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Environmental and Economic Aspects of Aviation Biofuels

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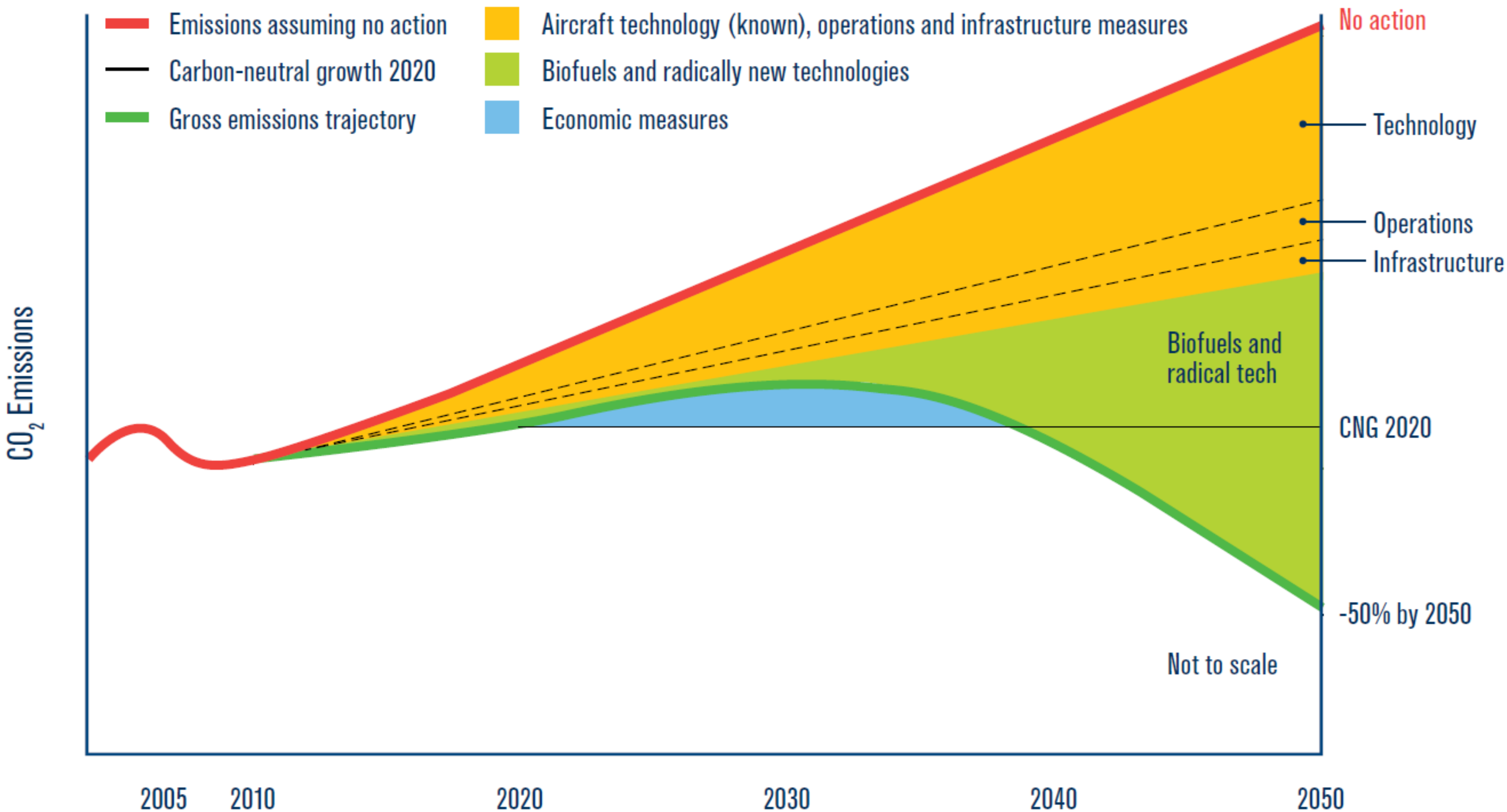
Why Biokerosene?

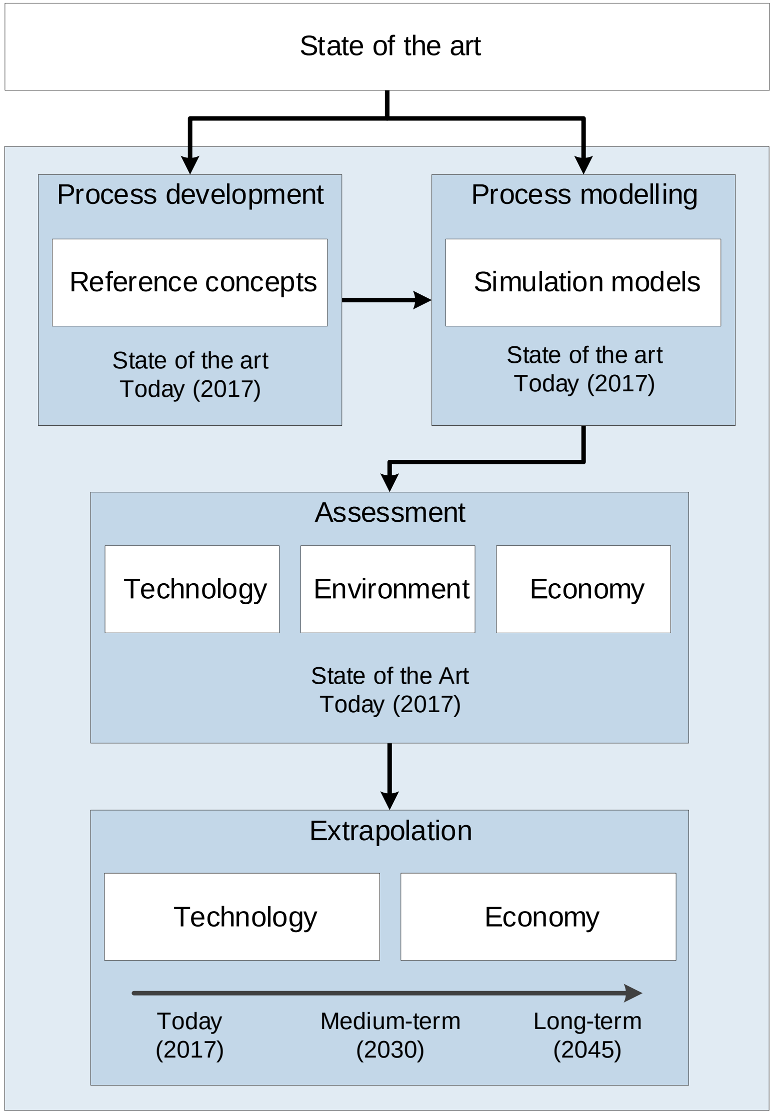


Quelle: IATA 2013

Background – Fuels for Aviation

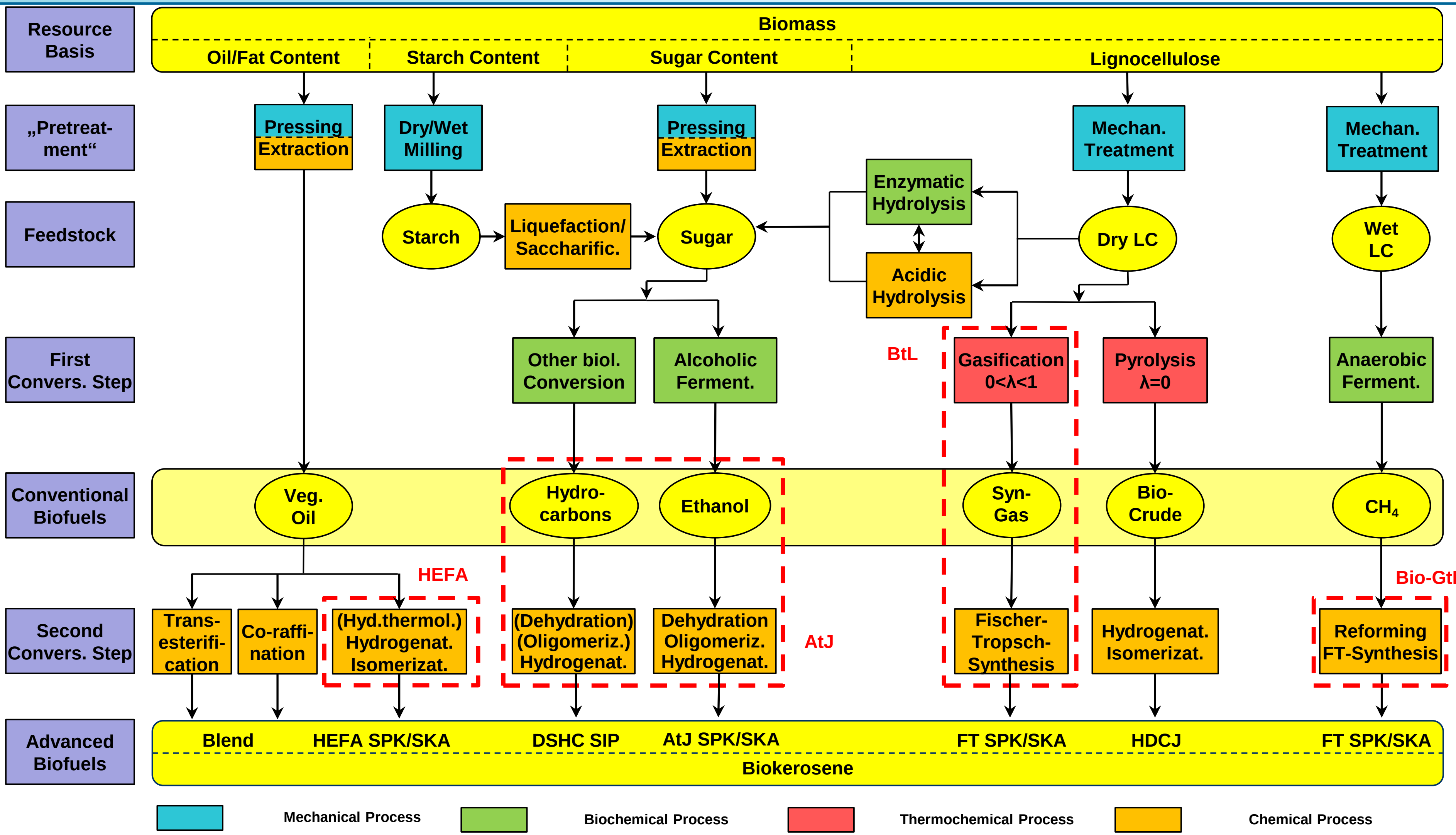
- Since airplanes are characterized by a service life of at least 20 to 30 years, liquid fuels for aviation will most likely be used for the next three decades
- Such energy carrier for aviation have to fulfill specific criteria, such as a high energy density, good combustion properties and various safety requirements
- Today, Jet A-1 fulfills all these criteria and therefore is one of the most widely used fuels for aviation
- However, this has the consequence that alternative fuels, such as e.g. biokerosene, have to meet the relevant specifications.

General Methodological Approach



- Analyzed parameter for the base year 2017:
  – Mass and energy balances
  – Process efficiency
  – Biokerosene production costs
  – GHG emissions
- Extrapolation to 2030 / 2045:
  – Process efficiency
  – Biokerosene production costs

Conversion routes



AtJ: Alcohol-to-Jet, BtL: Biomass-to-Liquid, DSHC: Direct Sugar to Hydrocarbons, FT: Fischer-Tropsch, GtL: Gas-to-Liquid, HEFA: Hydroprocessed Esters and Fatty Acids, HDCJ: Hydrotreated Depolymerized Cellulosic Jet, HTG: Hydrothermale Vergasung, HTL: Hydrothermale Verflüssigung, LC: Lignocellulose, SIP: Synthesized Iso-Paraffins, SKA: Synthetic Paraffinic Kerosene with Aromatics, SPK: Synthetic Paraffinic Kerosene

Assessed Process Routes

Alcohol-to-Jet

Wheat Straw

AtJ-WS

Wheat Grain

AtJ-WK

Biogas-to-Liquids

Substrate Mix

Bio-GtL-SM

Manure

Bio-GtL-Gü

Biomass-to-Liquids

Wheat Straw

BtL-WS

Willow

BtL-We

HEFA

Jatropha Oil

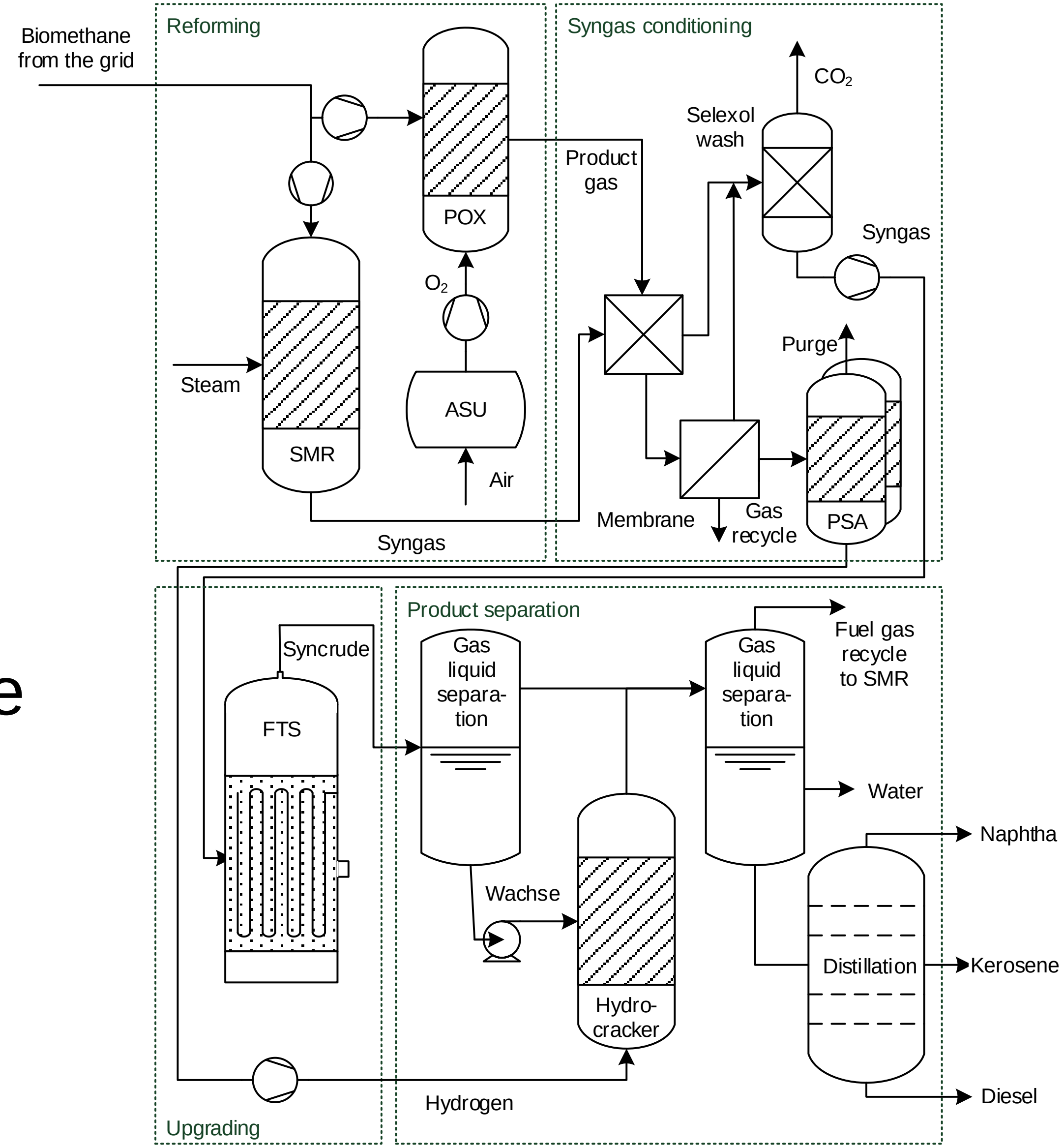
HEFA-JO

Palm Oil

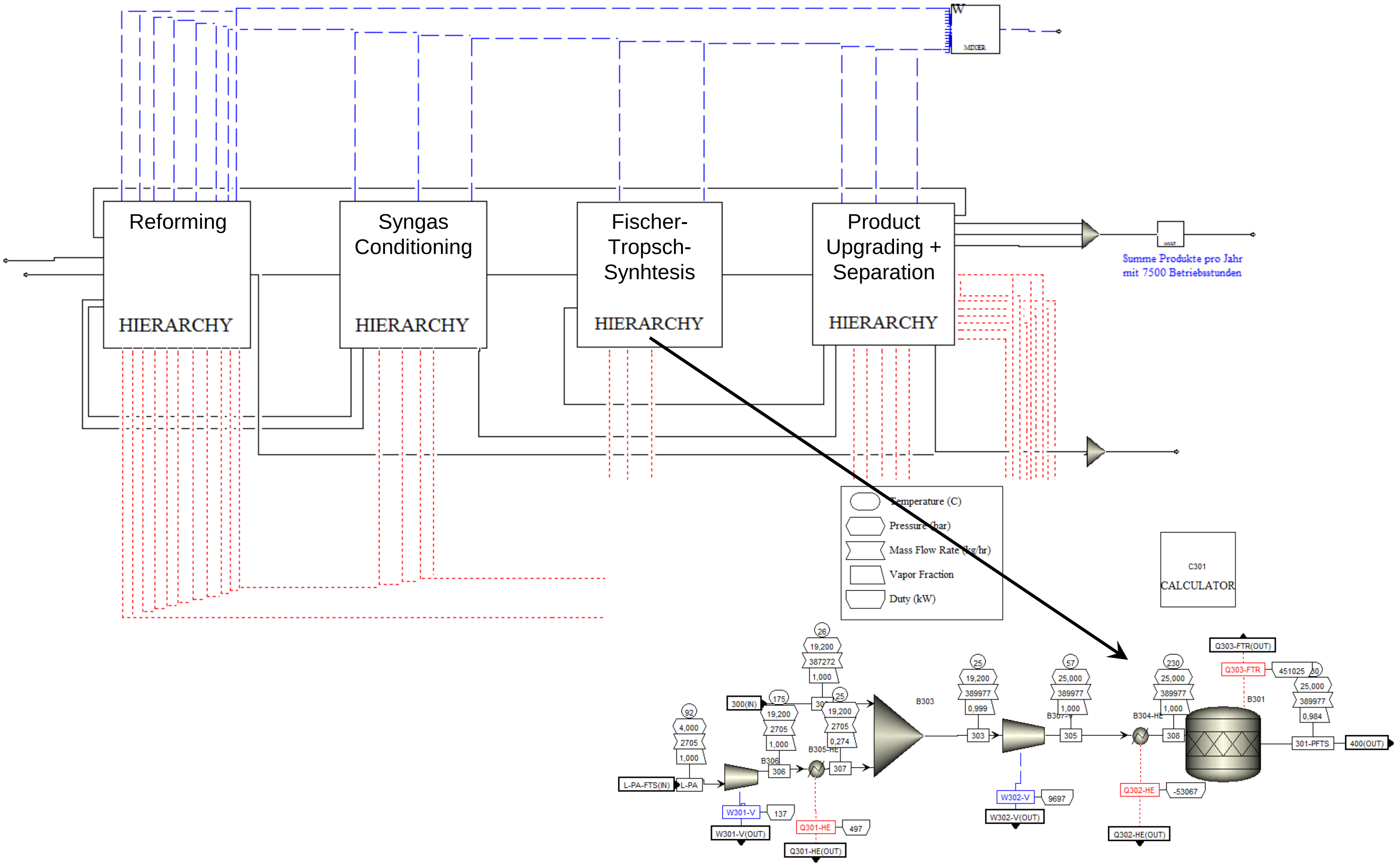
HEFA-PO

Bio-GtL Reference Concept

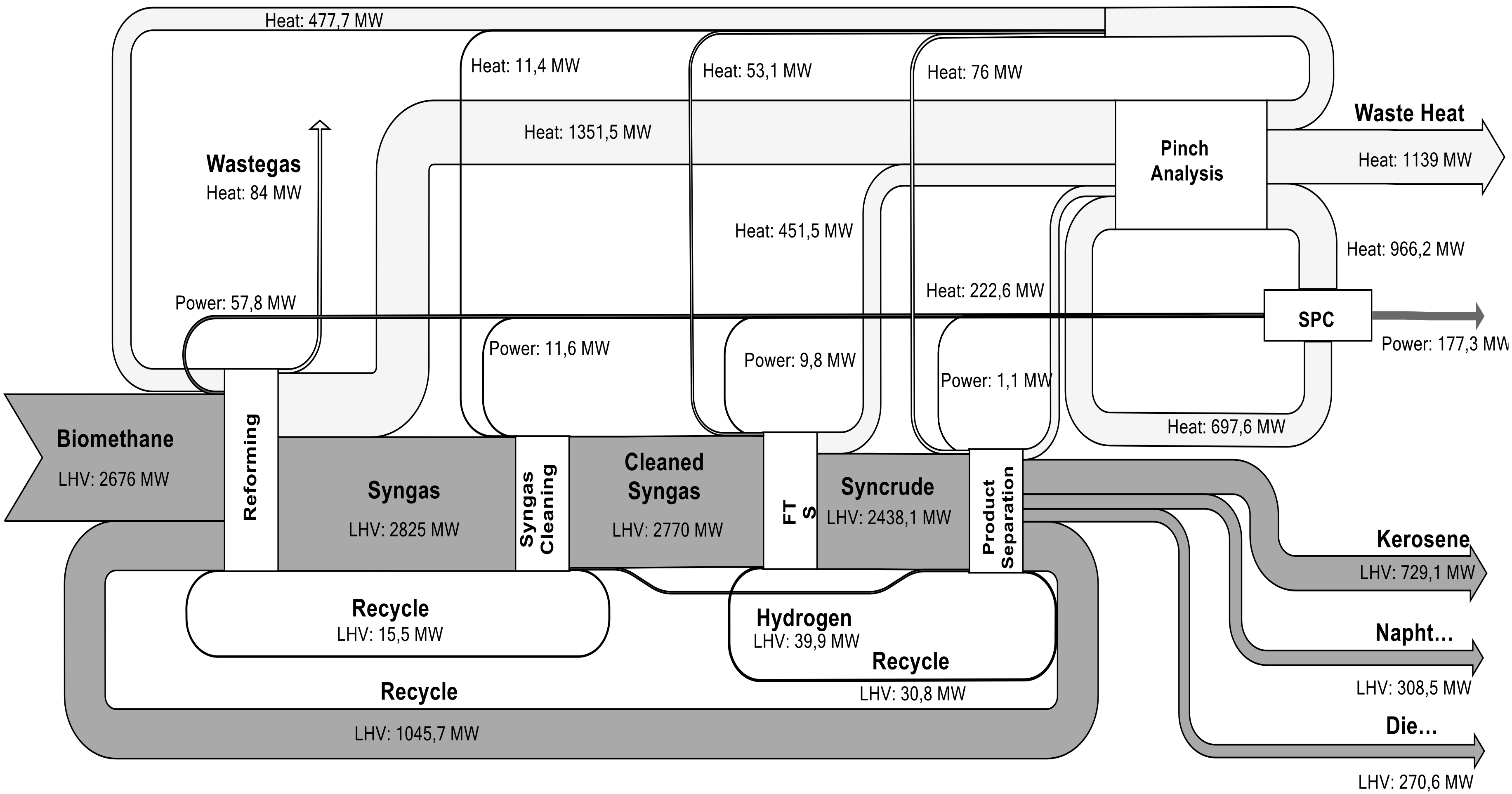
- Decentralized biogas production
- Biomethane collection, storage and provision via the natural gas grid
- Centralized, large scale conversion plant optimized on kerosene production



Bio-GtL Process Modelling



Calculation of the energy flows for the complete conversion process



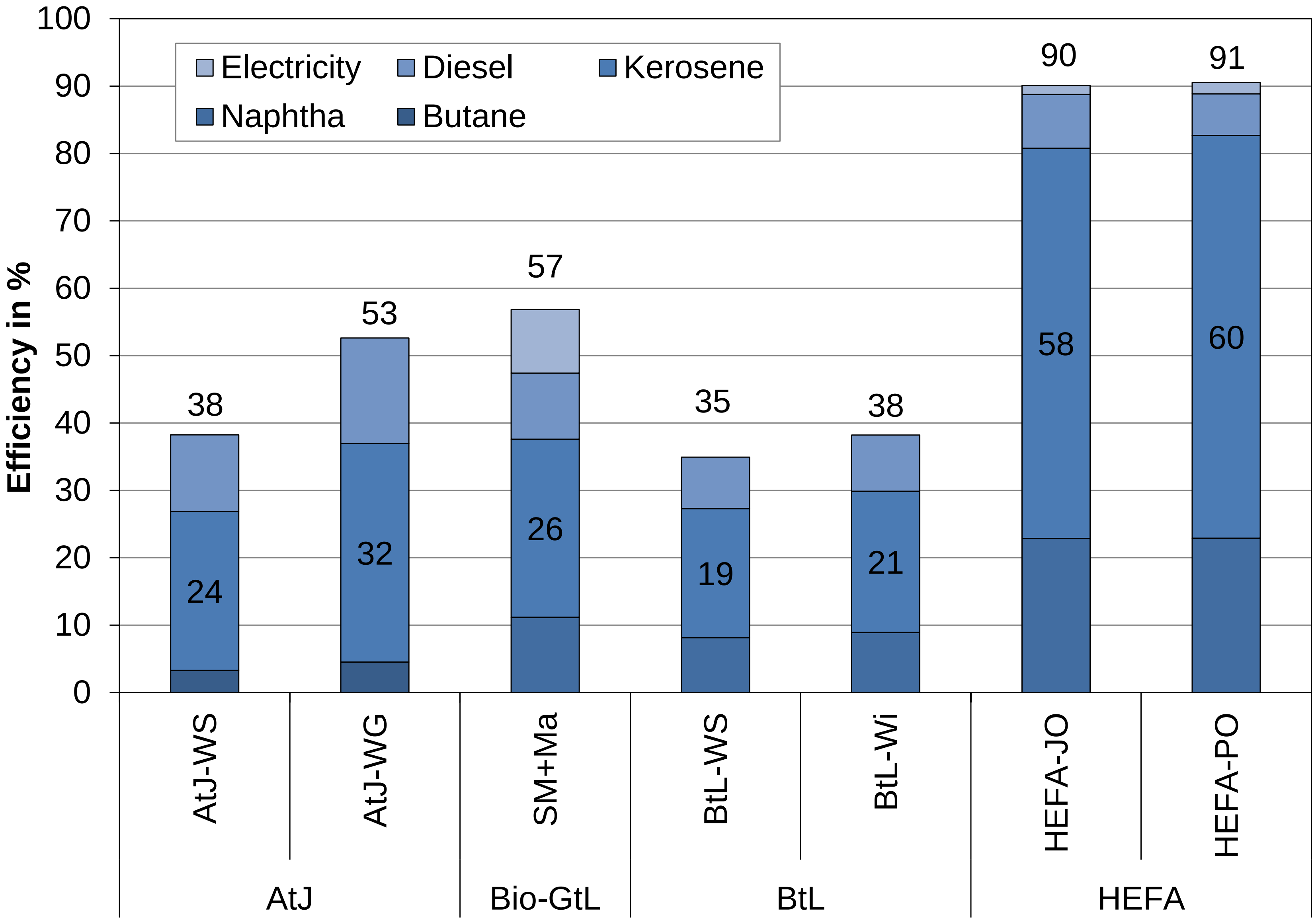
Process Efficiency Definition

Parameter that aggregates the energy efficiency of a process

$$\eta_{ges} = \frac{\sum \dot{W}_{Products} + P_{el}}{\sum \dot{W}_{Educts} + P_{el,own}}$$

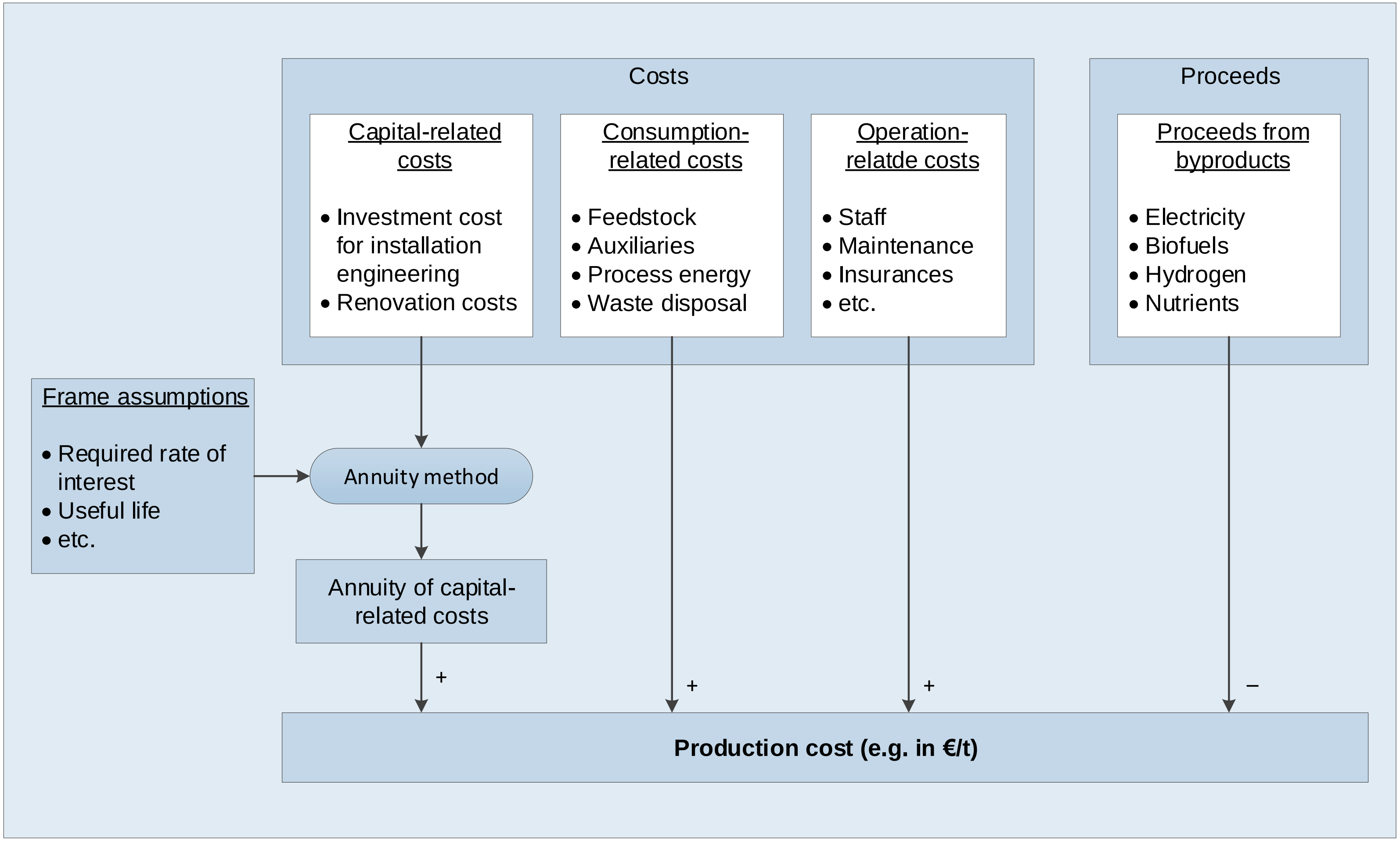
η_{ges}	Process efficiency of the overall process
$\dot{W}_{Products}$	Energy content of all products
$\dot{W}_{Educts}$	Energy content of all educts
P_{el}	Produced gross electricity
$P_{el,own}$	Own electricity consumption of the plan

Process Efficiency (2017)

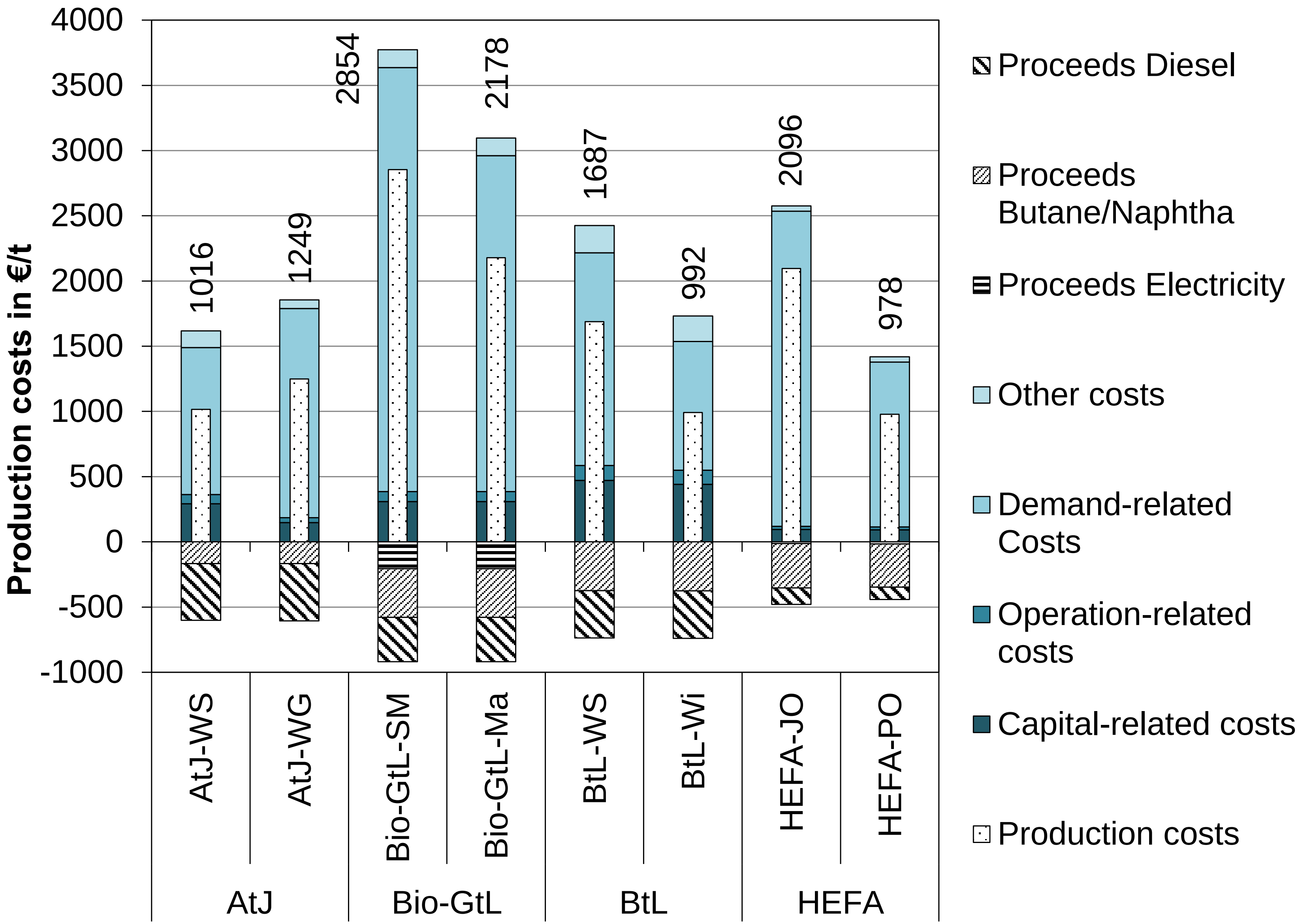


Methodology Cost Calculation

Calculation of the biokerosene production costs following annuity method (VDI 6025 and VDI 2067)

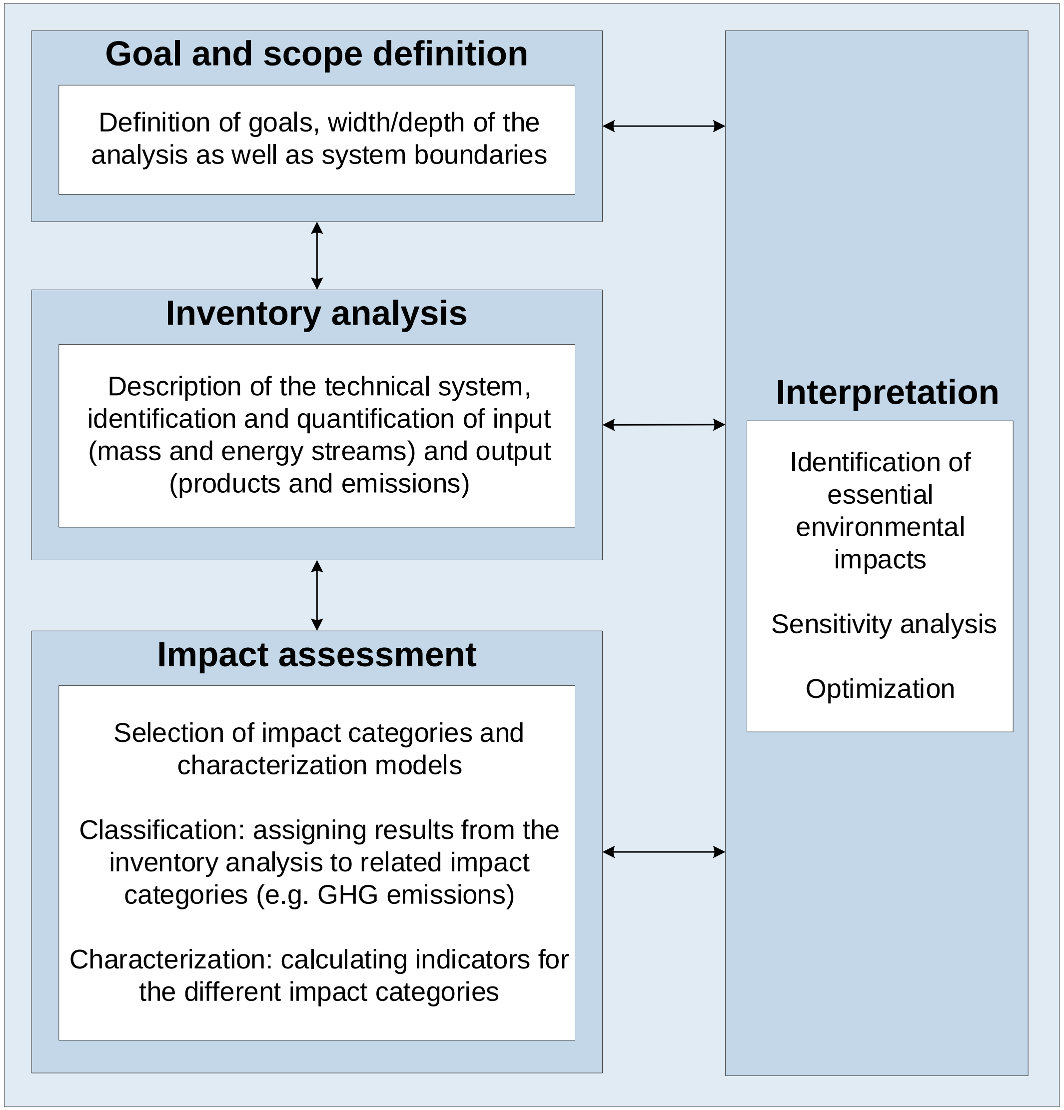


Kerosene Production Costs (2017)

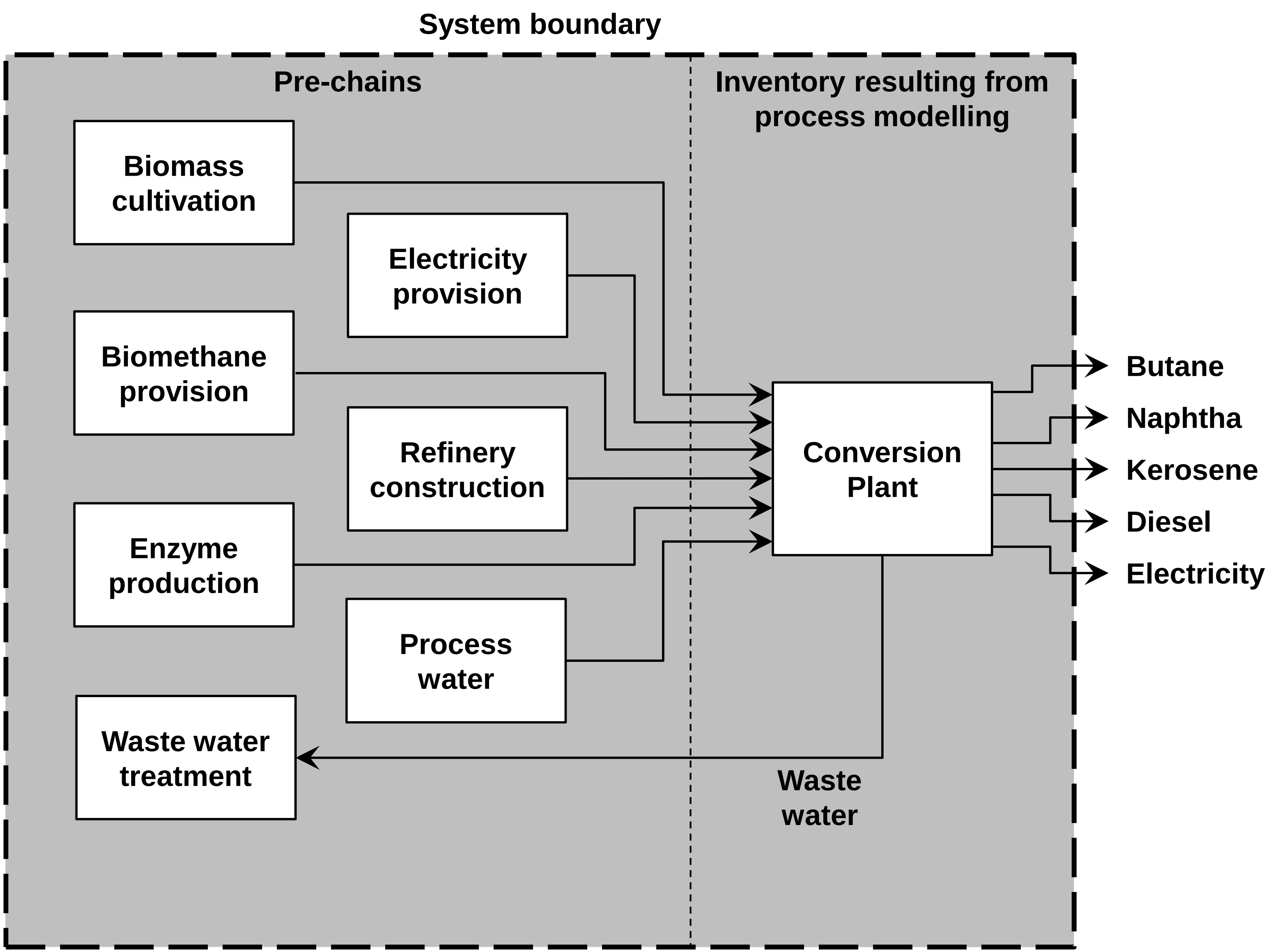


Methodology Lifecycle Analysis

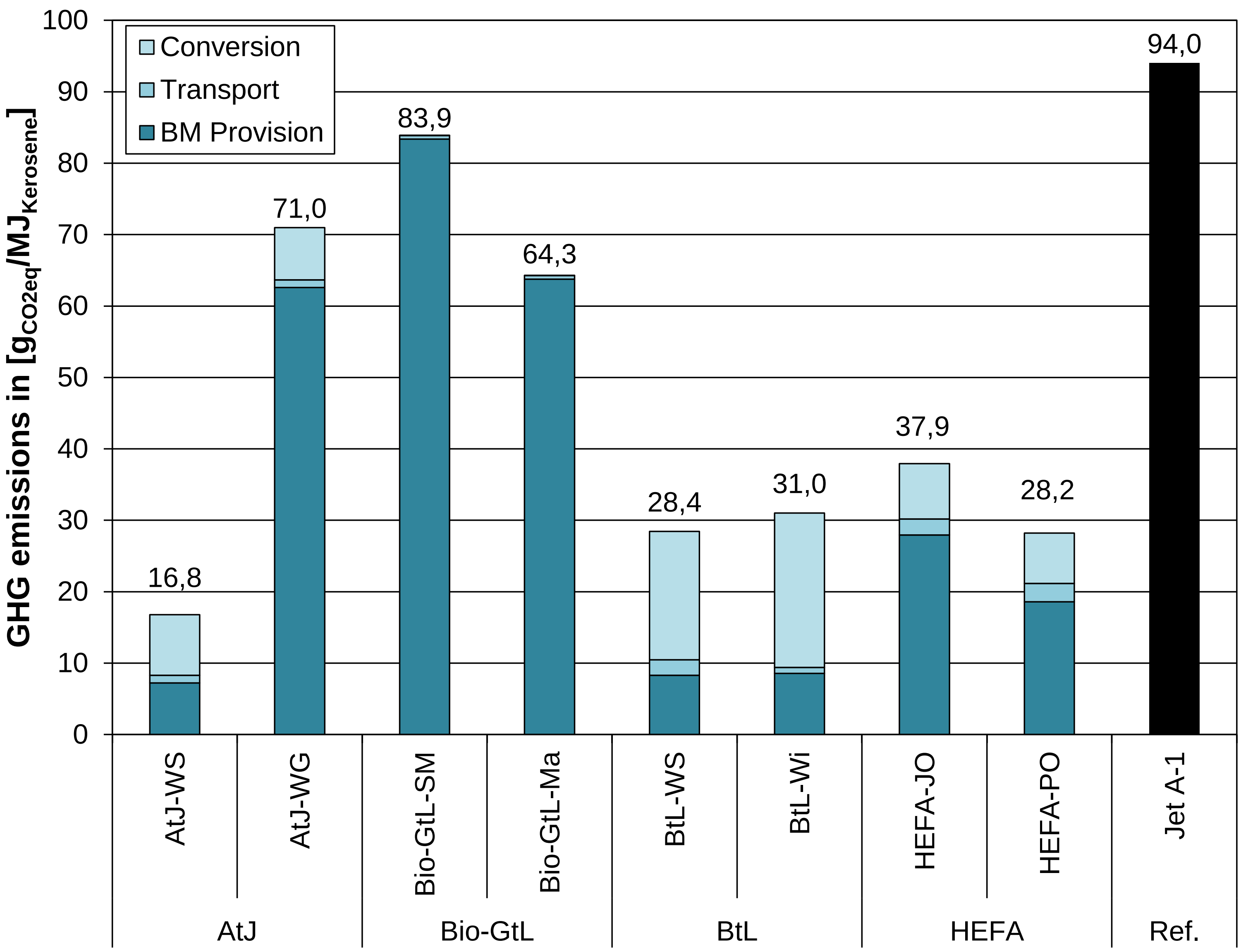
Assessment of the environmental impact of a process or product by means of a lifecycle analysis (LCA) according to DIN EN 14040 and 14044



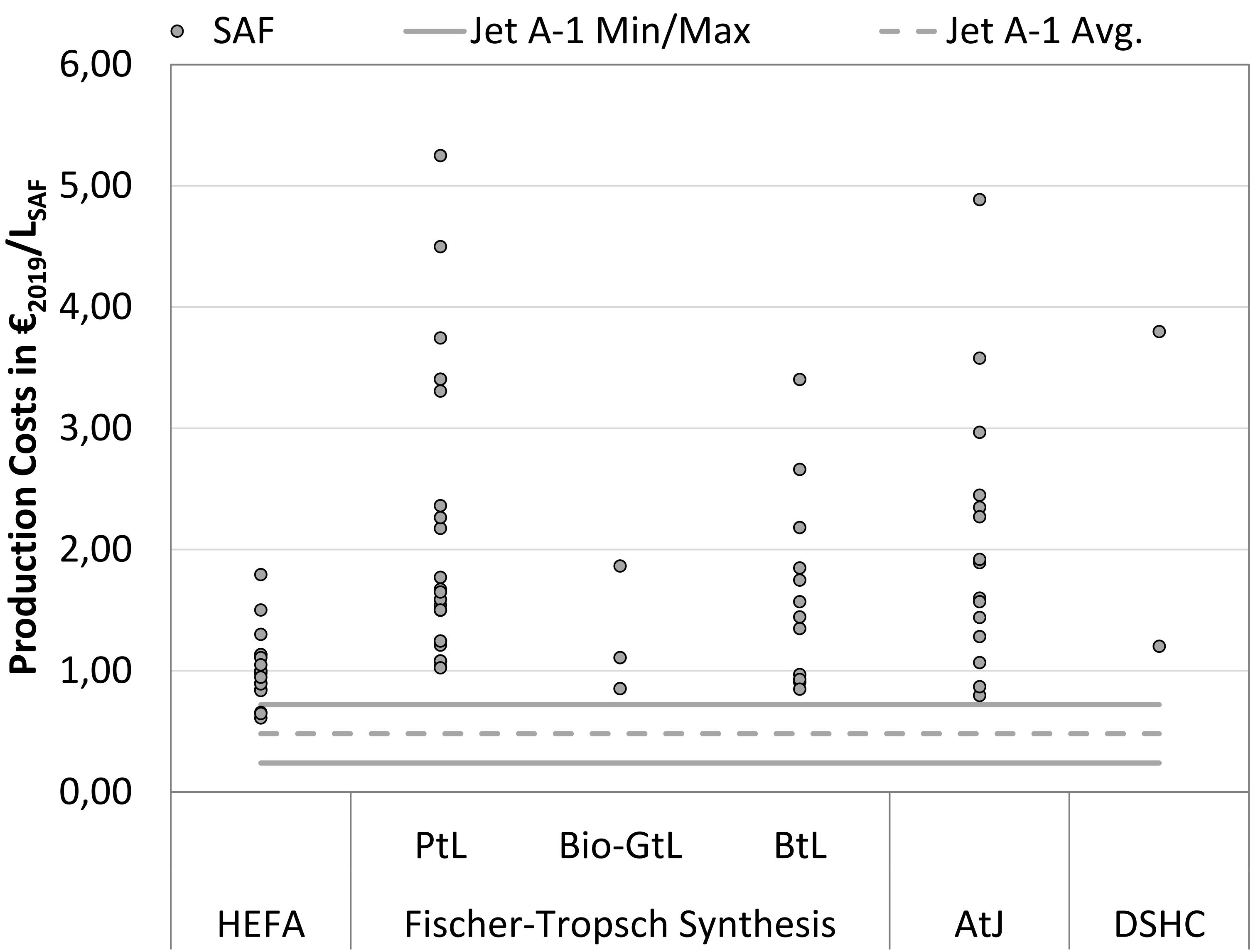
LCA System Boundary



Environmental Assessment (2017)

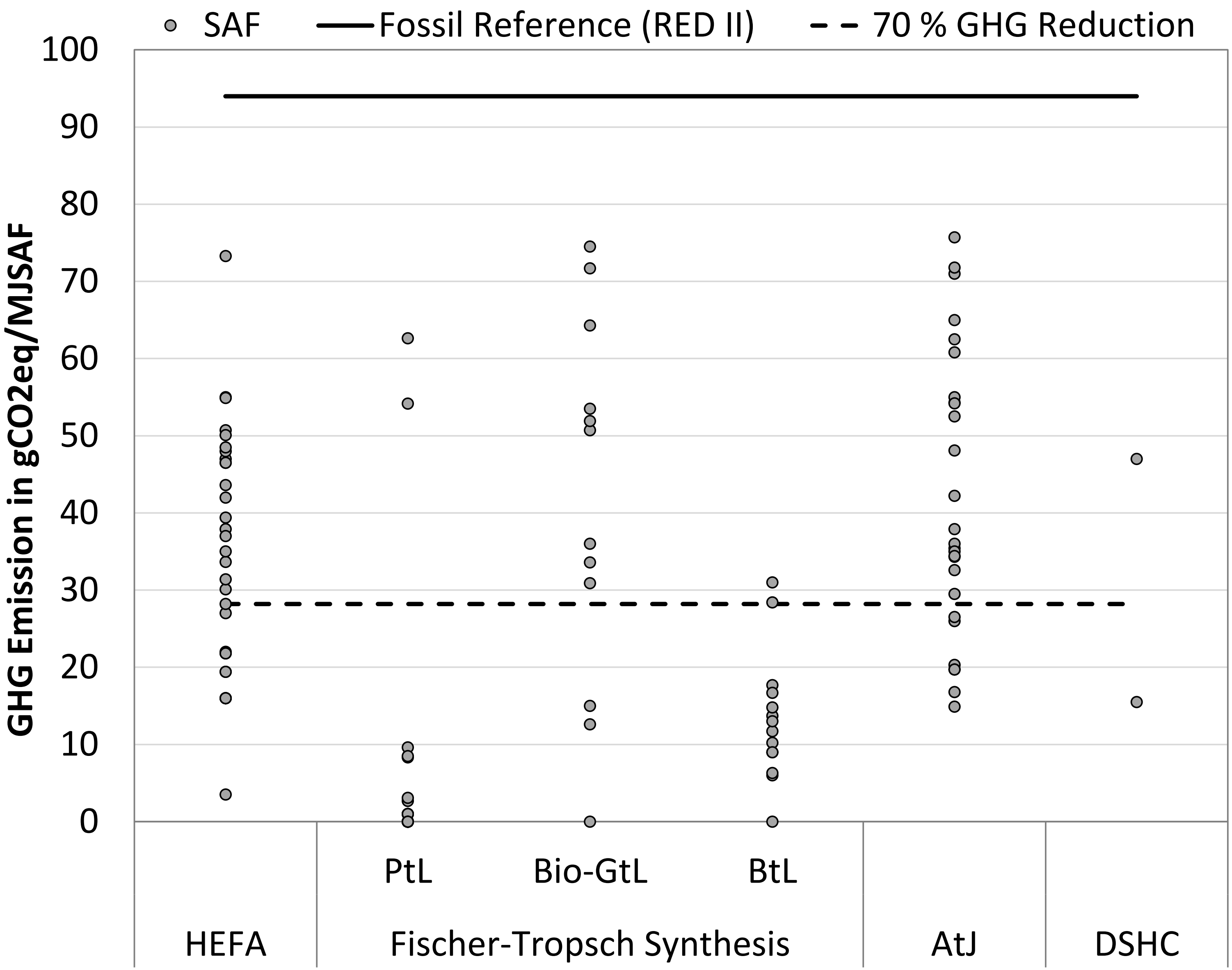


Classification of the Results (Economics)



Acknowledgment: Nils Bullerdiek

Classification of the Results (LCA)

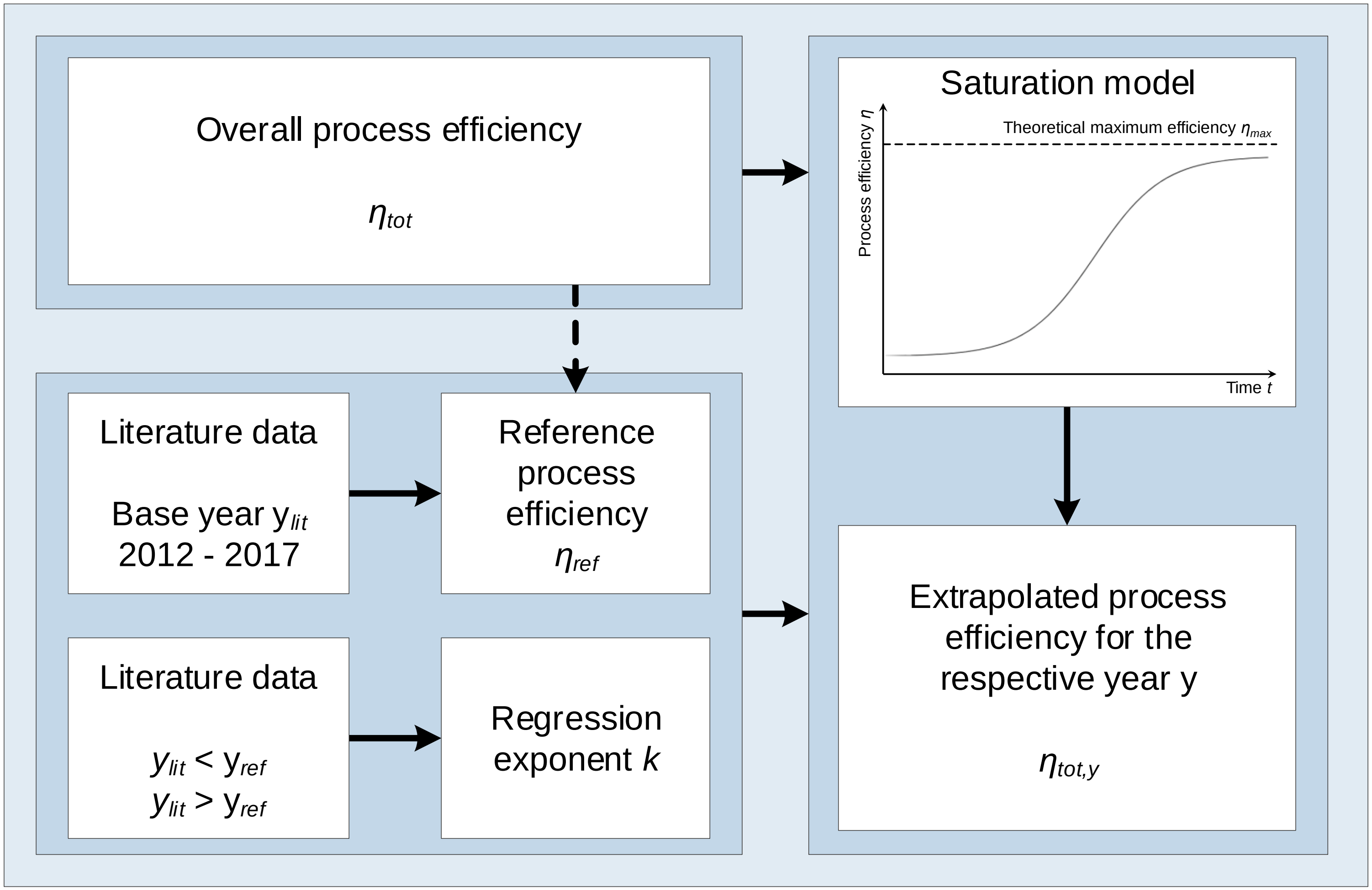


Preliminary Conclusion 2017 Concepts

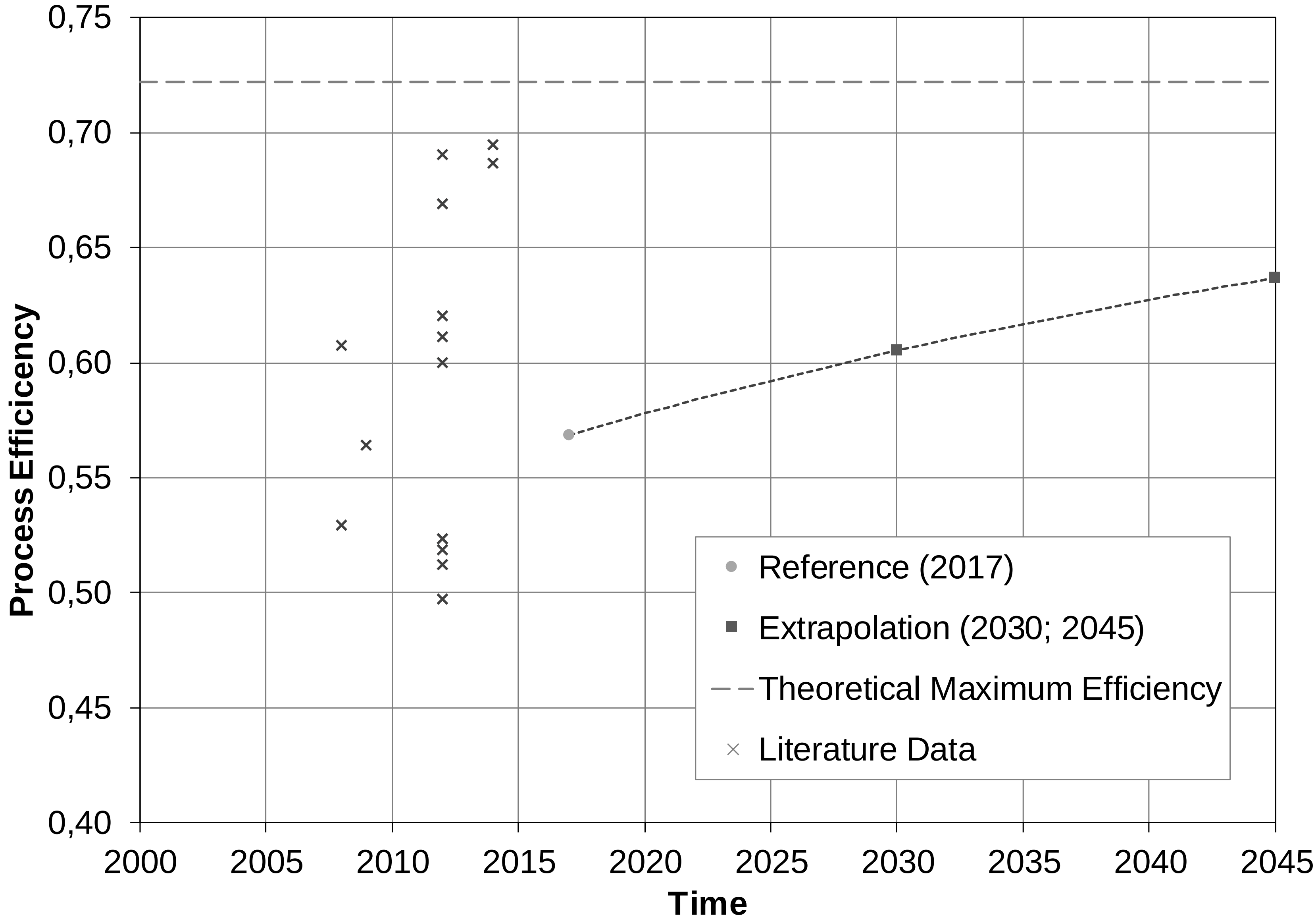
- Vegetable oil-based processes show the highest of technical efficiencies, as they make the most efficient use of nature's pre-synthesis
- The biokerosene production costs show a broad variety between 980 and 2850 €/t
- Depending on the raw material, a large fluctuation of the production costs can occur for the same process
- Having current prices for fossil jet A-1 of just over 600€/t in mind, none of the processes would be economically competitive
- GHG emission reductions also show a large variety between 10 to 82 % compared to fossil jet fuel

Extrapolaion Methodology

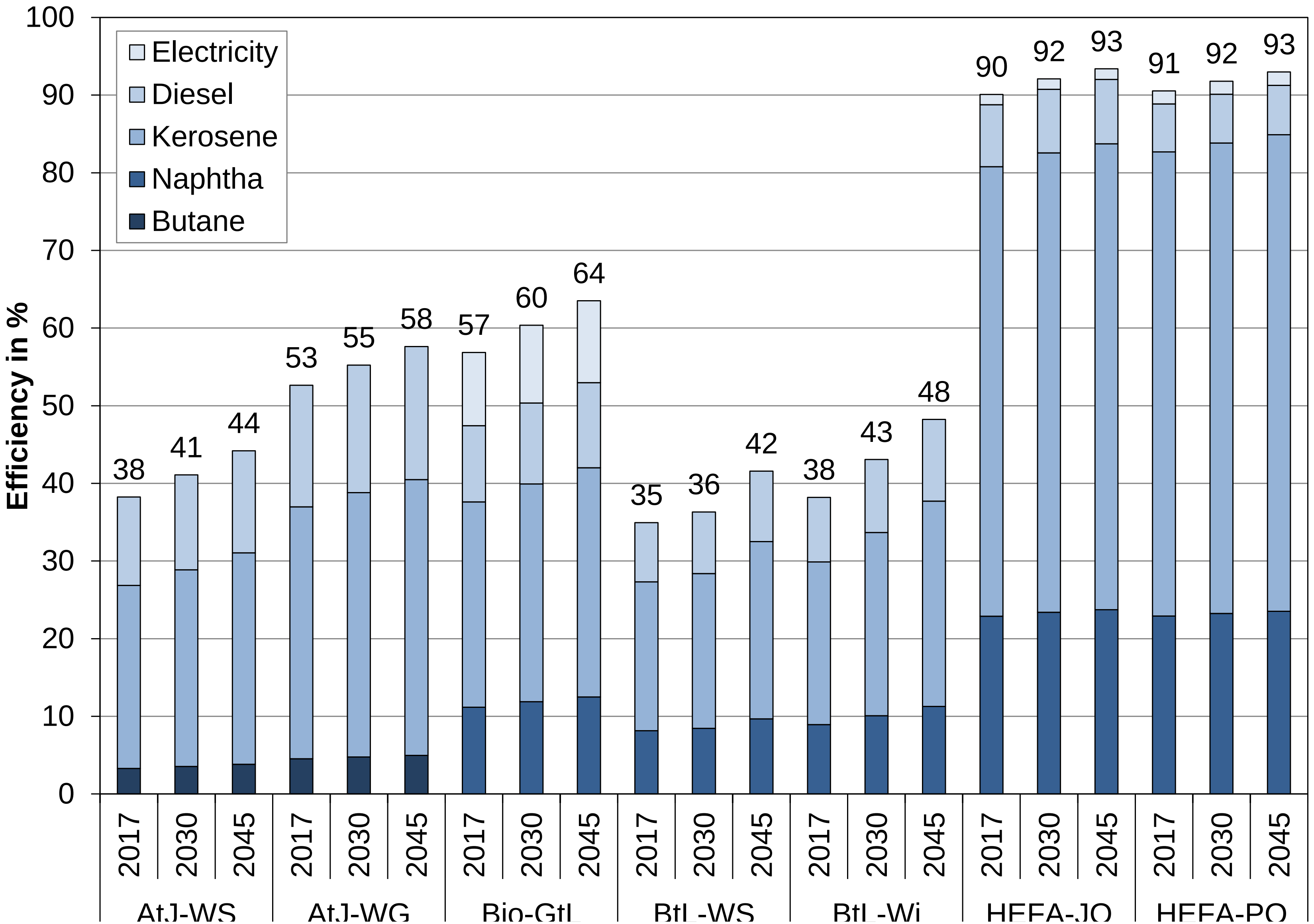
Process efficiency extrapolation via saturation approach



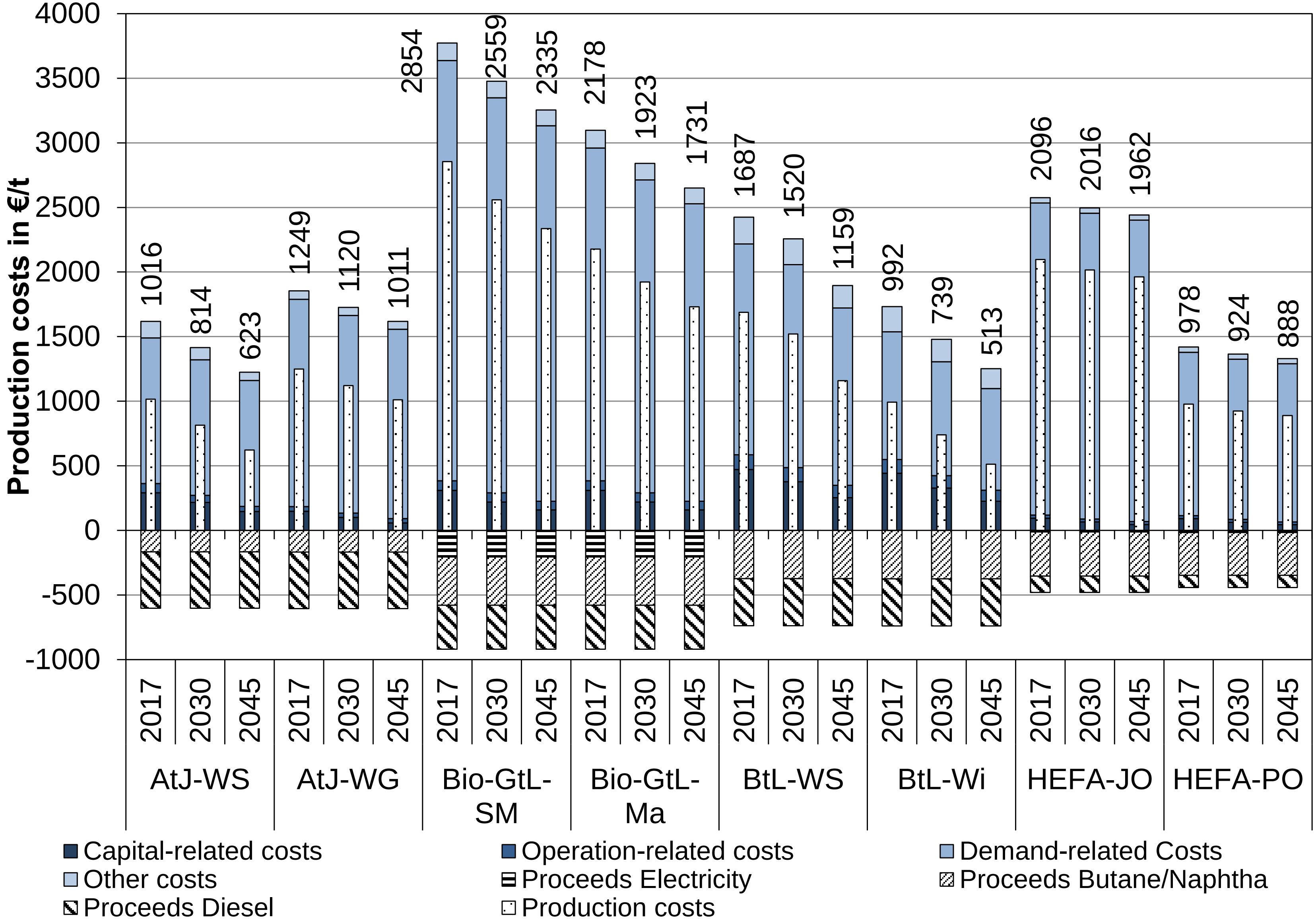
Technical Extrapolation (Example Bio-GtL)



Results Technical Extrapolation



Results Economic Extrapolation



Conclusion and Outlook

- The kerosene production costs can most likely be reduced significantly by an efficient fuel production at industrial scales
- If capacity buildup and efficiency improvements occur accordingly, biokerosene could become marketable and also price competitive in the future
- For a future cost competitive production of biokerosene, especially processes based on solid biomass (i.e., lignocellulose) appear to be most suitable
- For all processes, the selected feedstock determines the outcome, therefore sustainable and efficient biomass provision is essential for a cost-effective and environmental sound production of biokerosene

Thank you for your attention!

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