Guiding technology development using LCA

The case of bio-based adipic acid production

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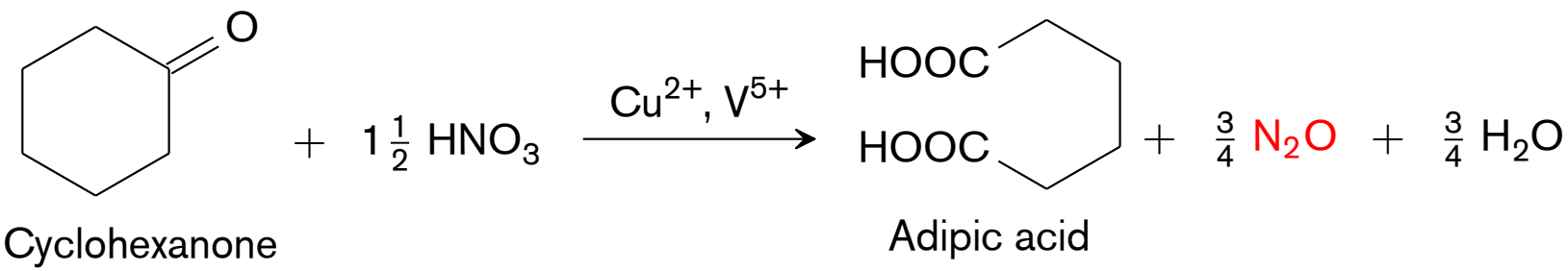
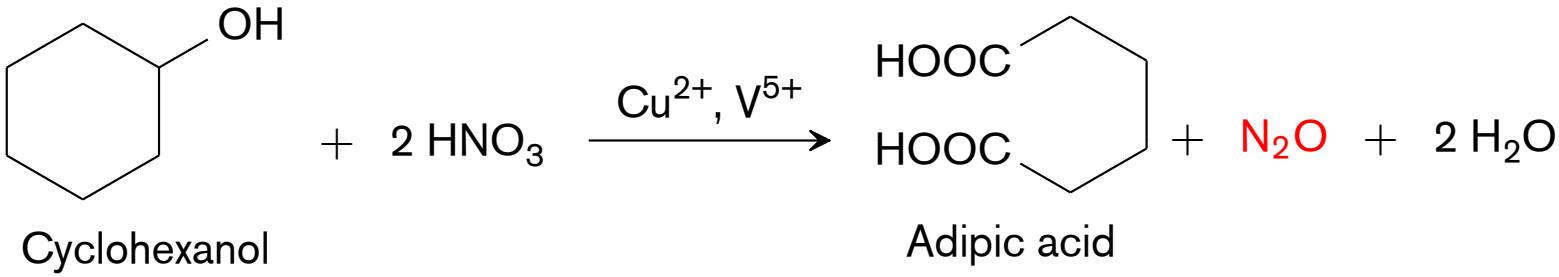
Outline

Adipic acid

- Main application → Production of nylon-6,6
- Traditional production from fossil resources → KA oil[1]

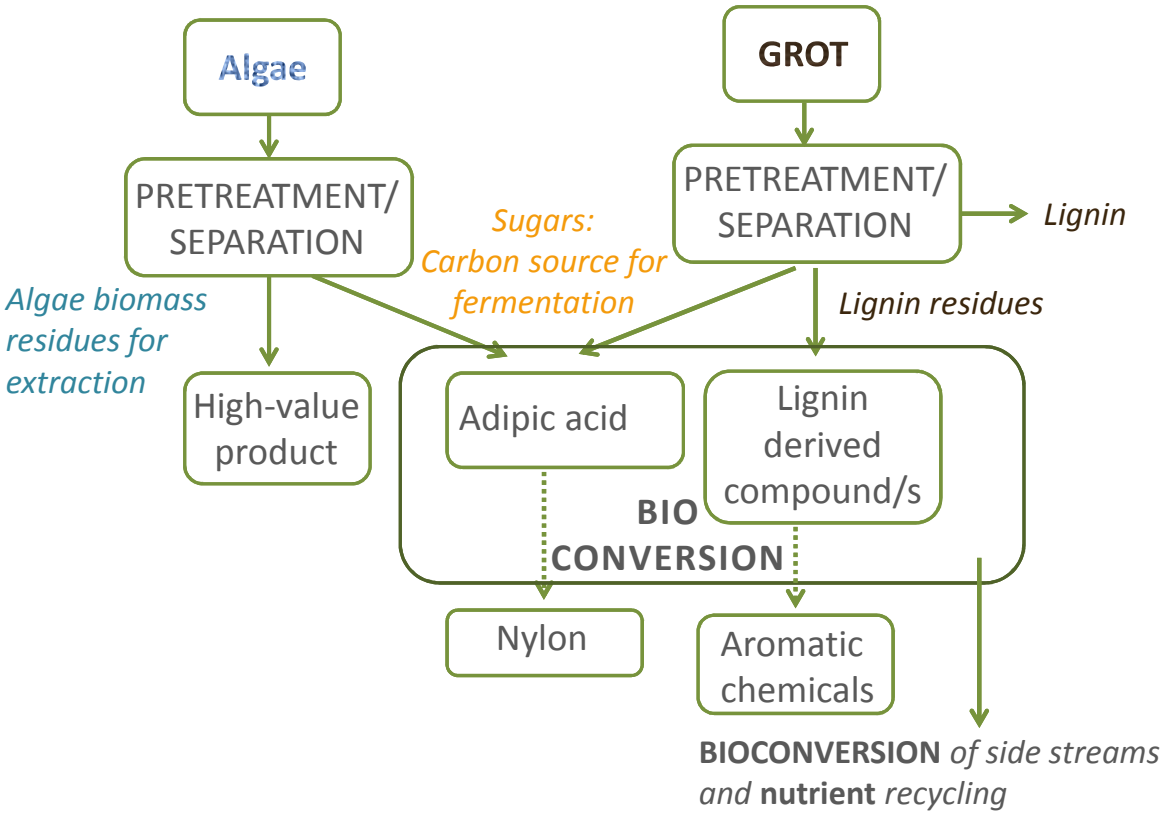




[1] A. Shimizu, K. Tanaka, and M. Fujimori. *Chemosphere - Global Change Science* 2.3-4 (2000), pp. 425–434.

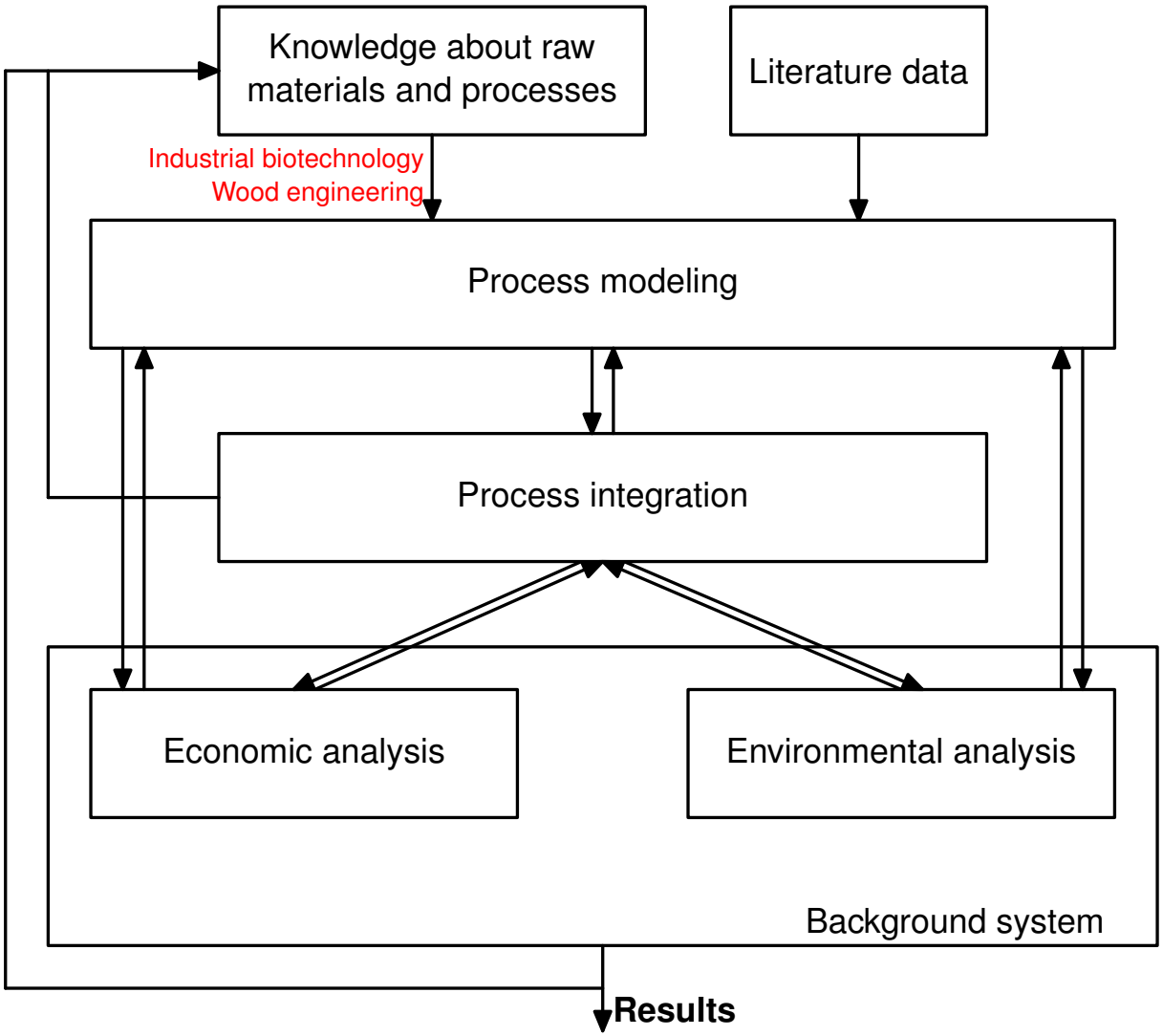
BioBuF research project

- Biorefinery concept for the production of bulk and fine chemicals



- Bulk chemical → Adipic acid, lignin-derivative, e.g. terephthalic acid
- Fine chemical → Lutein

Information flow in the project



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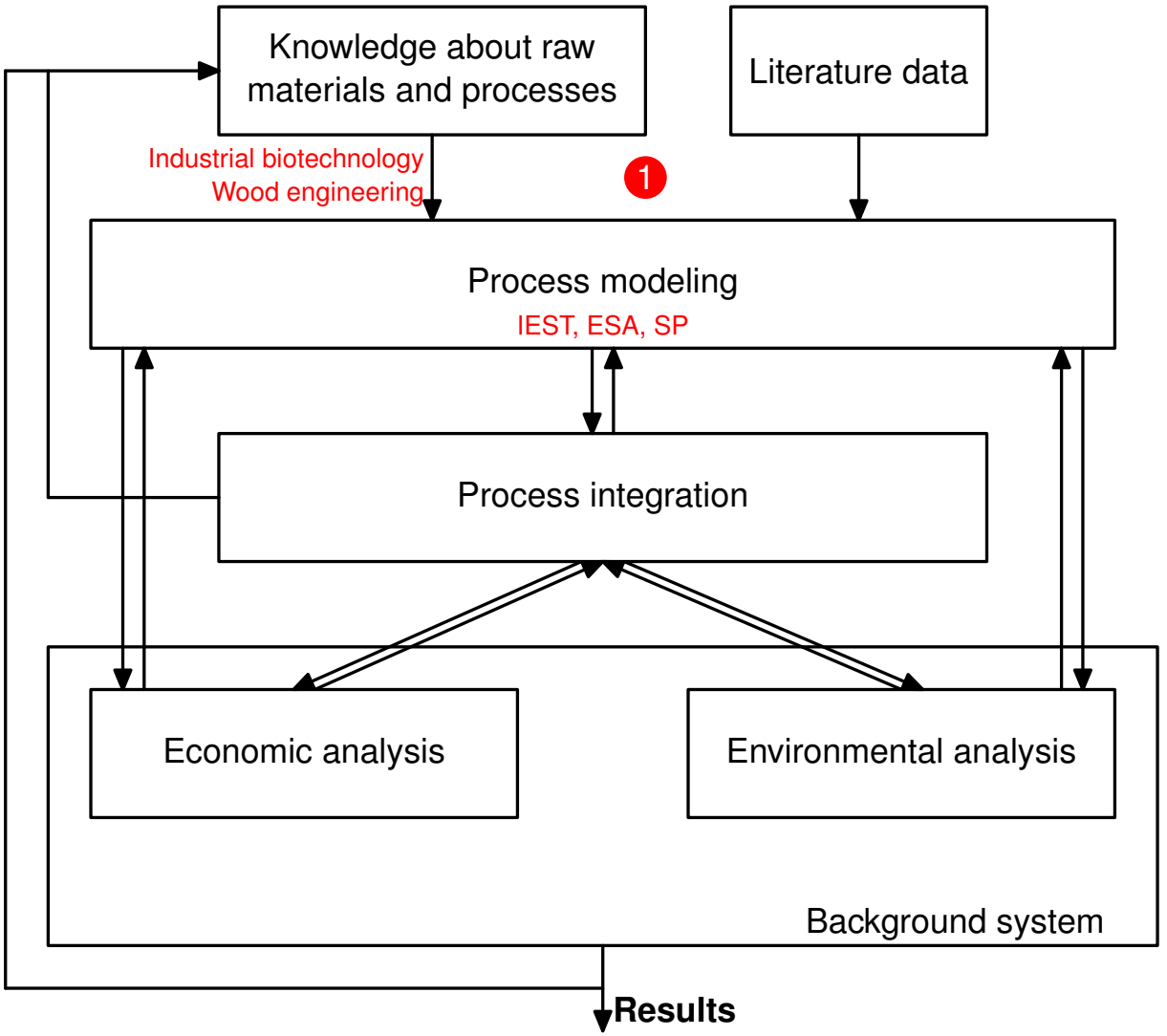
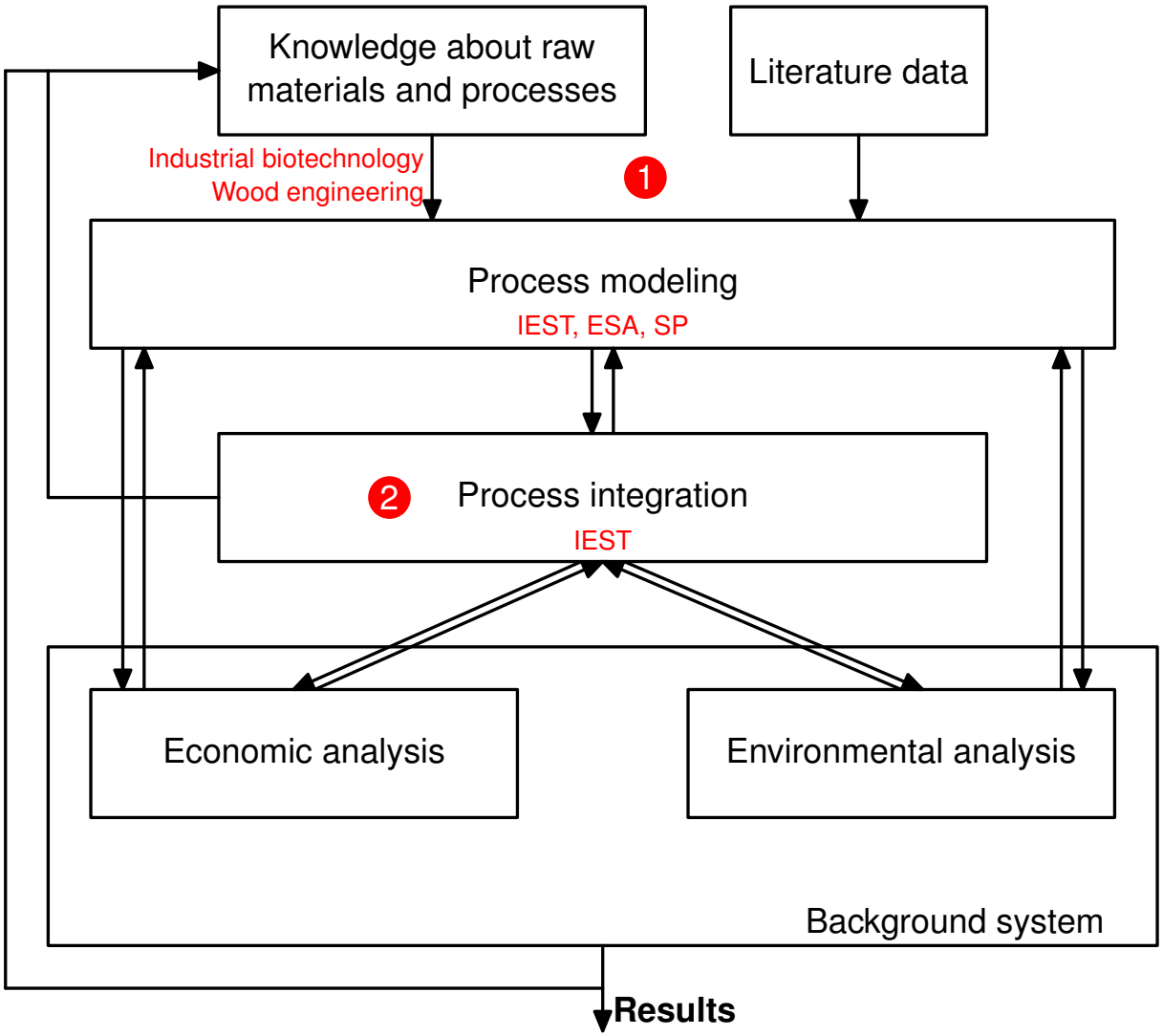


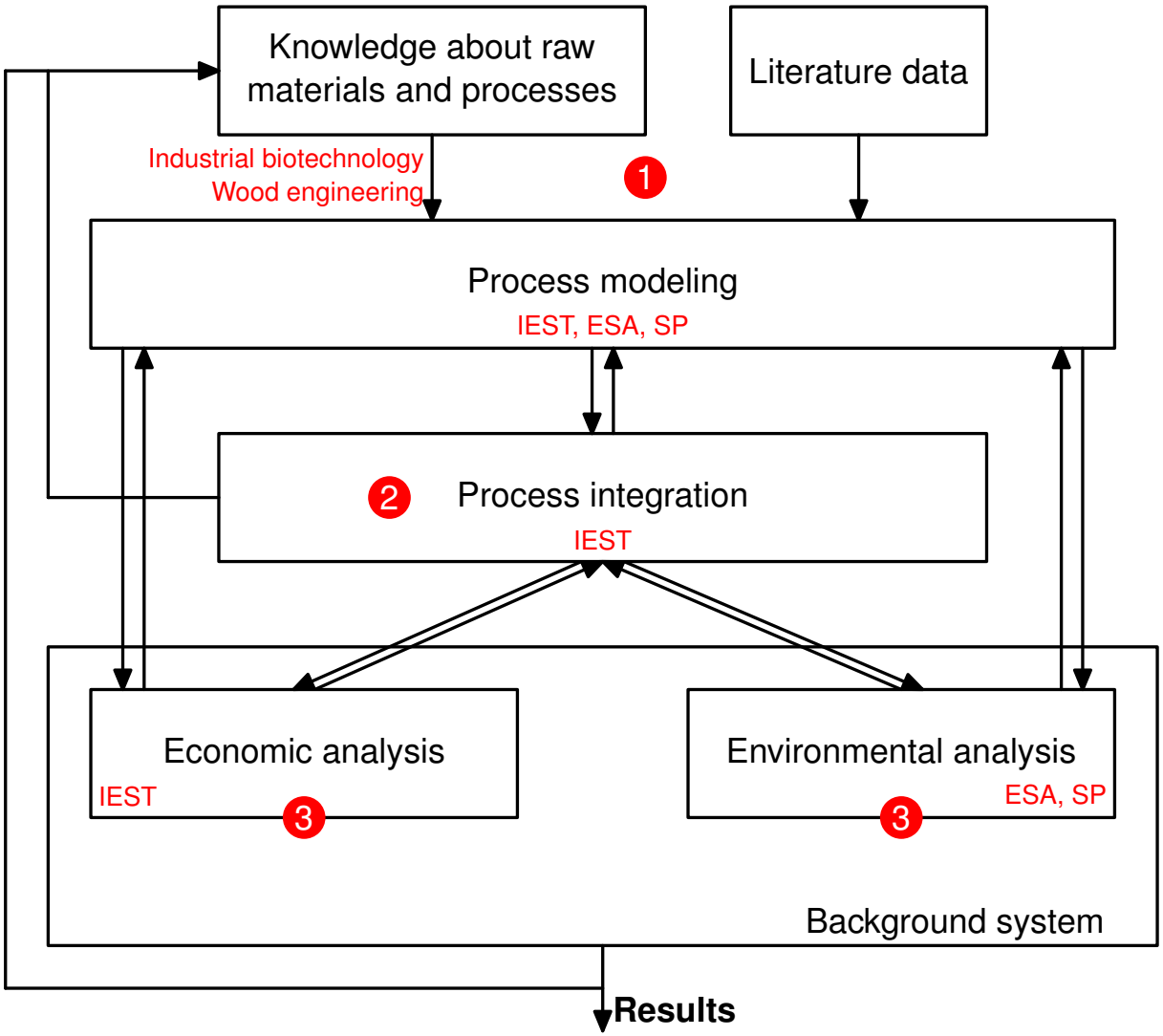
1 Modelling based on experimental, lab-scale data

Information flow in the project



1. Modelling based on experimental, lab-scale data
2. Process integration

Information flow in the project



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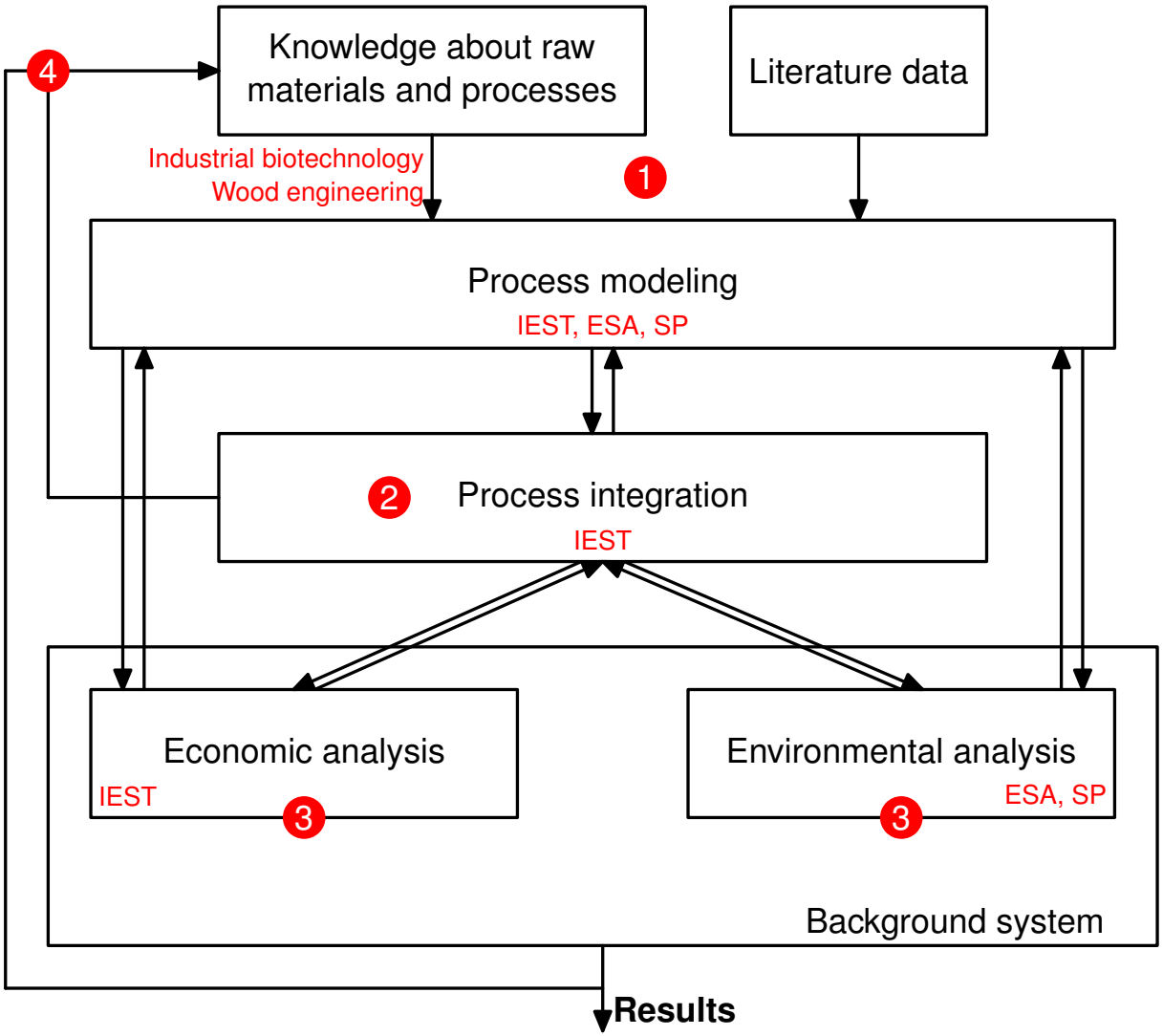
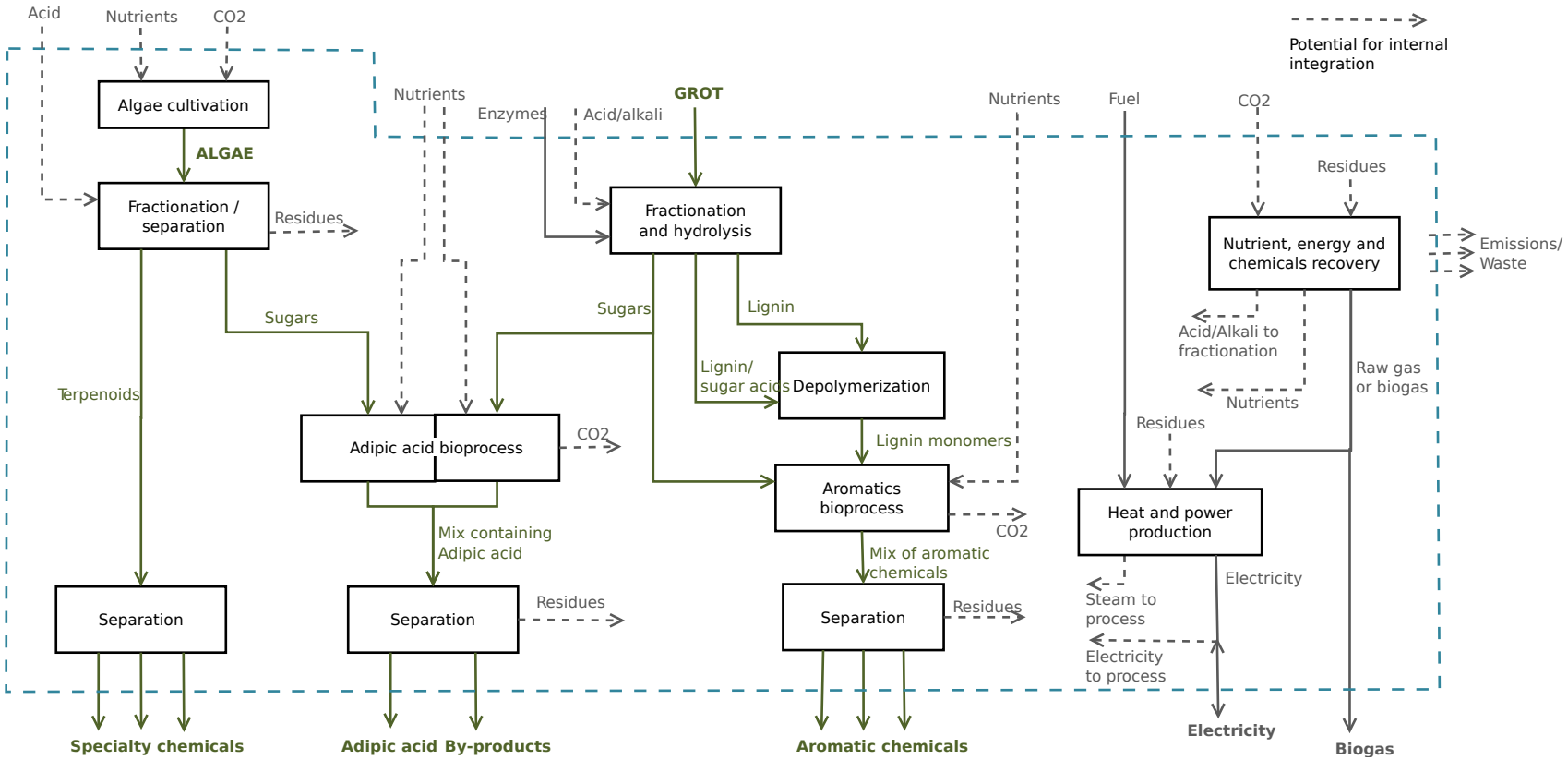


1. Modelling based on experimental, lab-scale data
2. Process integration
3. Economic and environmental analysis
4. Feedback to development

Process flow diagram of the biorefinery concept



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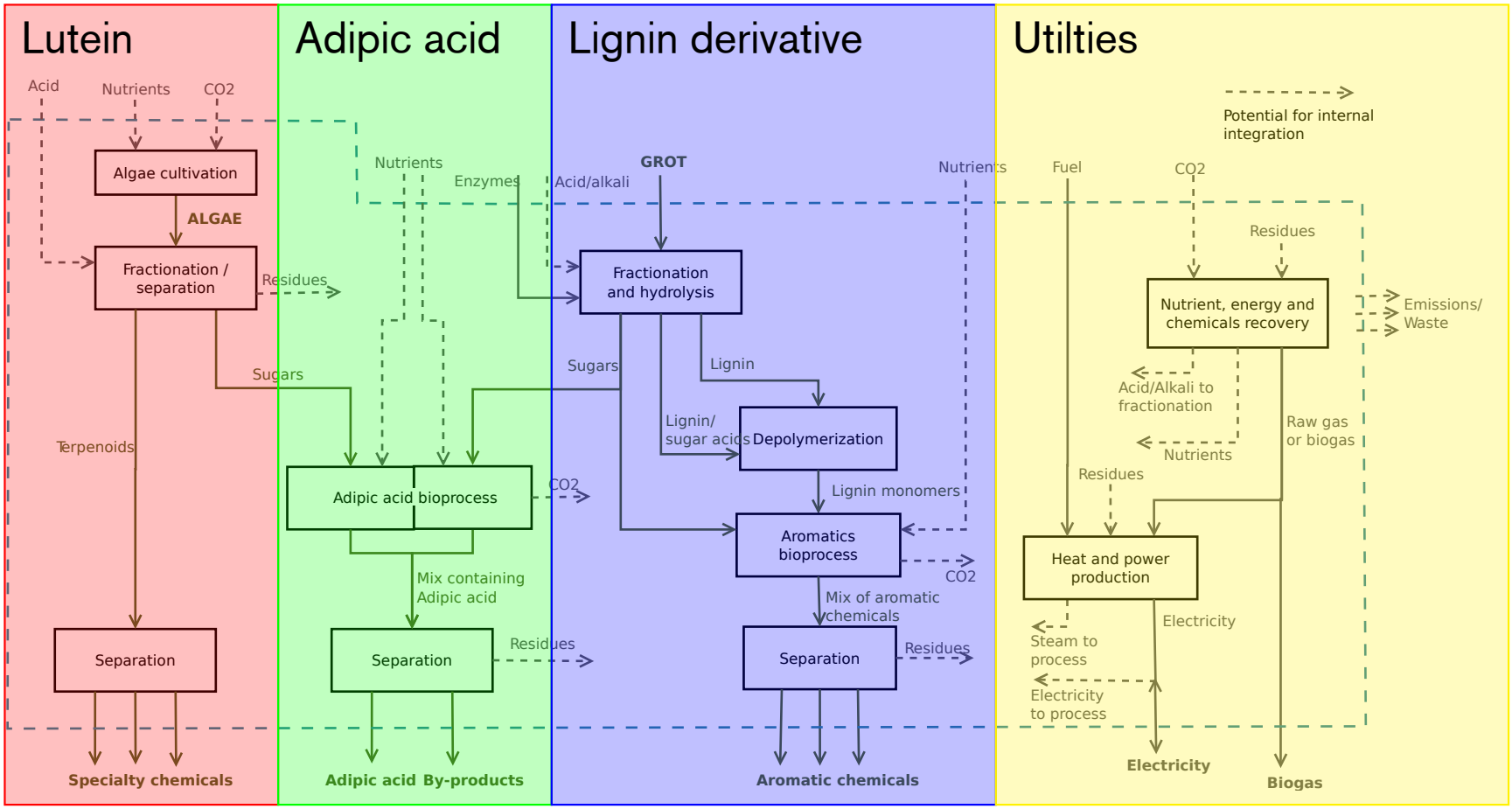

- Tool for (internal) cooperation and (external) communication

Some indicative calculations

- Theoretical emission factor of N_2O is 300 kg per tonne of adipic acid produced[2]
- ecoinvent process for adipic acid production[3]
  - Uses KA oil for adipic acid production
  - 80% of the N_2O produced is removed by abatement technologies
  - Global warming $\approx$ 25 kg CO_2-eq/kg adipic acid produced

[2] L. Li et al. *Environmental Science and Technology* 48.9 (2014), pp. 5290–5297.

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  - Global warming $\approx$ 25 kg CO_2-eq/kg adipic acid produced
- Switch from fossil to renewable resource and using a biochemical process
  - Elimination of N_2O emissions $\rightarrow$ 75% reduction of global warming
  - Switch to renewable resource $\rightarrow$ 10% reduction of global warming

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Further reduction of environmental impacts?

- Separation of adipic acid from the fermentation broth
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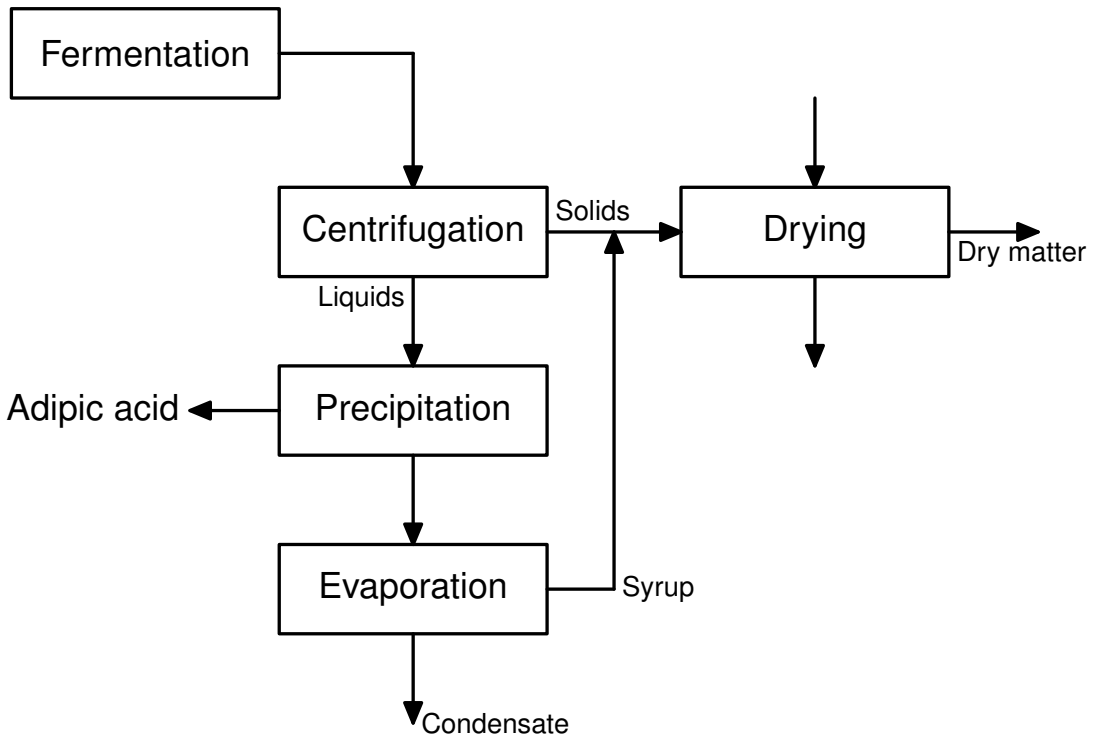

- Calculated energy need for separation $\approx$ 92 MJ/kg adipic acid
- ecoinvent process $\rightarrow$ NREU $\approx$ 126 MJ/kg adipic acid
- Careful screening of possible separation alternatives

Lessons learned so far

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  - Reduction of N_2O emissions
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- LCA methodological issues
  - Data availability within the project (and external)
  - Uncertainties
  - What is most important to consider?
  - Communication of LCA results

THANK YOU
Any questions?

BIOBUF