Environmental assessment of a biorefinery concept for production of bulk and fine chemicals

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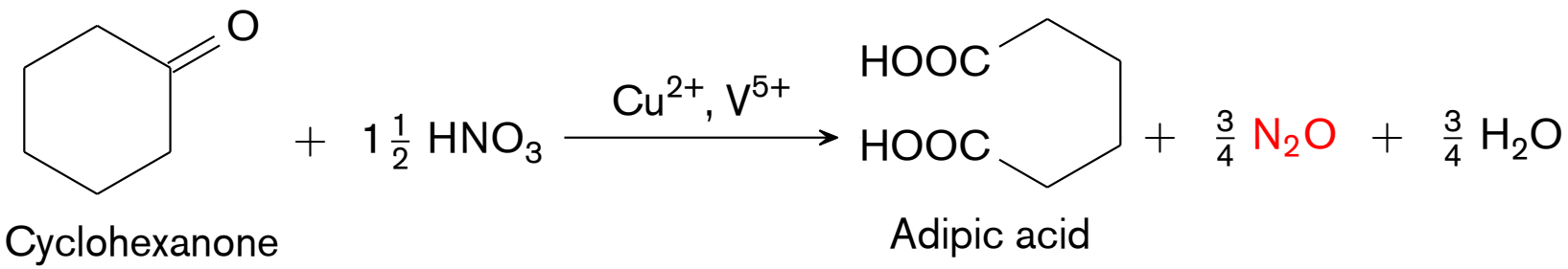
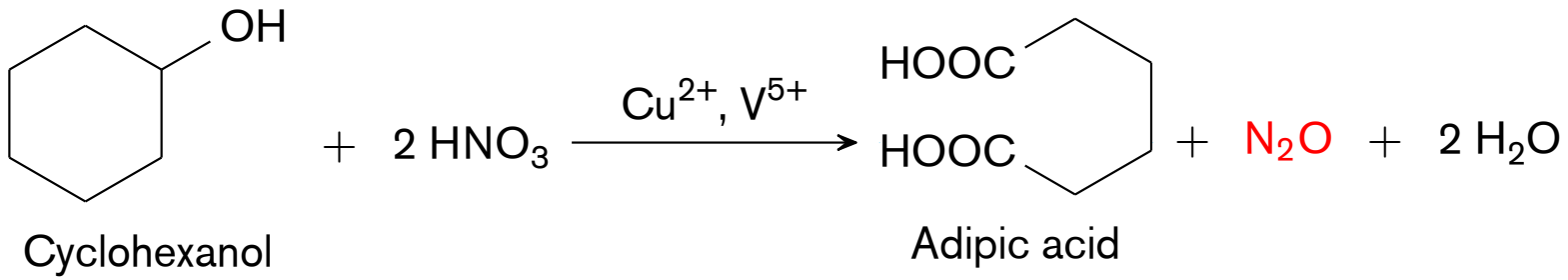
July 9, 2019

Outline

Fossil-based production of adipic acid

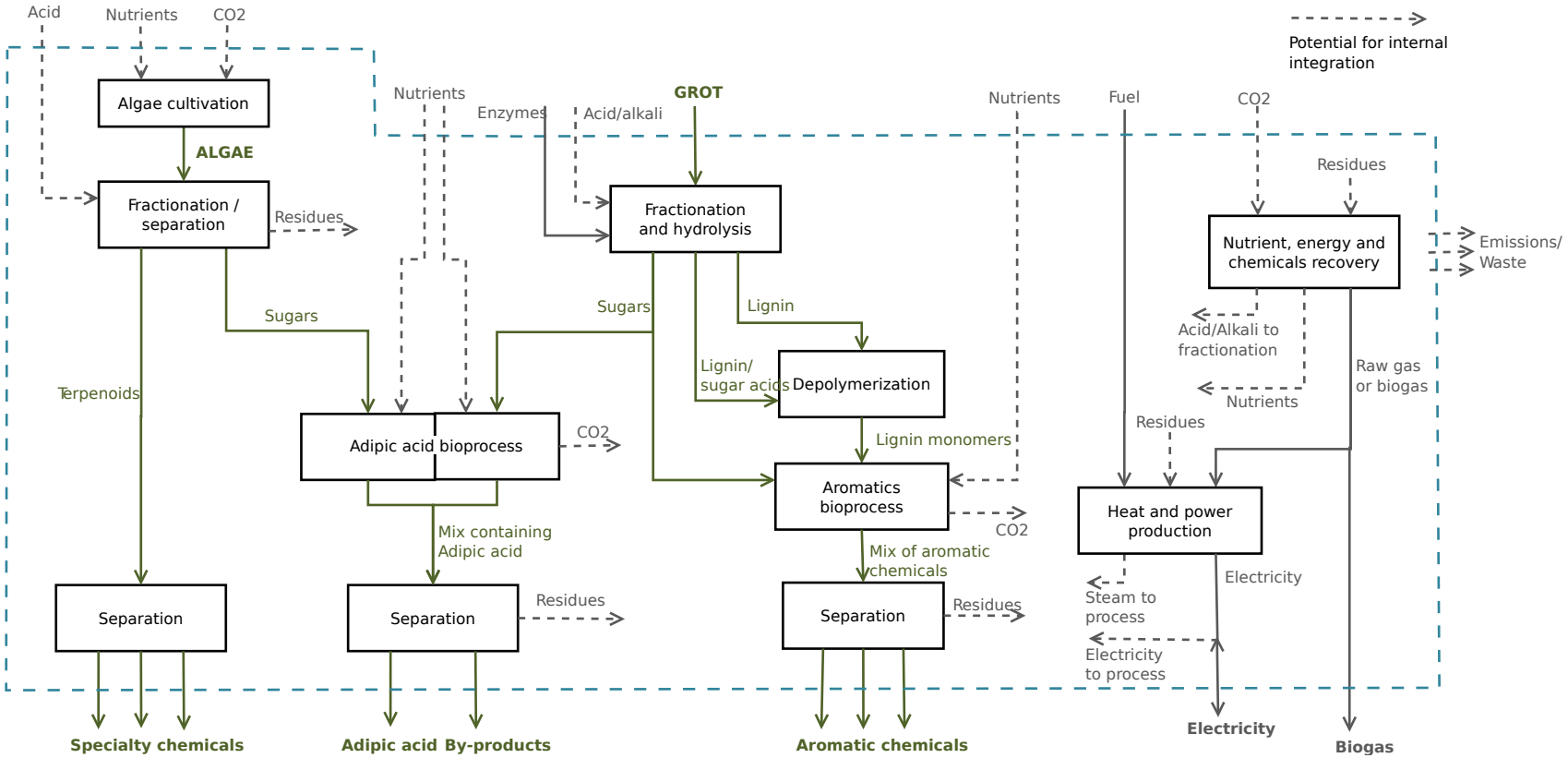
- Traditional production from fossil resources → KA oil[1]





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

Adipic acid production in a novel biorefinery concept



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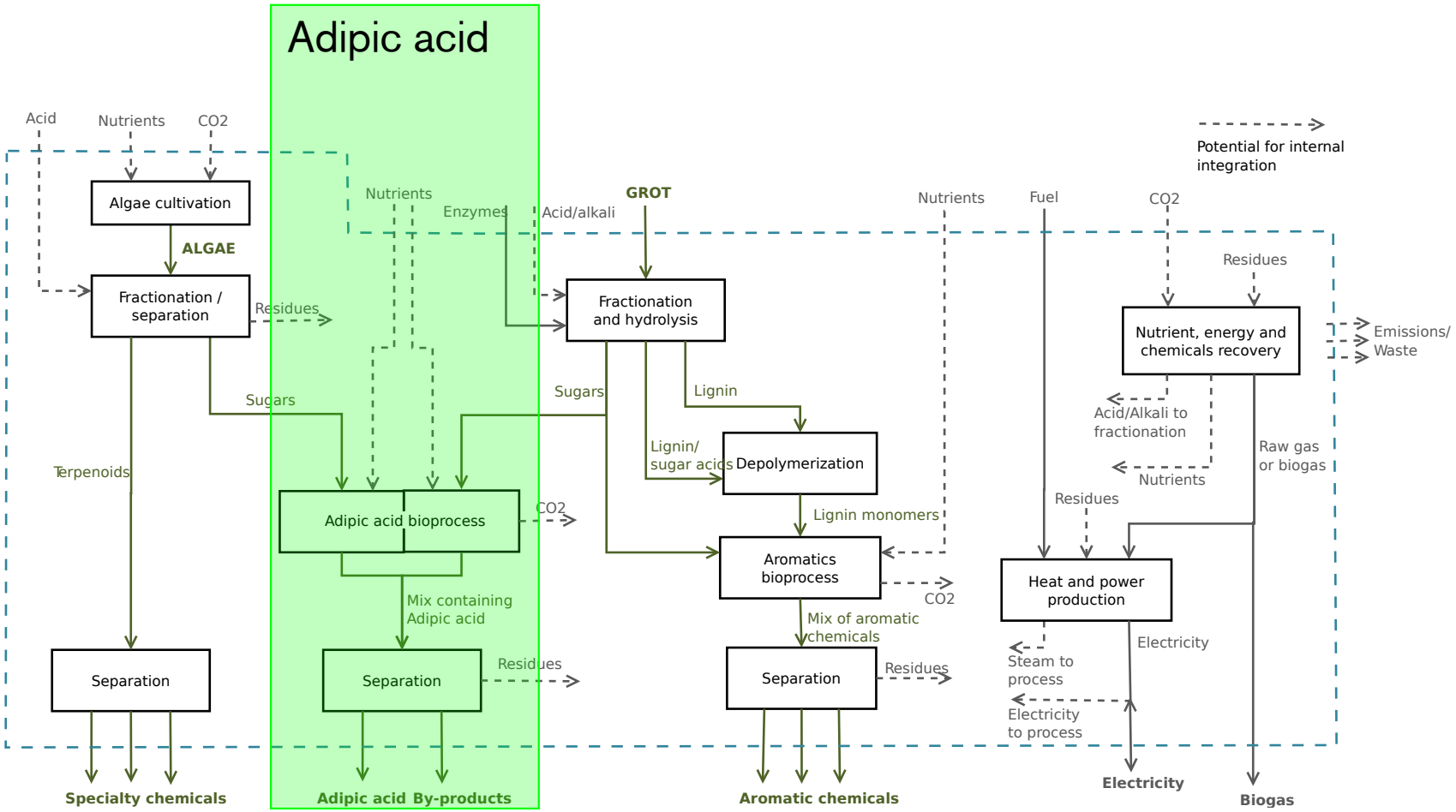

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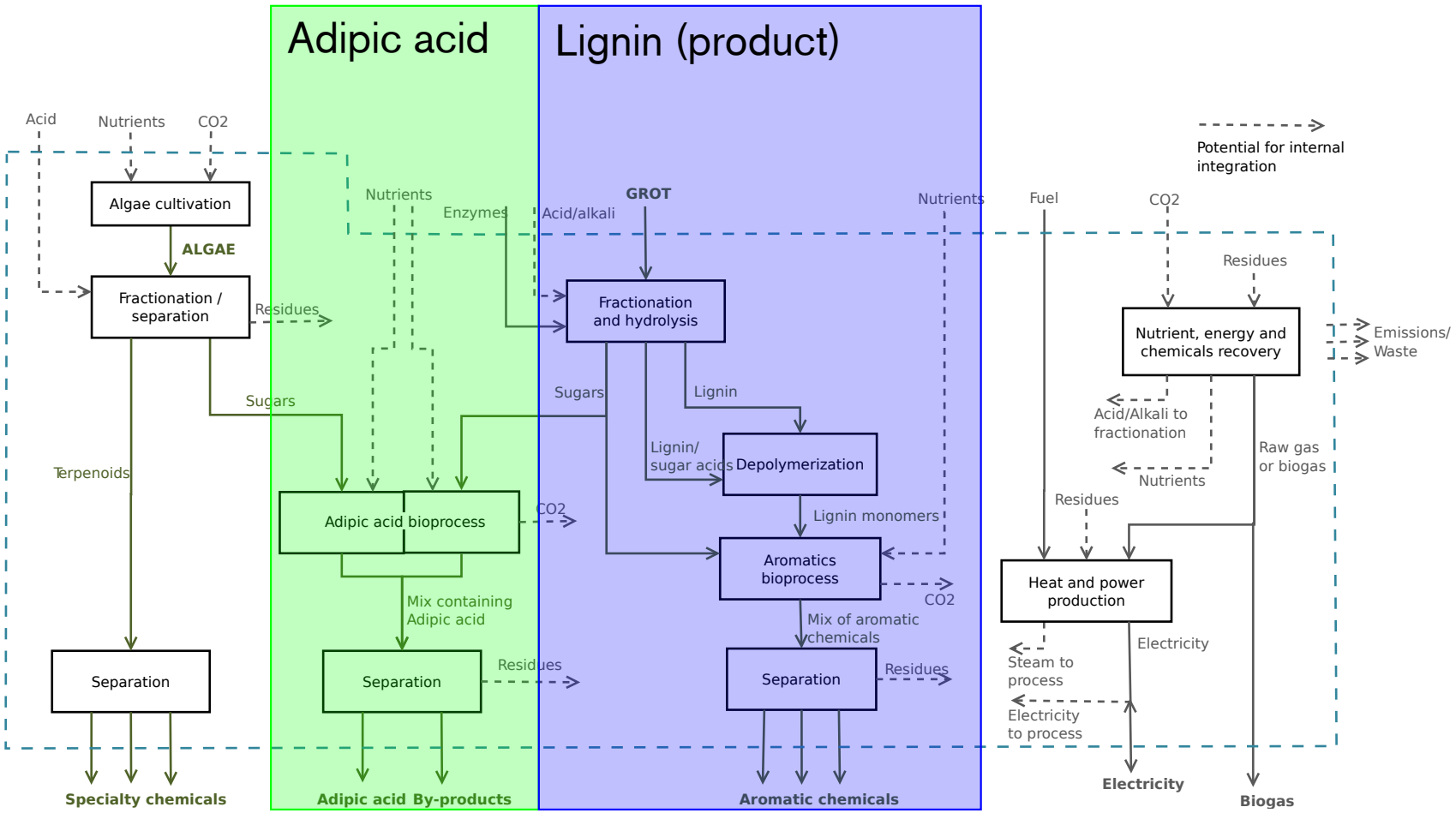

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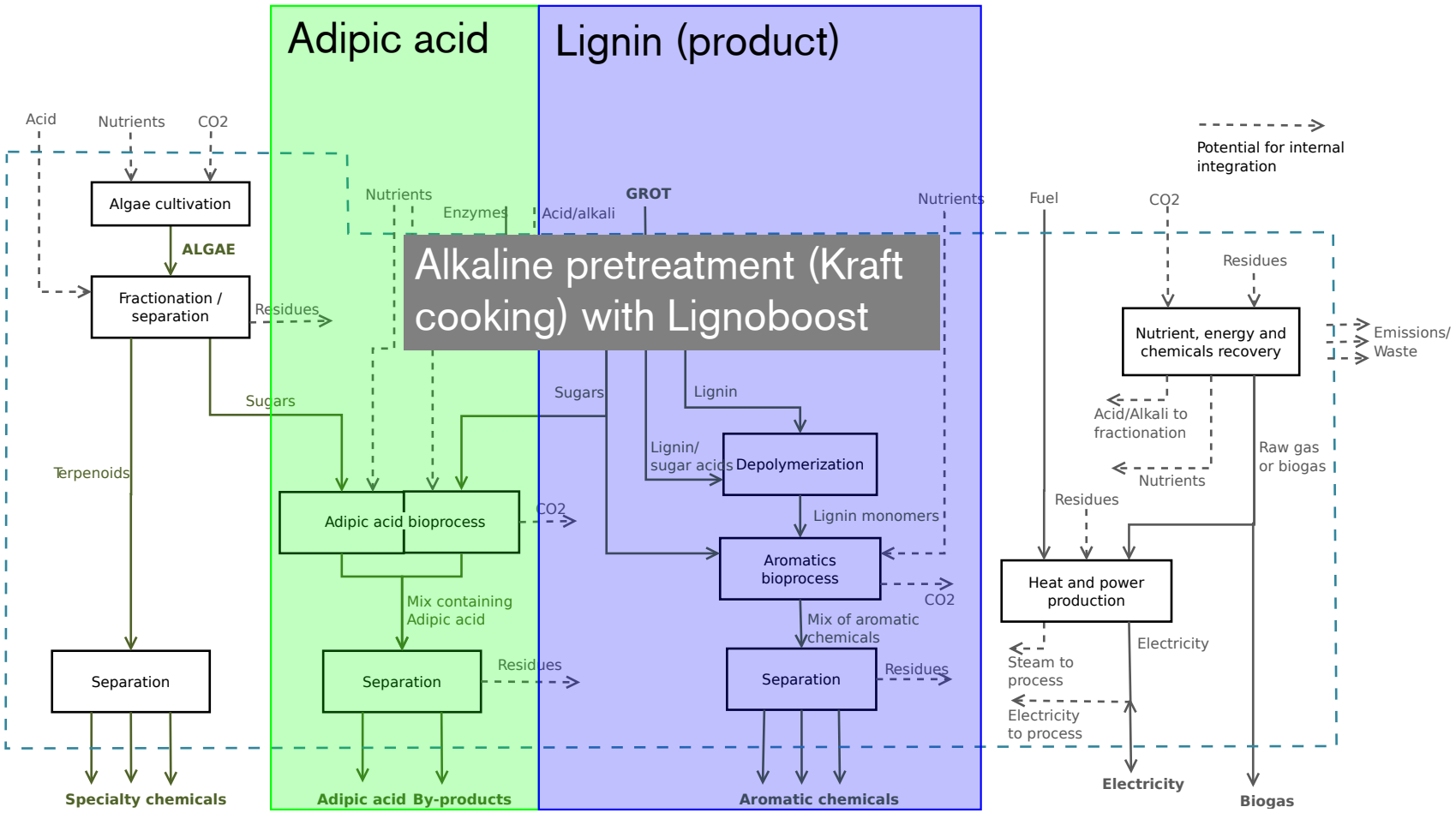

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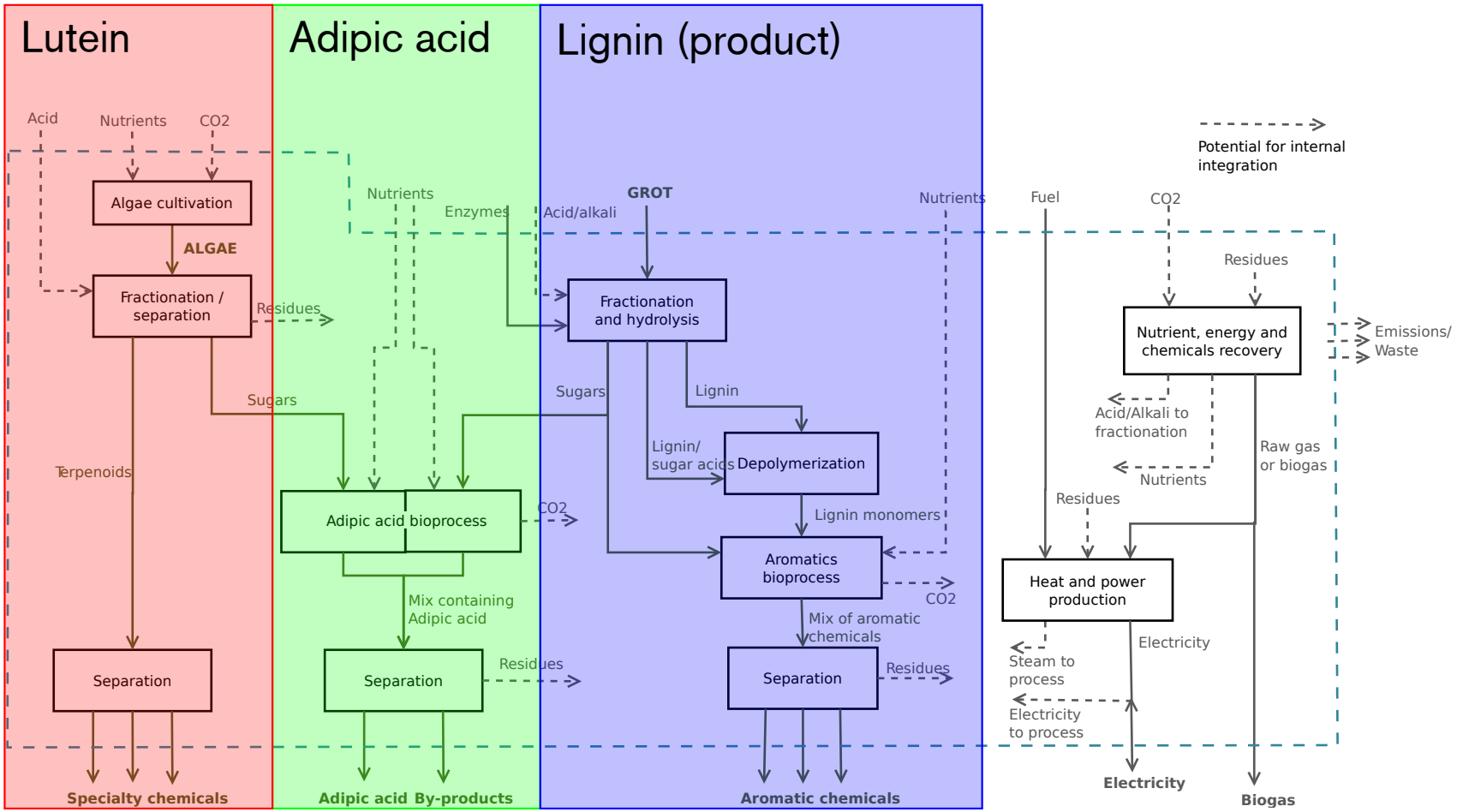

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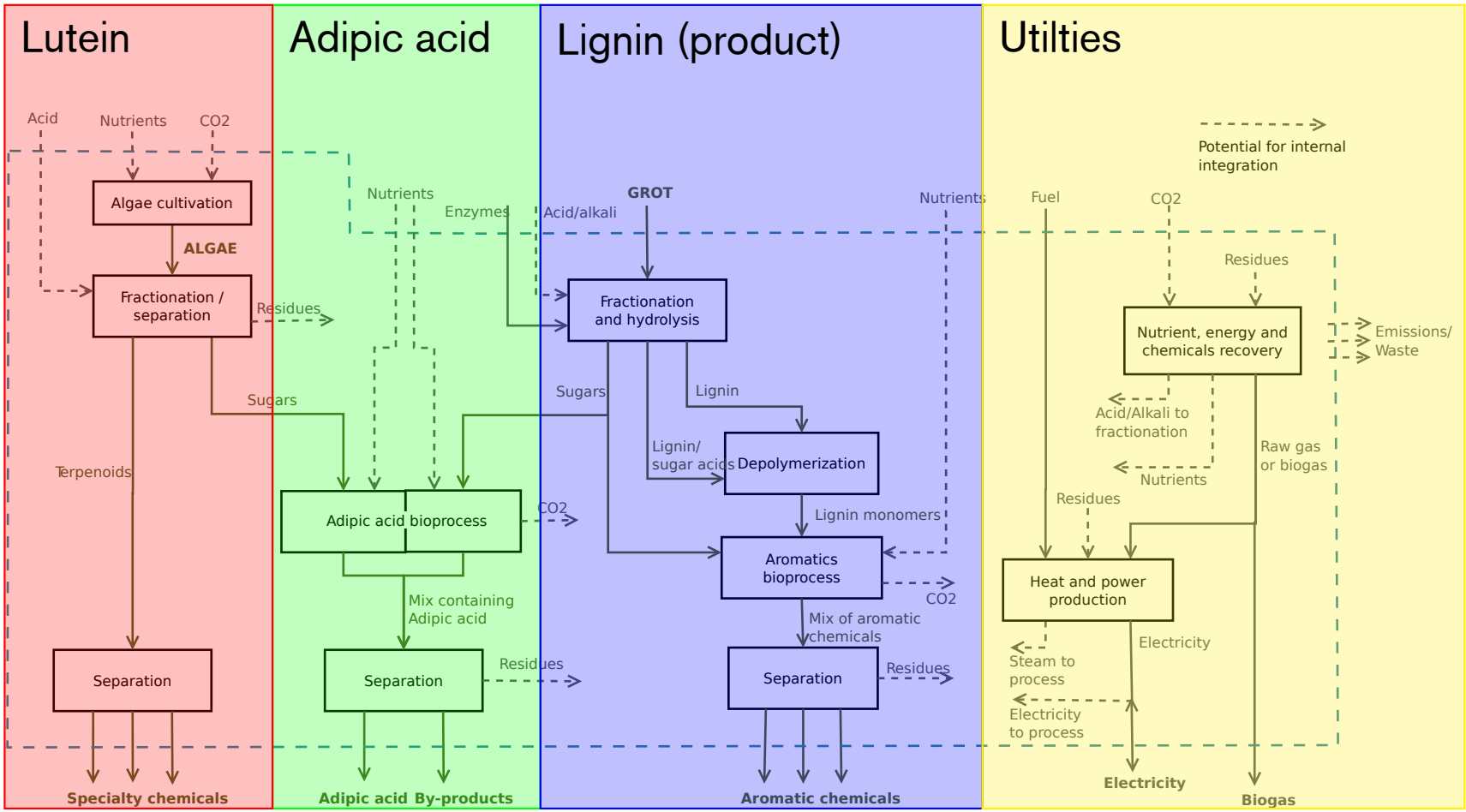

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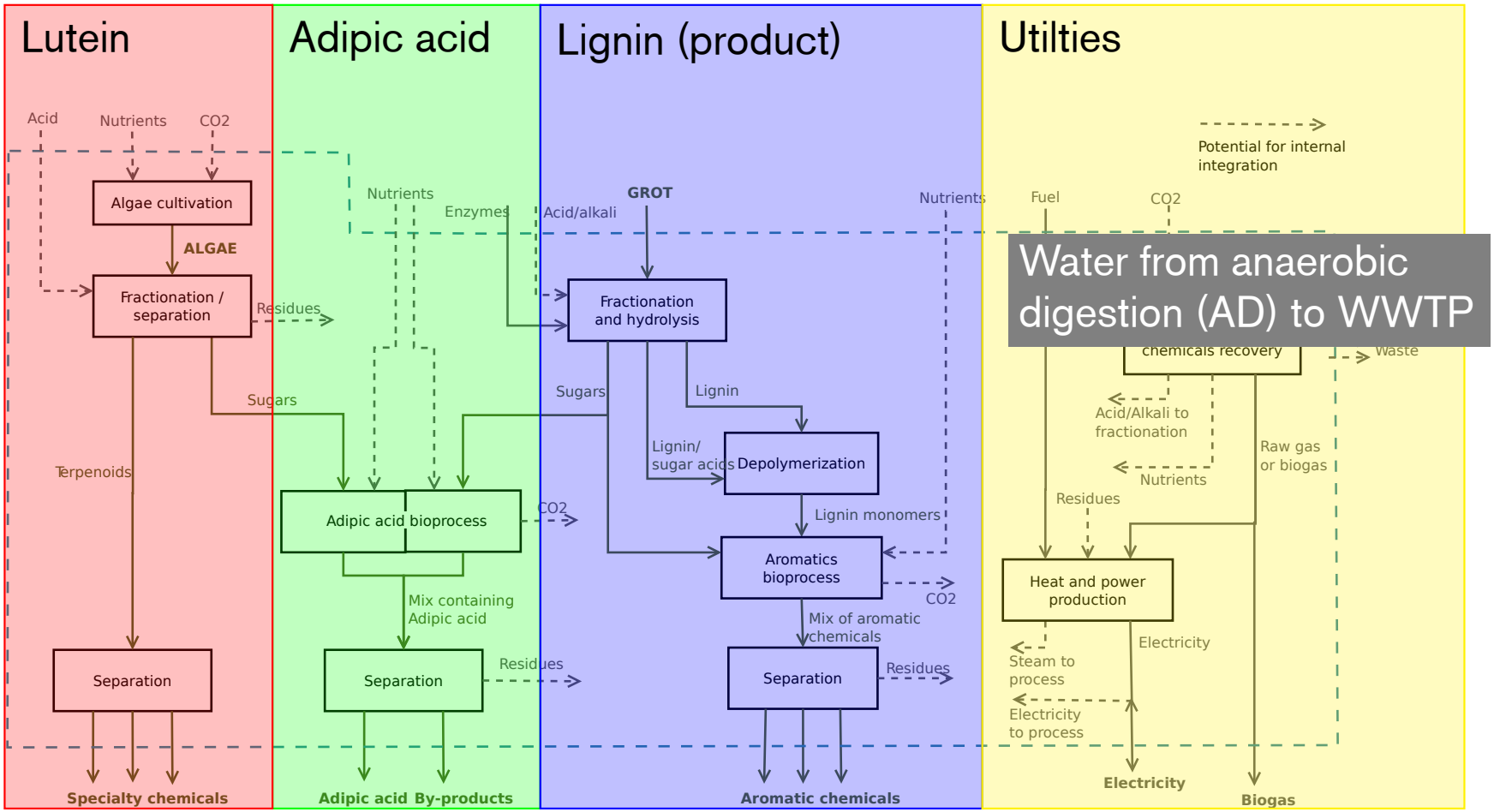

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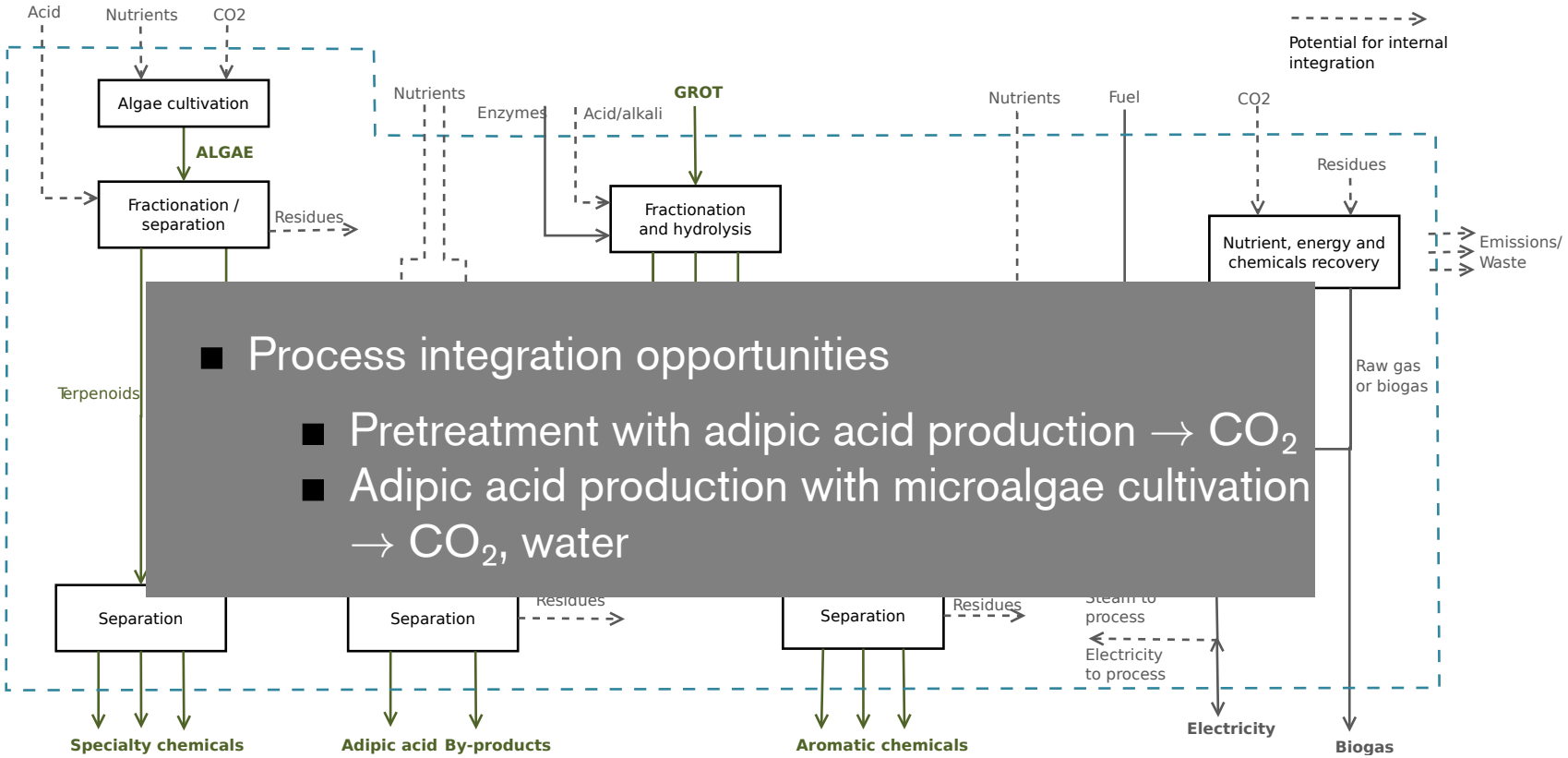

- Process integration opportunities
  - Pretreatment with adipic acid production $\rightarrow CO_2$
  - Adipic acid production with microalgae cultivation $\rightarrow CO_2$, water

Applying prospective life cycle assessment

- Appropriate methodological choices need to be made[2]
  - Technology alternatives
  - Foreground system
  - Background system

[2] R. Arvidsson et al. *J Ind Ecol* 22 (2018), pp. 1286–1294.

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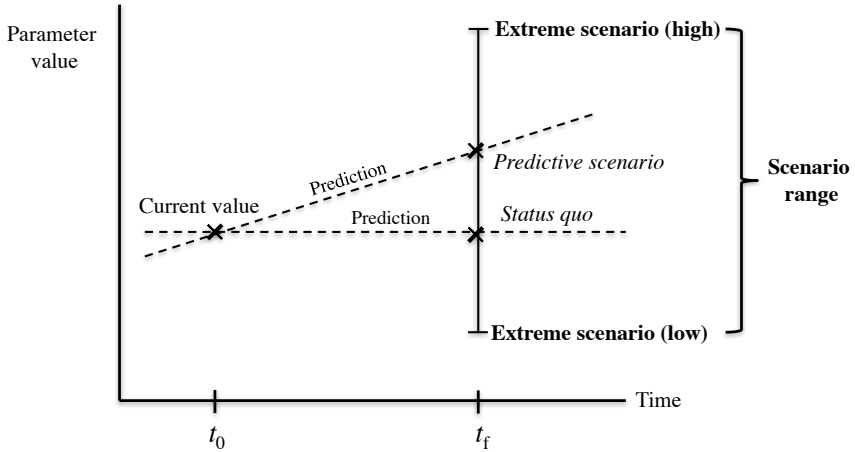

- Predictive scenarios → Based on forecasts or trends
- Scenario ranges → Illustrate potential environmental impact

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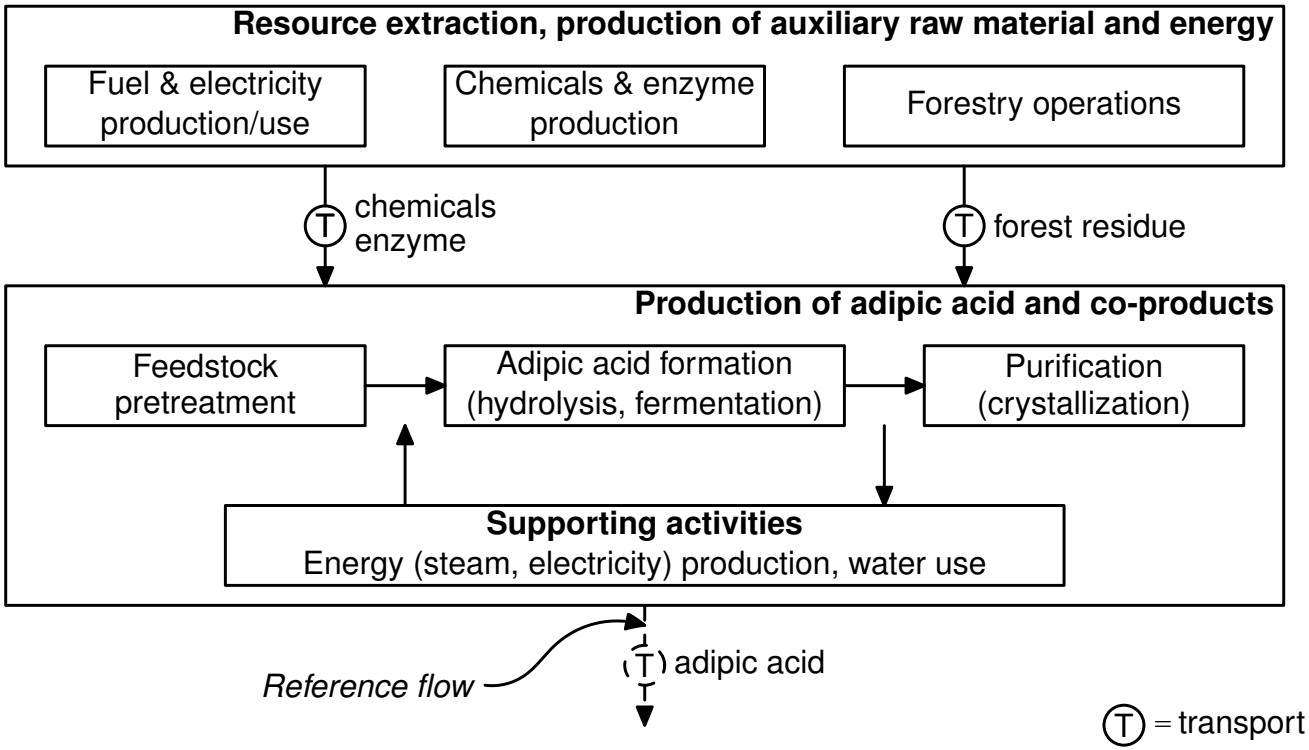
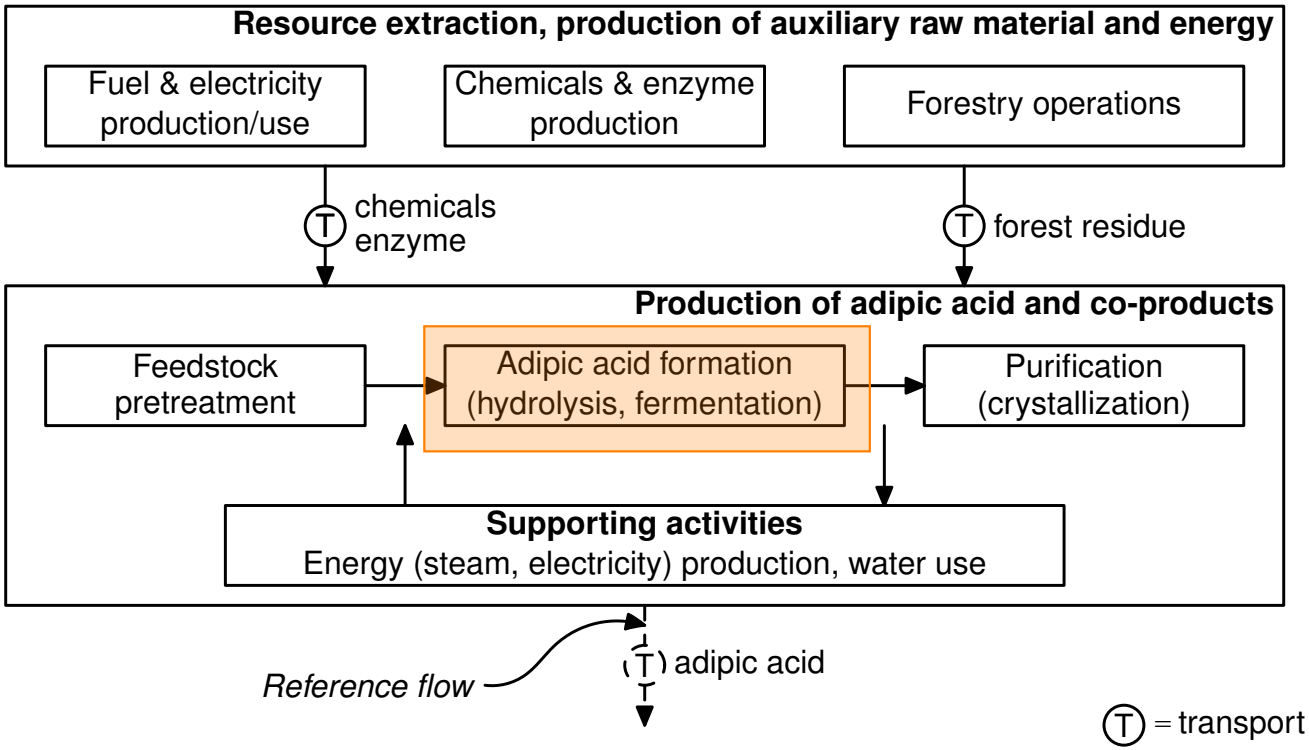
Life cycle assessment



- 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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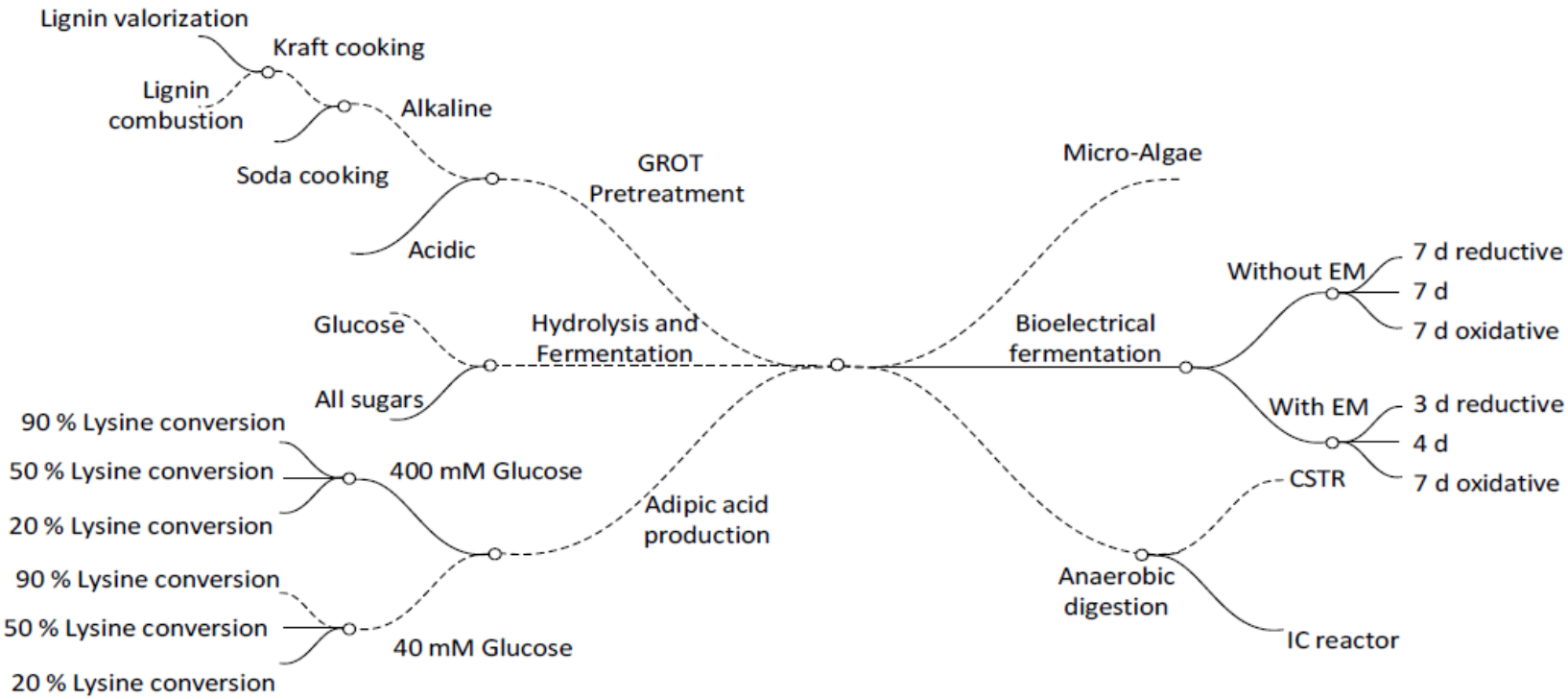
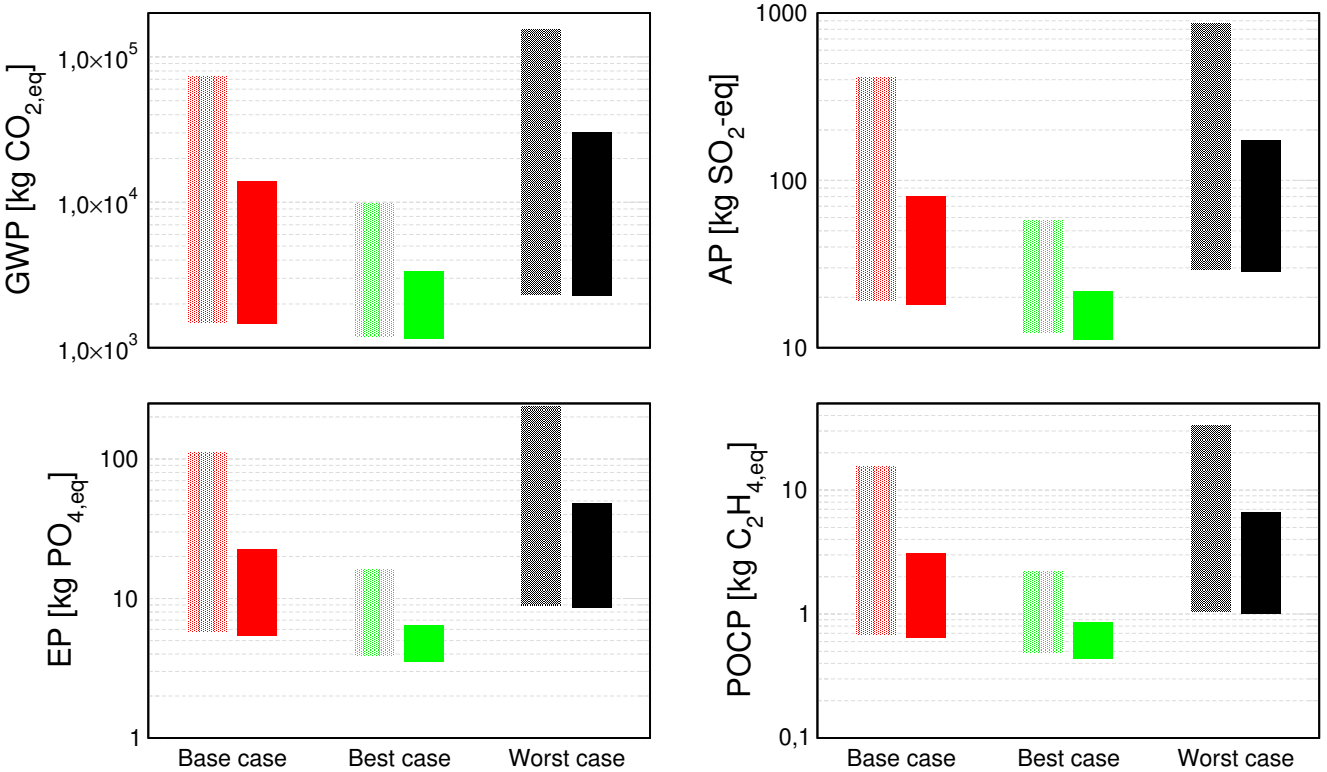
Construction of process alternatives



- 24 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
  - Anaerobic digestion → conventional AD, IC reactor

Ranges of environmental impacts



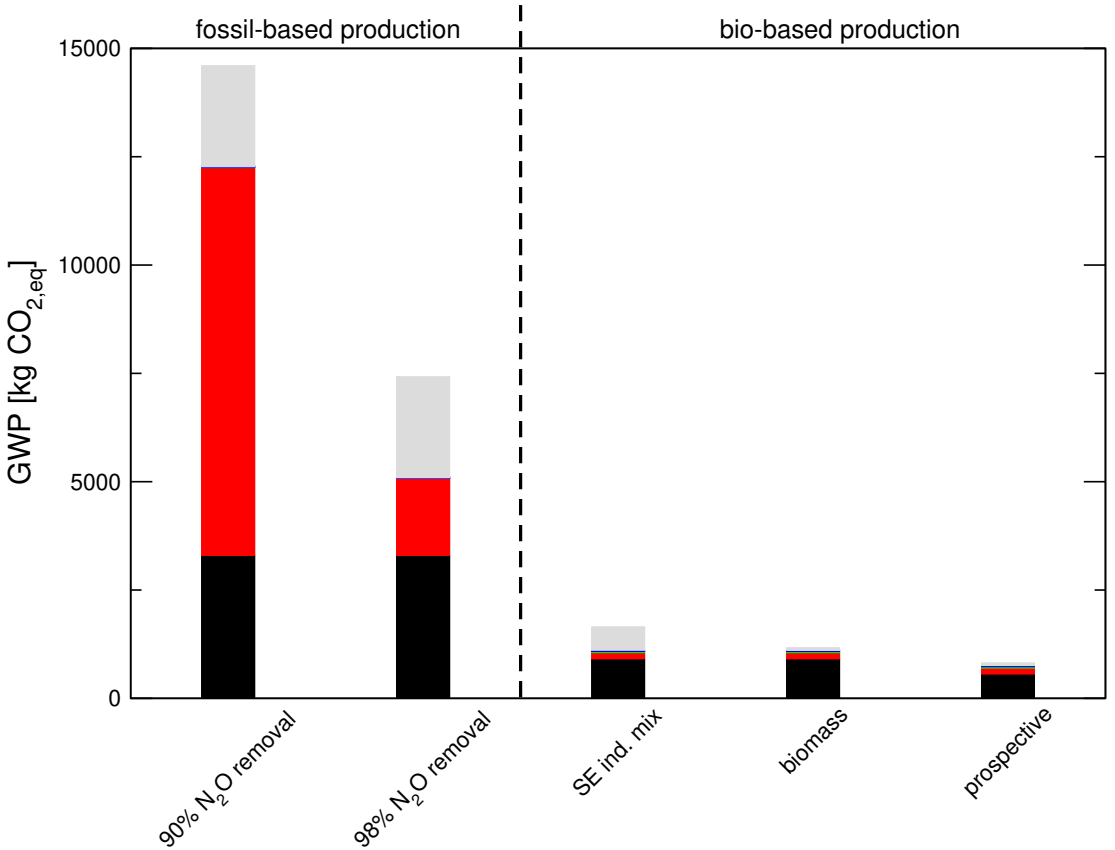
Semi-transparent bars:
Conventional AD

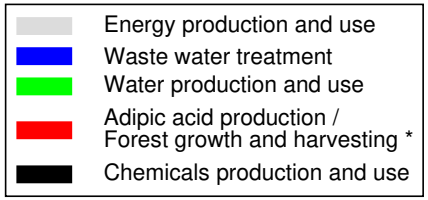
Solid bars:
Internal circulation AD

- Variation due to
  - Heating and cooling demand of the alternative
  - Foreground energy system
  - Design of the AD

Improvements in climate impact

From fossil-based to bio-based production (best case, minimum heat demand, IC AD)





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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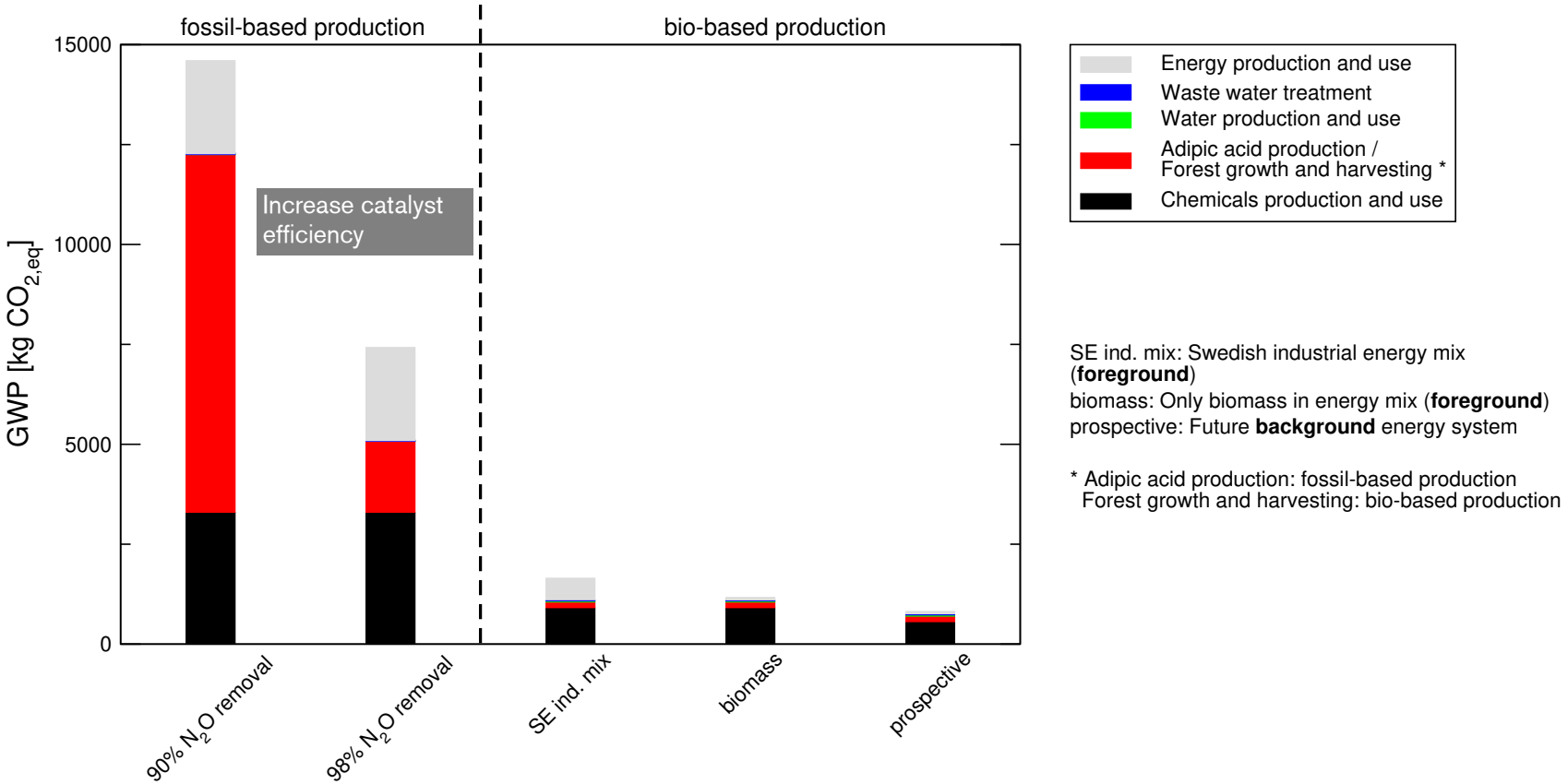

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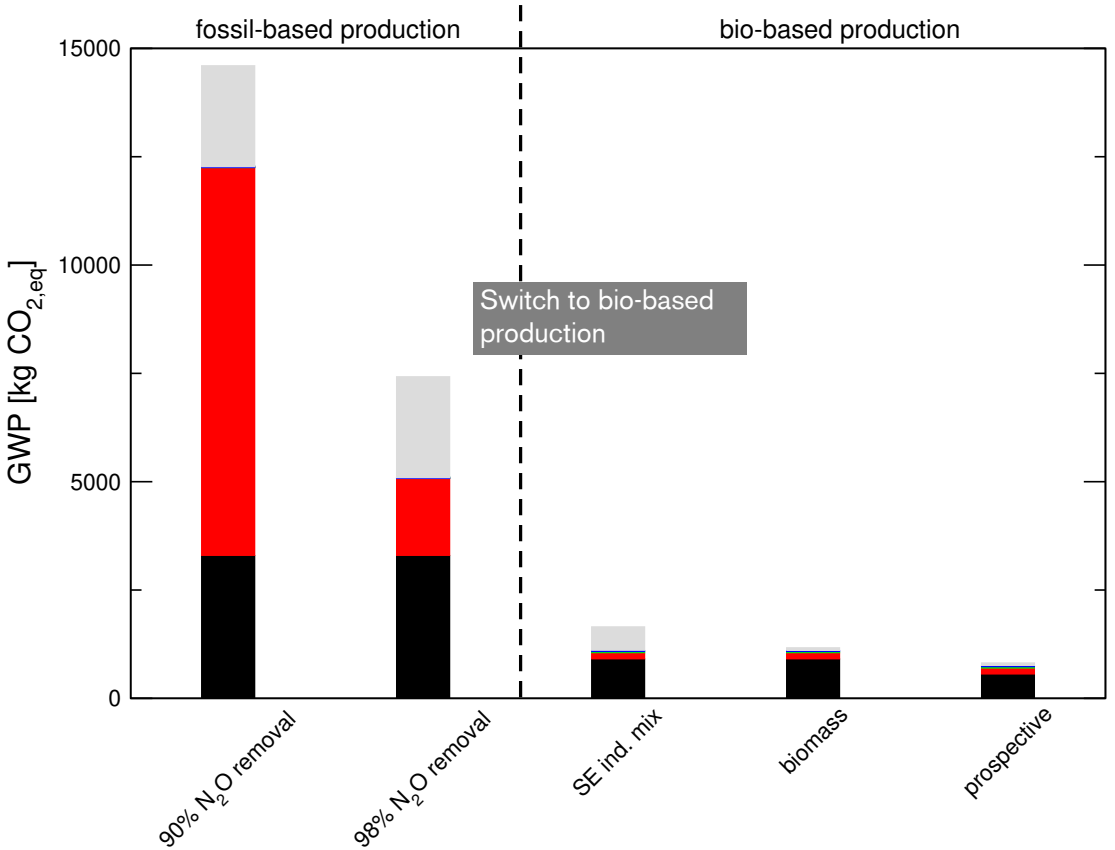

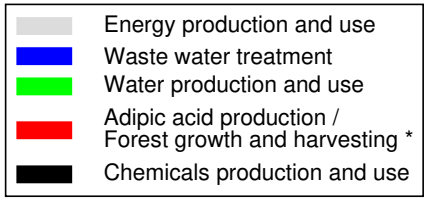

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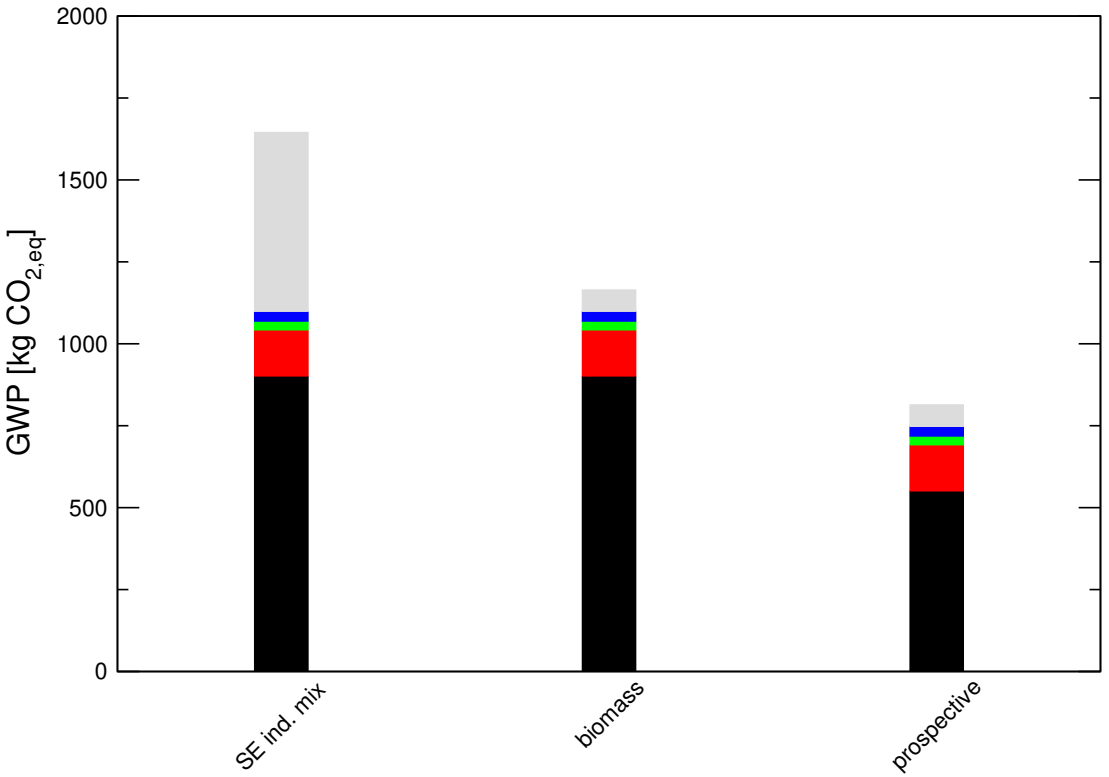

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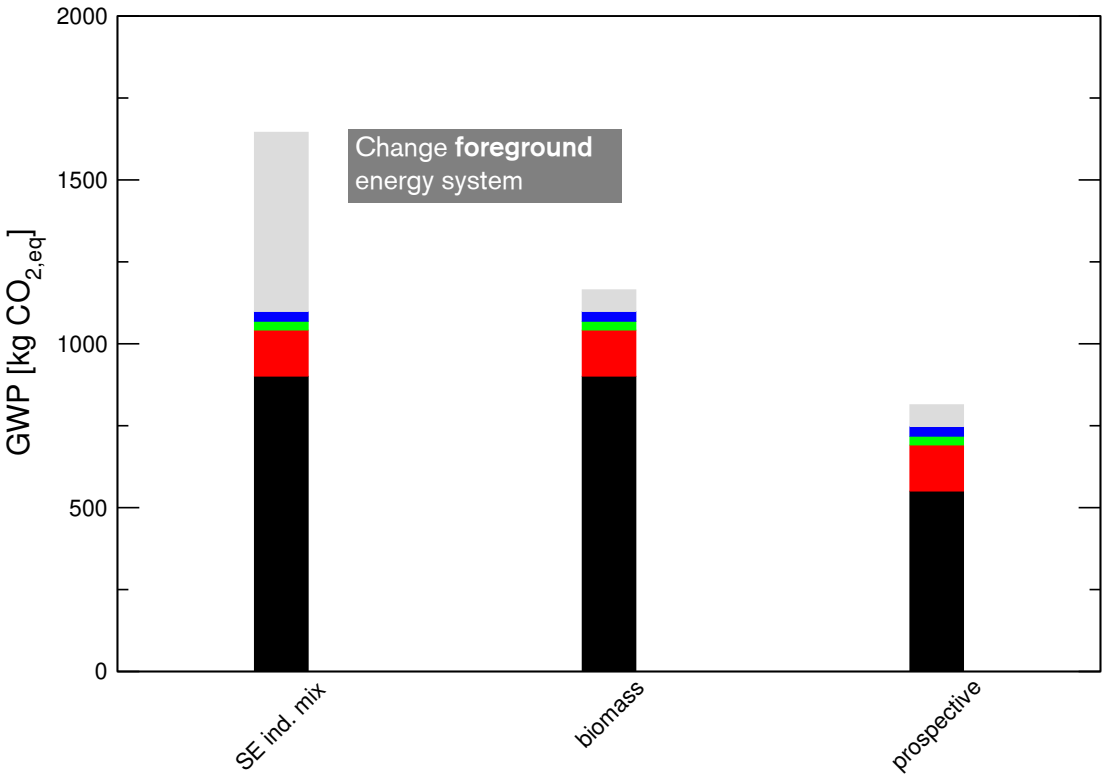

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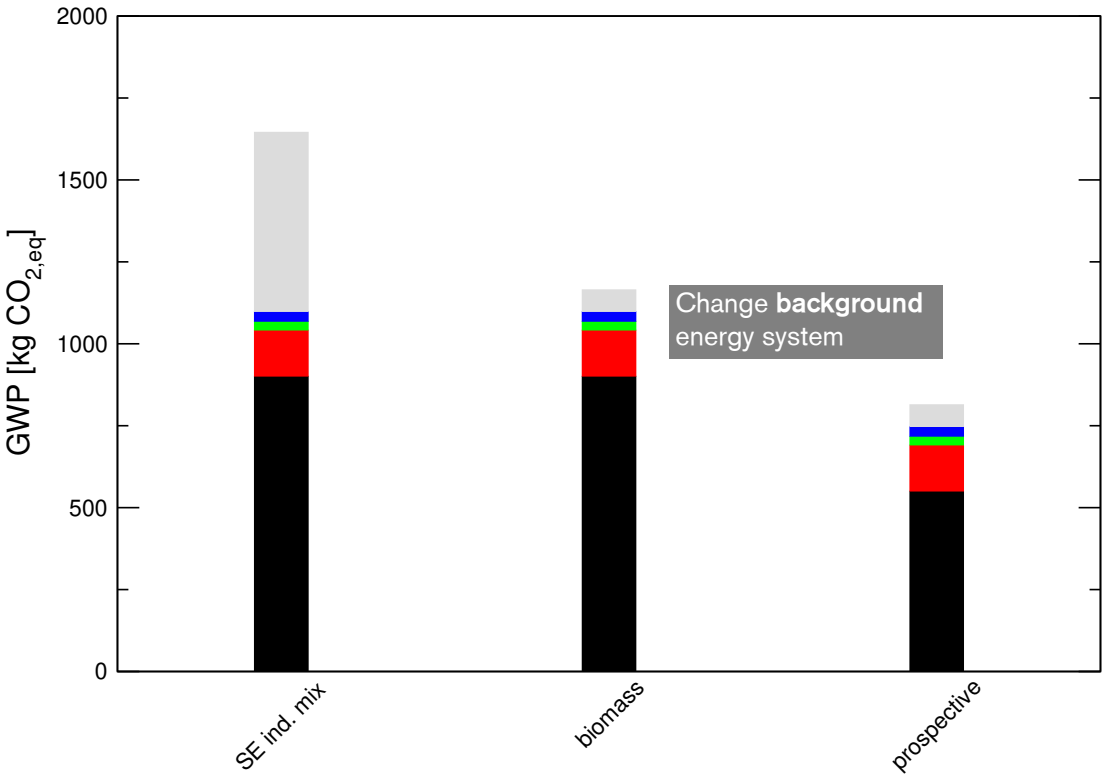

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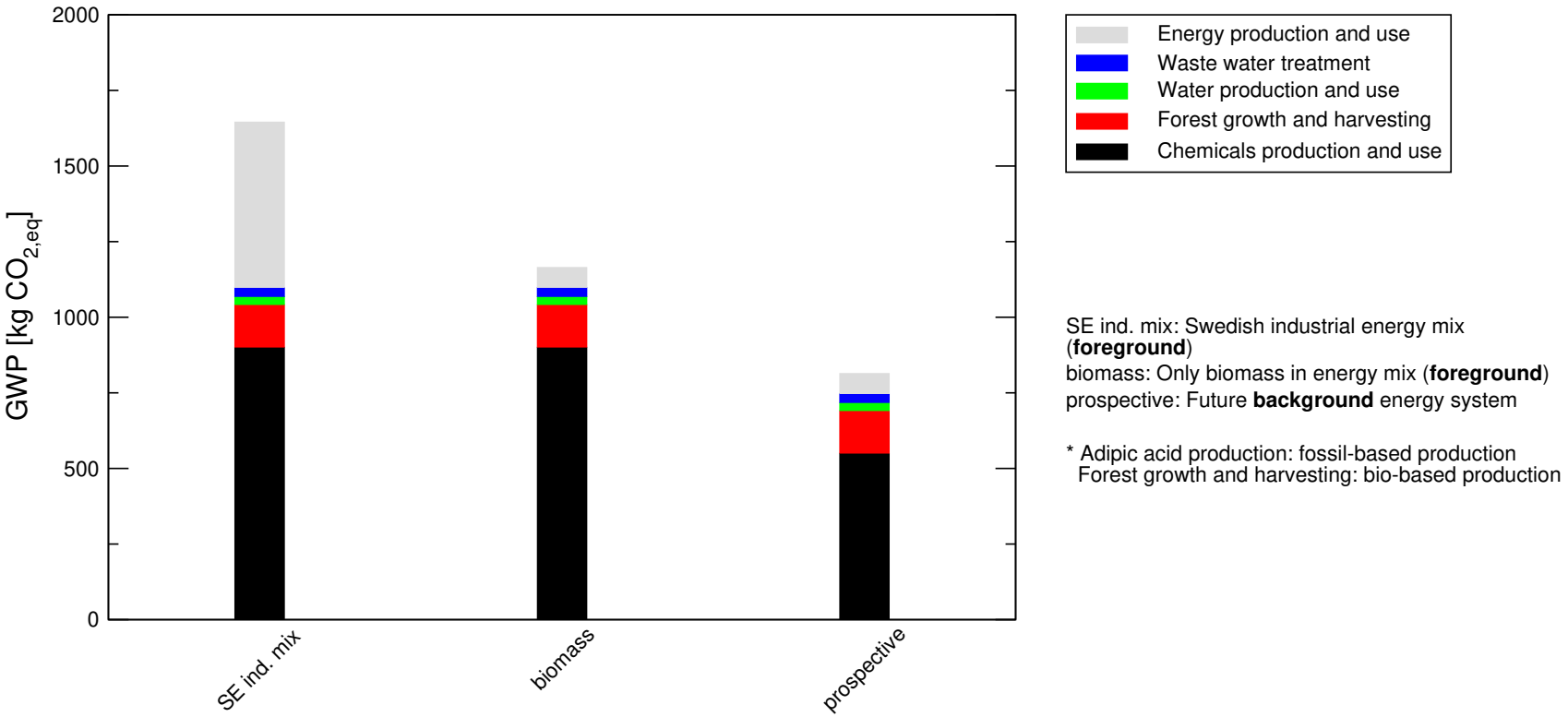

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- Further improvements are possible
- Change in background energy system mainly affects chemicals production

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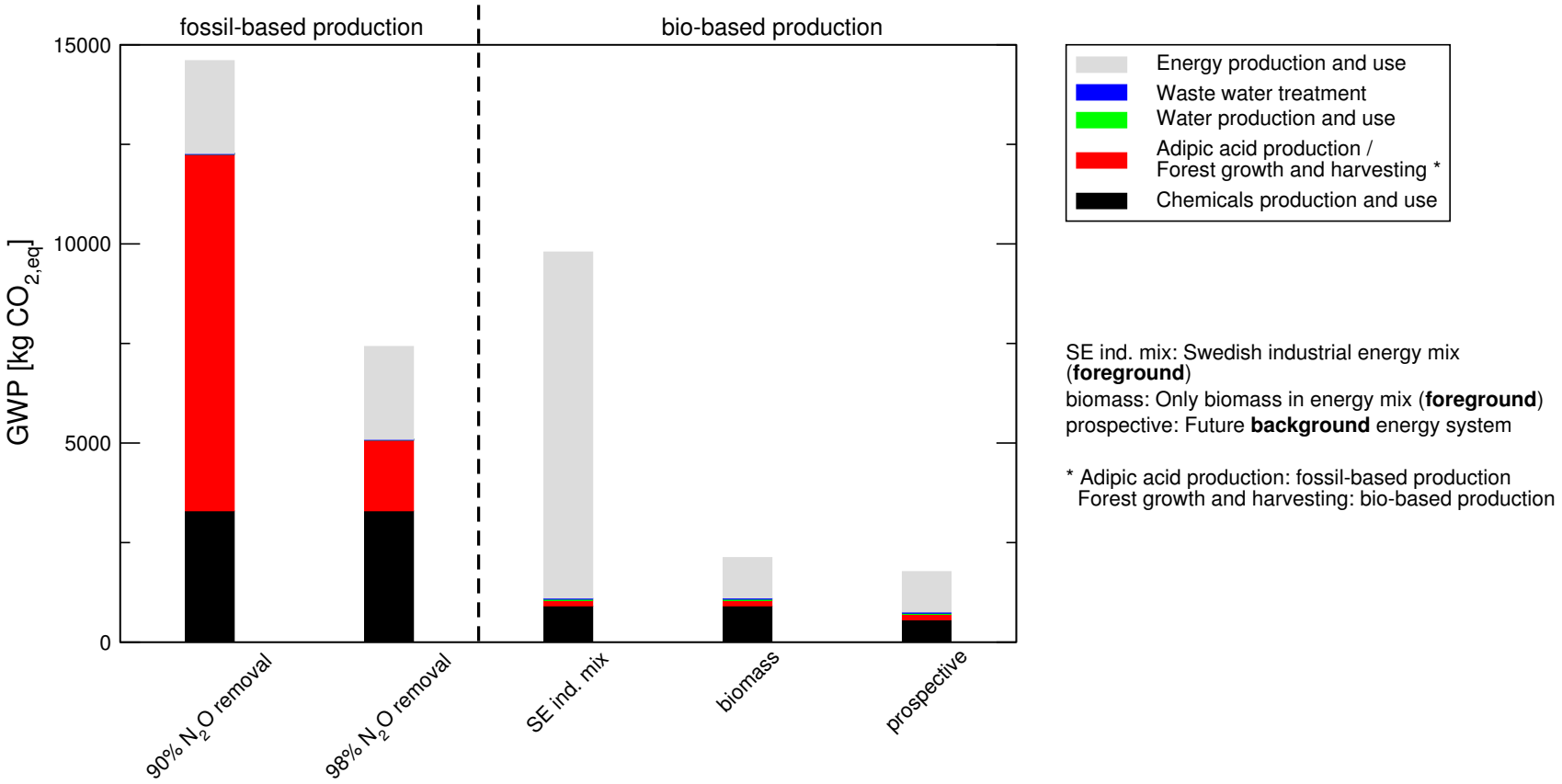
From fossil-based to bio-based production (best case, maximum heat demand, conventional AD)



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

Conclusion

- Technology
  - Switch to bio-based production of adipic acid can lower environmental impacts significantly
  - Clean foreground energy system and choice of technology is important
  - Future changes in the background energy system may improve chemicals production and use

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  - Switch to bio-based production of adipic acid can lower environmental impacts significantly
  - Clean foreground energy system and choice of technology is important
  - Future changes in the background energy system may improve chemicals production and use
- Methodology
  - Inventory data generated with detailed process simulation
  - Construction of process alternatives helps identify process and environmental risks
  - Changes in background energy system need to be facilitated

THANK YOU

Any questions?