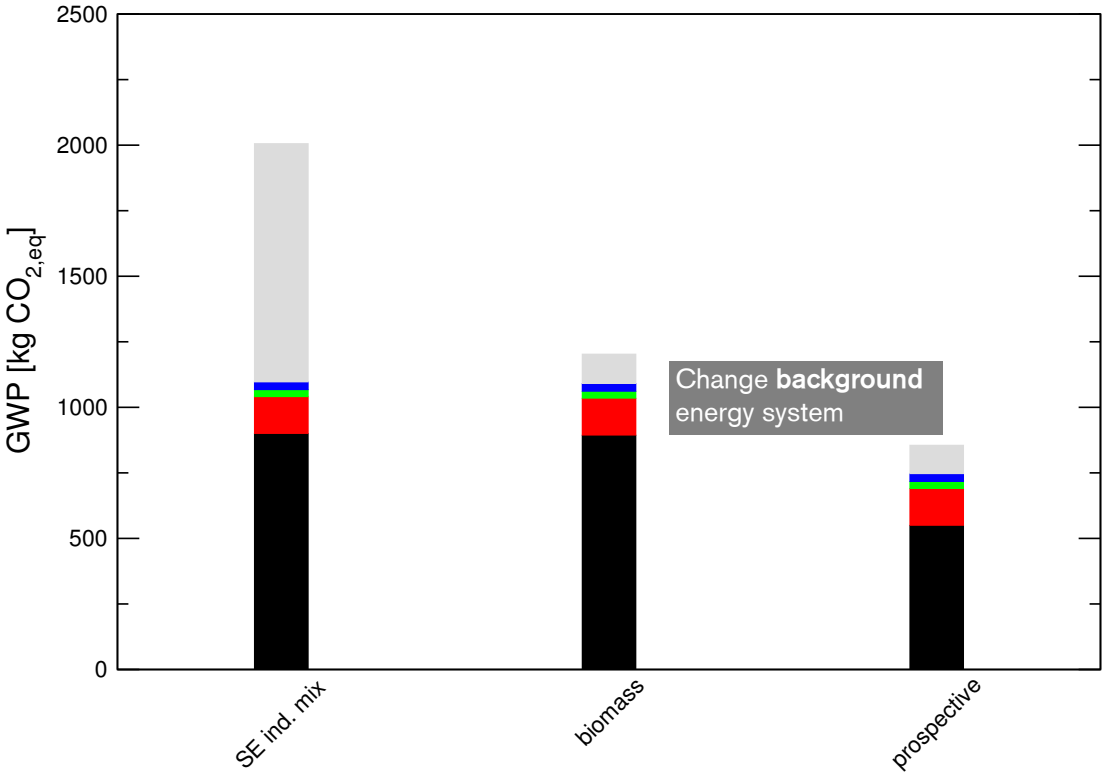

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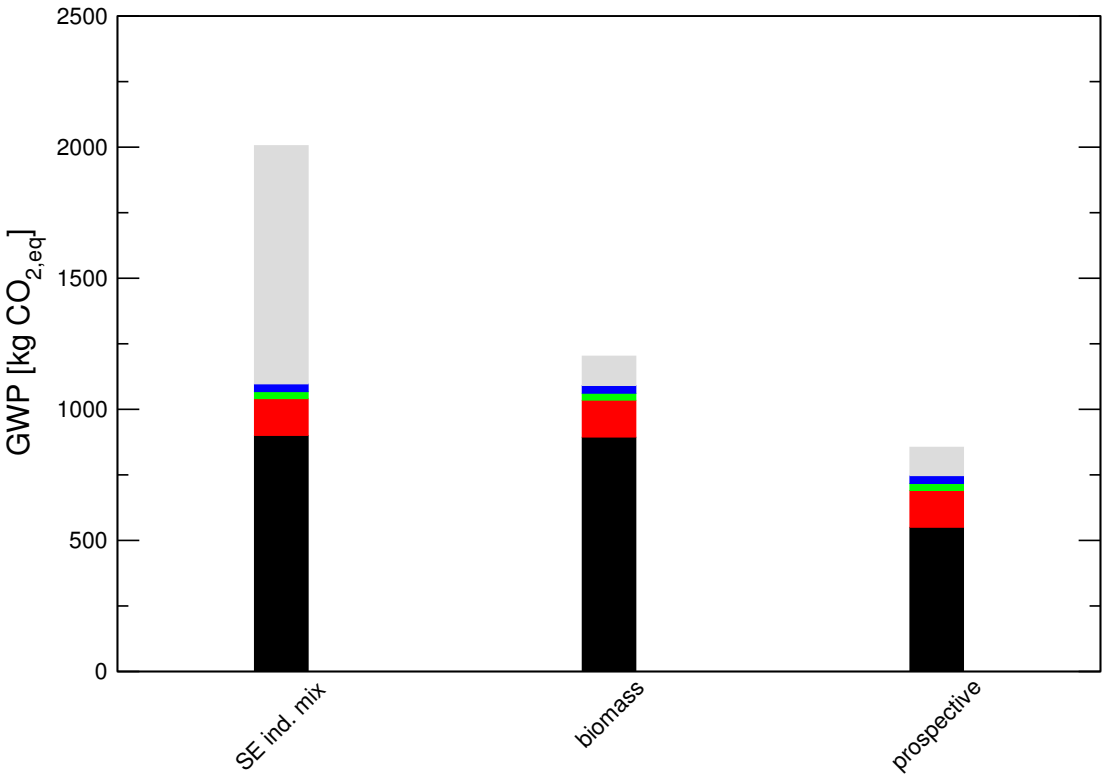

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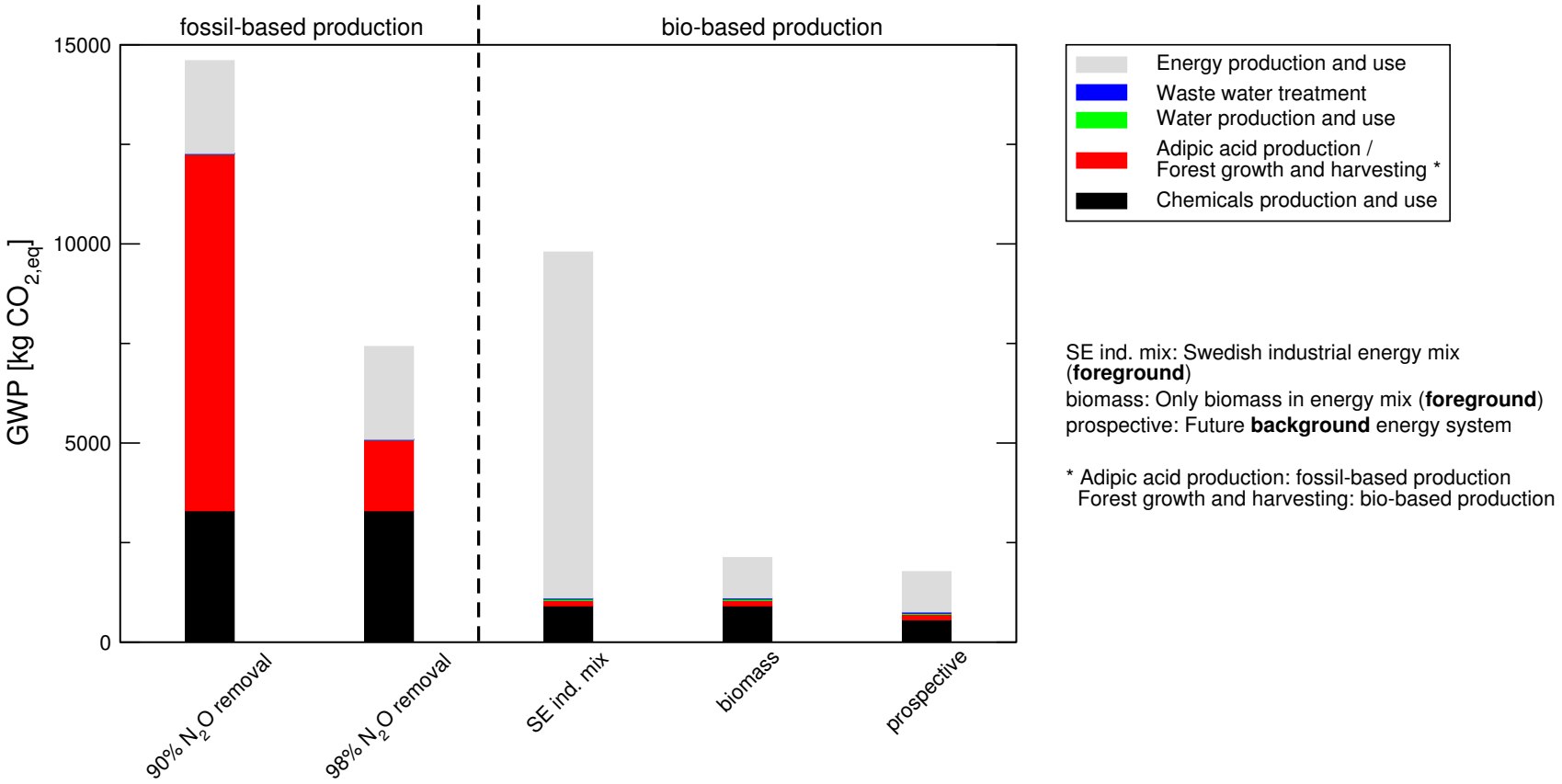
- Further improvements in the foreground system are possible
- Change in background energy system mainly affects chemicals production

Improvements in global warming potential

From fossil-based to bio-based production (maximum heating and cooling demand)



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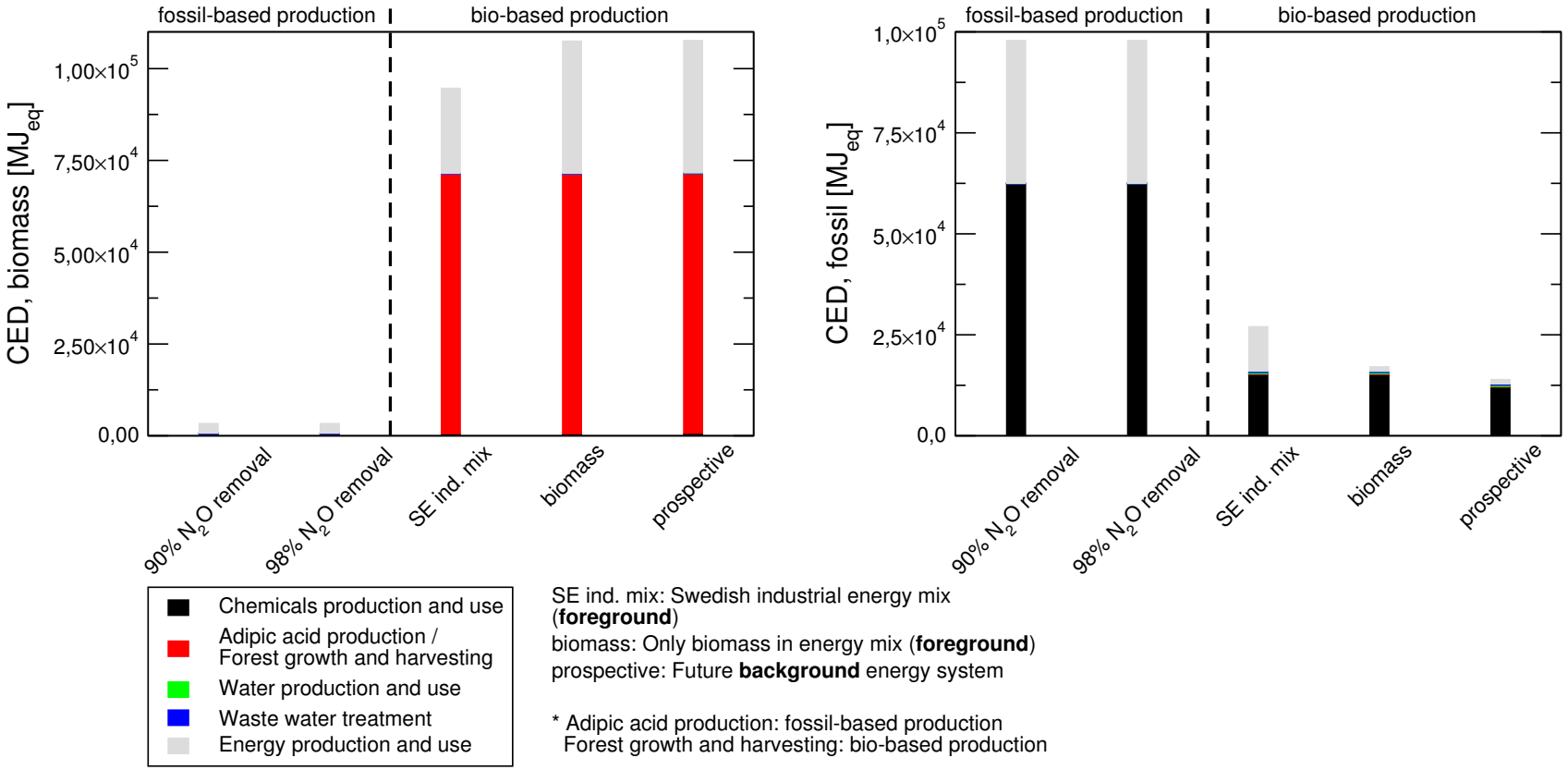
- Fossil-based production could be the better option
- Clean foreground energy system is crucial

Changes in energy use

From fossil-based to bio-based production (minimum heating and cooling demand)



- Prospective scenario does not affect renewable energy use
- Changes in environmental impact driven by changes in fossil energy use

Conclusion

- Technology
  - Switch to bio-based production of adipic acid can lower environmental impacts significantly
  - Changes in foreground and background both affect environmental performance
    - Clean foreground energy system is crucial
    - Future changes in the background energy system may improve chemicals production and use

Conclusion

- Technology
  - Switch to bio-based production of adipic acid can lower environmental impacts significantly
  - Changes in foreground and background both affect environmental performance
    - Clean foreground energy system is crucial
    - Future changes in the background energy system may improve chemicals production and use
- Methodology
  - Construction of process alternatives helps identify process and environmental risks
  - Inventory data generated with detailed process simulation
  - Making changes in datasets to model future background energy systems need to be facilitated

THANK YOU
Any questions?

BIOBUF