# Techno-economic studies for the FLEXCHX process

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DLR e.V.

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# Outline

A. Motivation & Project Idea

B. Techno-economic analysis

C. Life cycle assessment

D. Conclusion & Outlook

# Outline

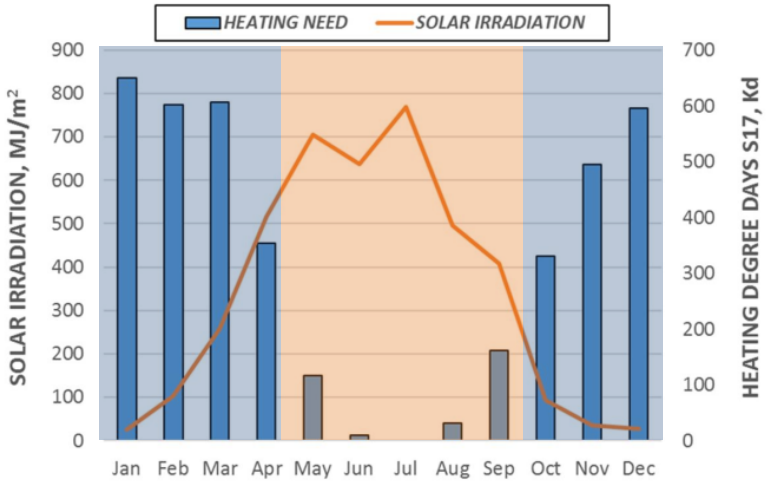


FlexCHX project has received funding from the European Union's Horizon 2020 research and innovation Programme under Grant Agreement No 763919.

# The FLEXCHX process response to energy market alteration

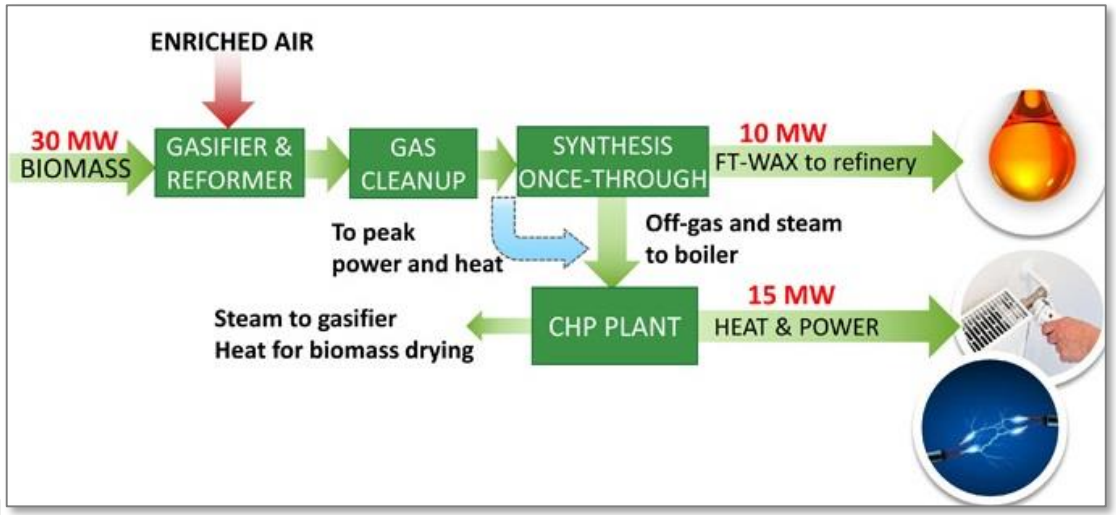
## Winter Mode[1]

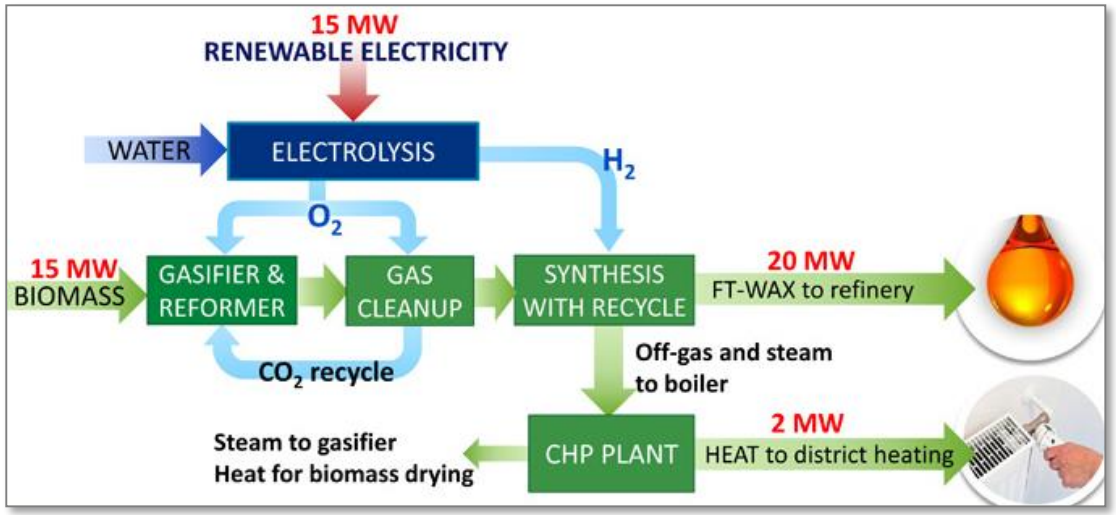
High district heating demand & lack of renewable electricity




## Summer Mode [1]

Low district heating demand & readily available renewable electricity




[1] FLEXCHX project proposal

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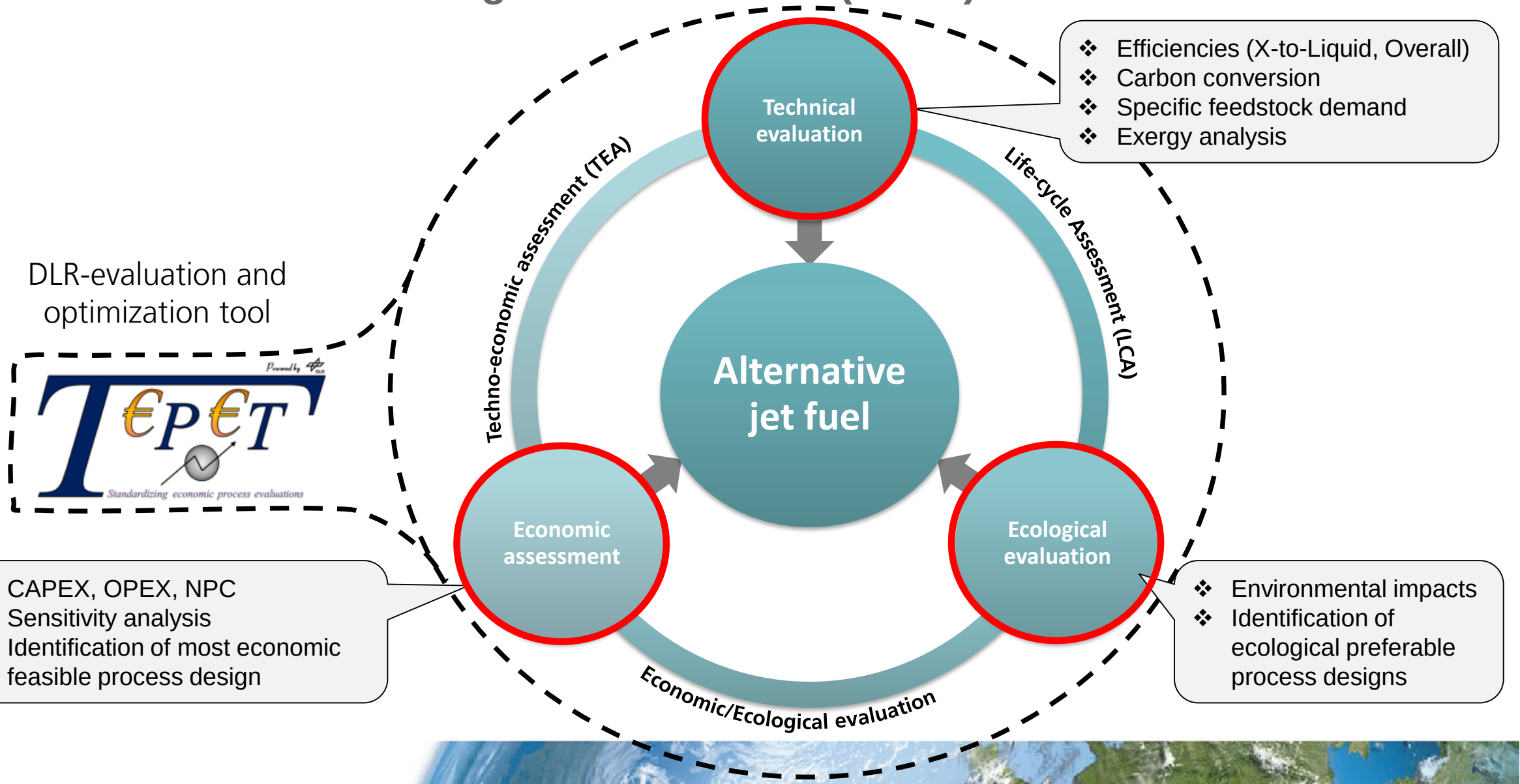
# Techno-Economic and ecological assessment (TEEA)



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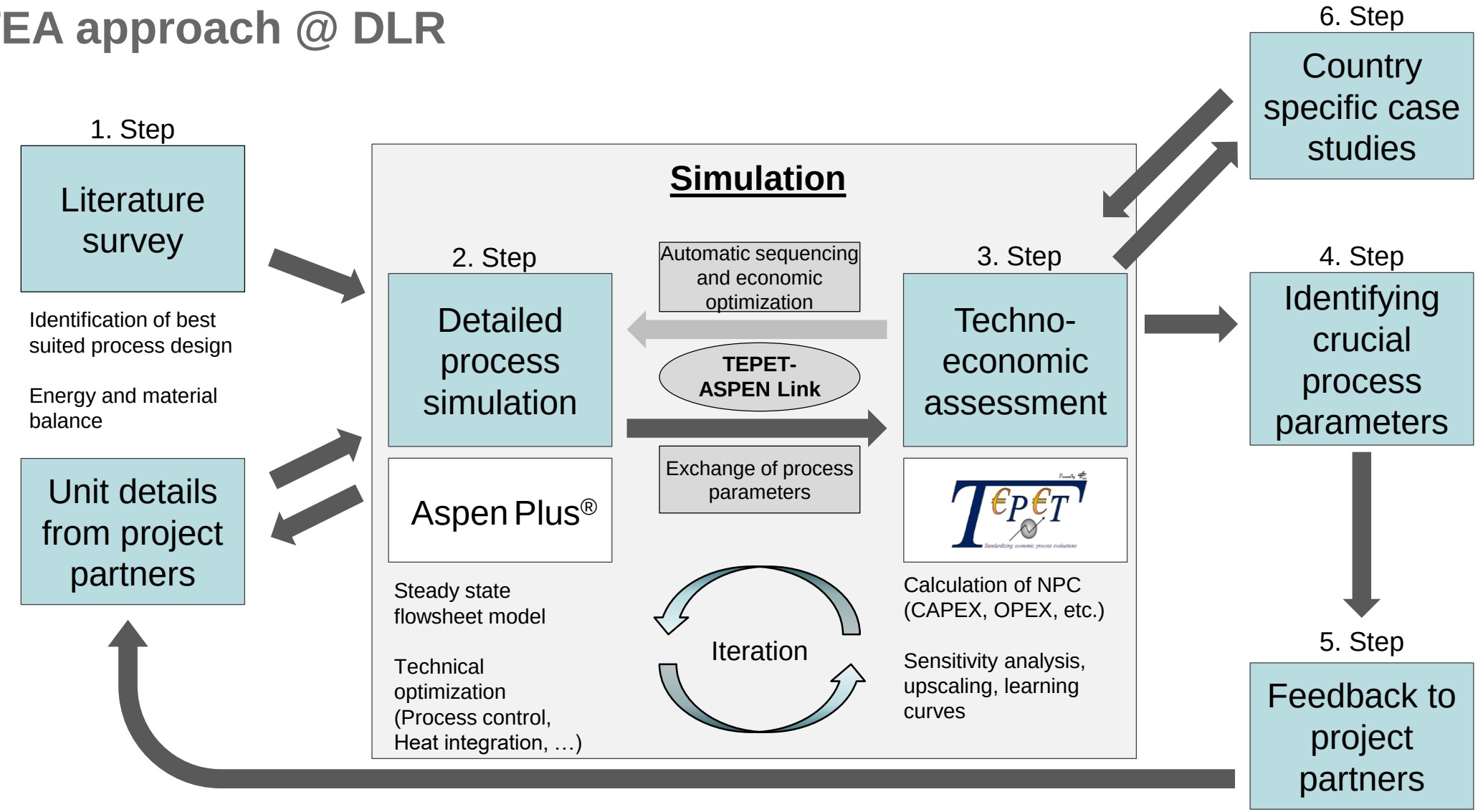
# TEA approach @ DLR



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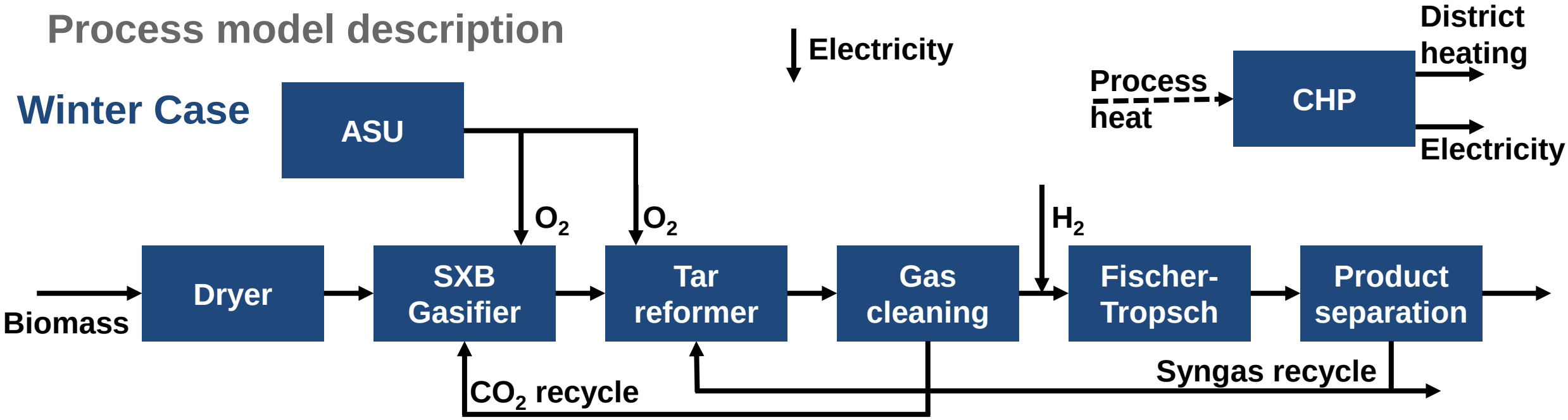
# Process model description

## Winter Case




## Key modelling assumptions:

- Model for novel SXB gasifier developed by **VTT**
- FT model developed with **INERATEC** [1] microreactor performance data @ 80 % CO conversion
- 80 % methane conversion in reformer based on novel **Johnson Mattheys** catalyst performance
- PEM electrolyzer assuming 75 $\%_{LHV}$ efficiency [2]

[1] Hamelinck, C. N., Faaij, A. P., den Uil, H., & Boerrigter, H. (2004). Production of FT transportation fuels from biomass; technical options, process analysis and optimisation, and development potential. *Energy*, *29*(11), 1743-1771.
[2] Buttler, A., & Spliethoff, H. (2018). Current status of water electrolysis for energy storage, grid balancing and sector coupling via power-to-gas and power-to-liquids: A review. *Renewable and Sustainable Energy Reviews*, *82*, 2440-2454.

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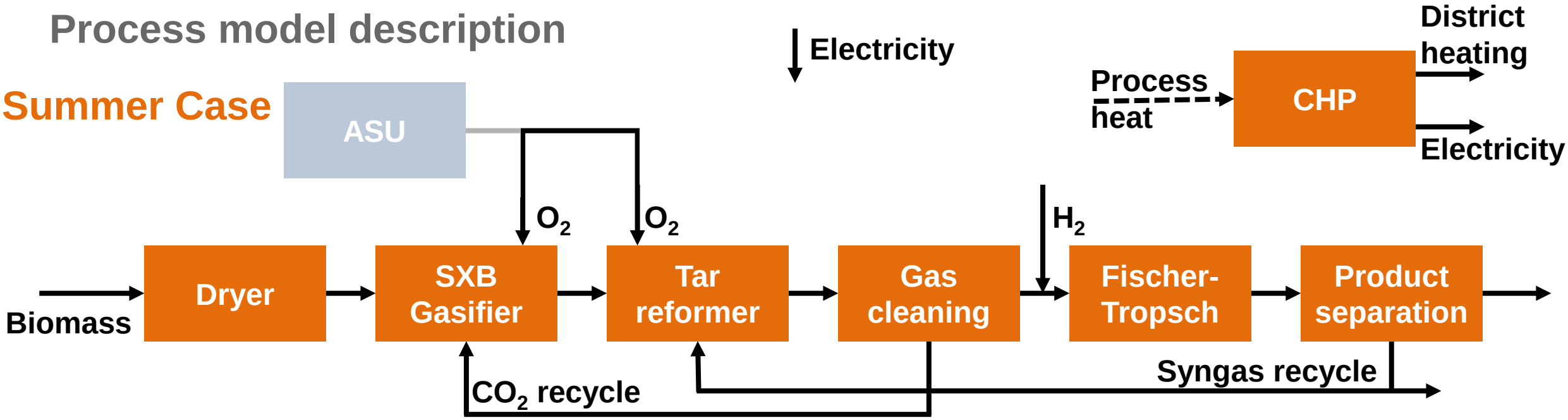


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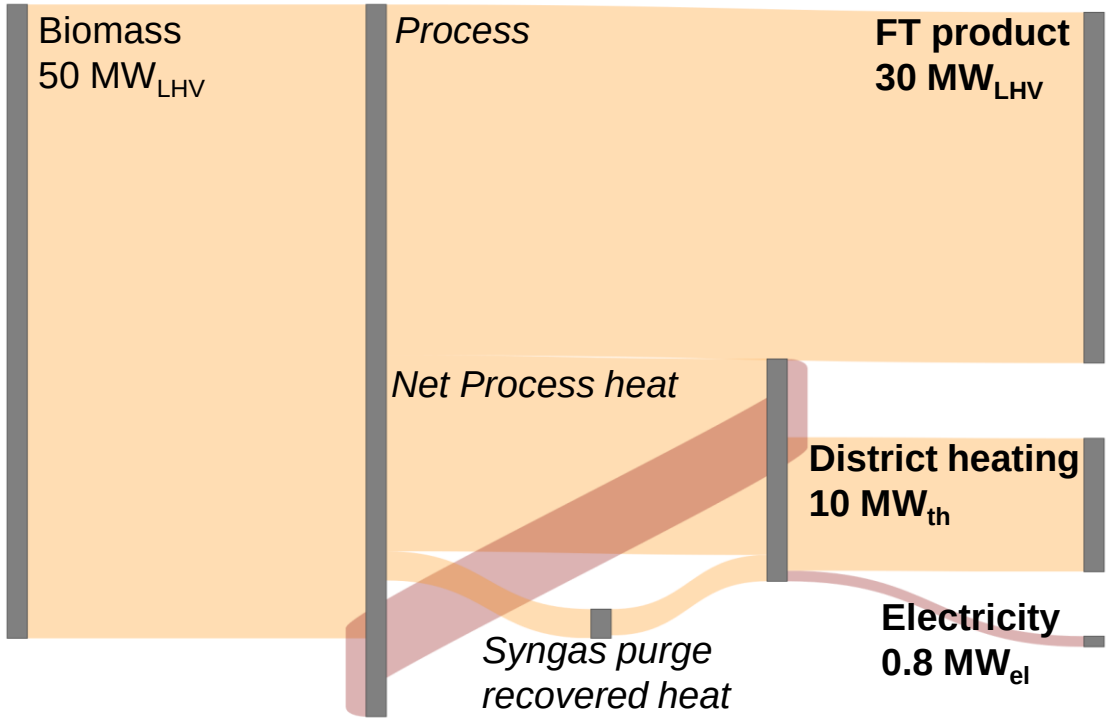
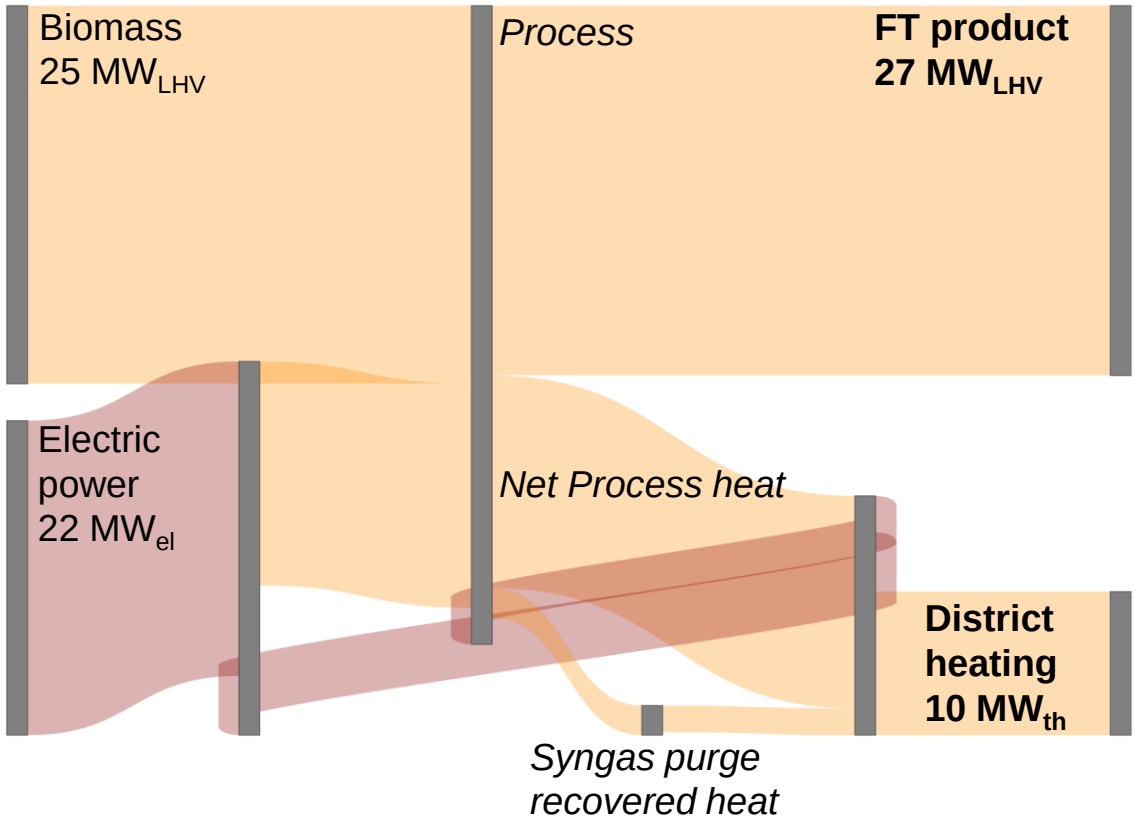
# Simulation results: Energy efficiency

## Winter Mode




## Summer Mode




→ **Fuel efficiency: ca. 60 % in Winter mode and ca. 57 % in Summer mode**

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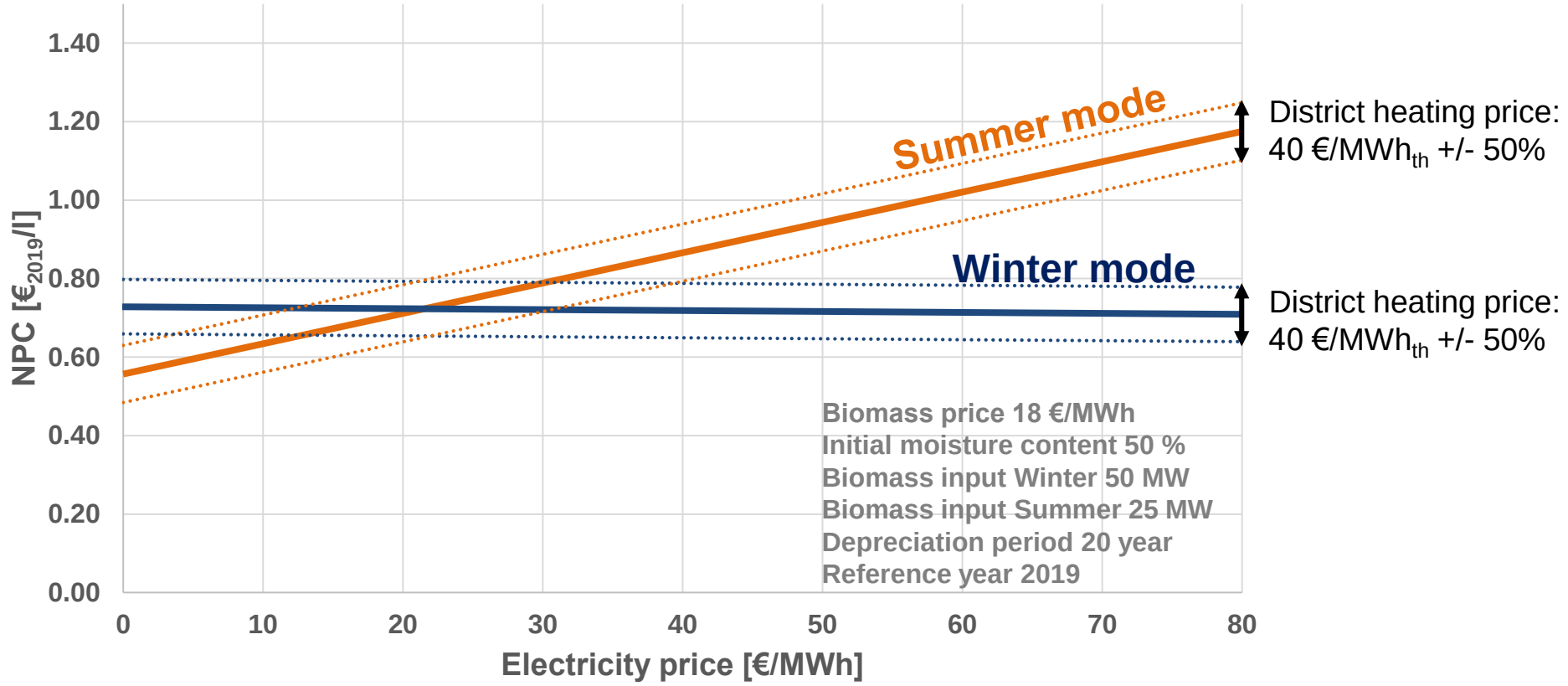
# Economic analysis glimpse for 50 $MW_{LHV}$ biomass input FLEXCHX plant




→ **Summer mode has an economic edge at electricity costs of < 20 €/$MWh_e$**

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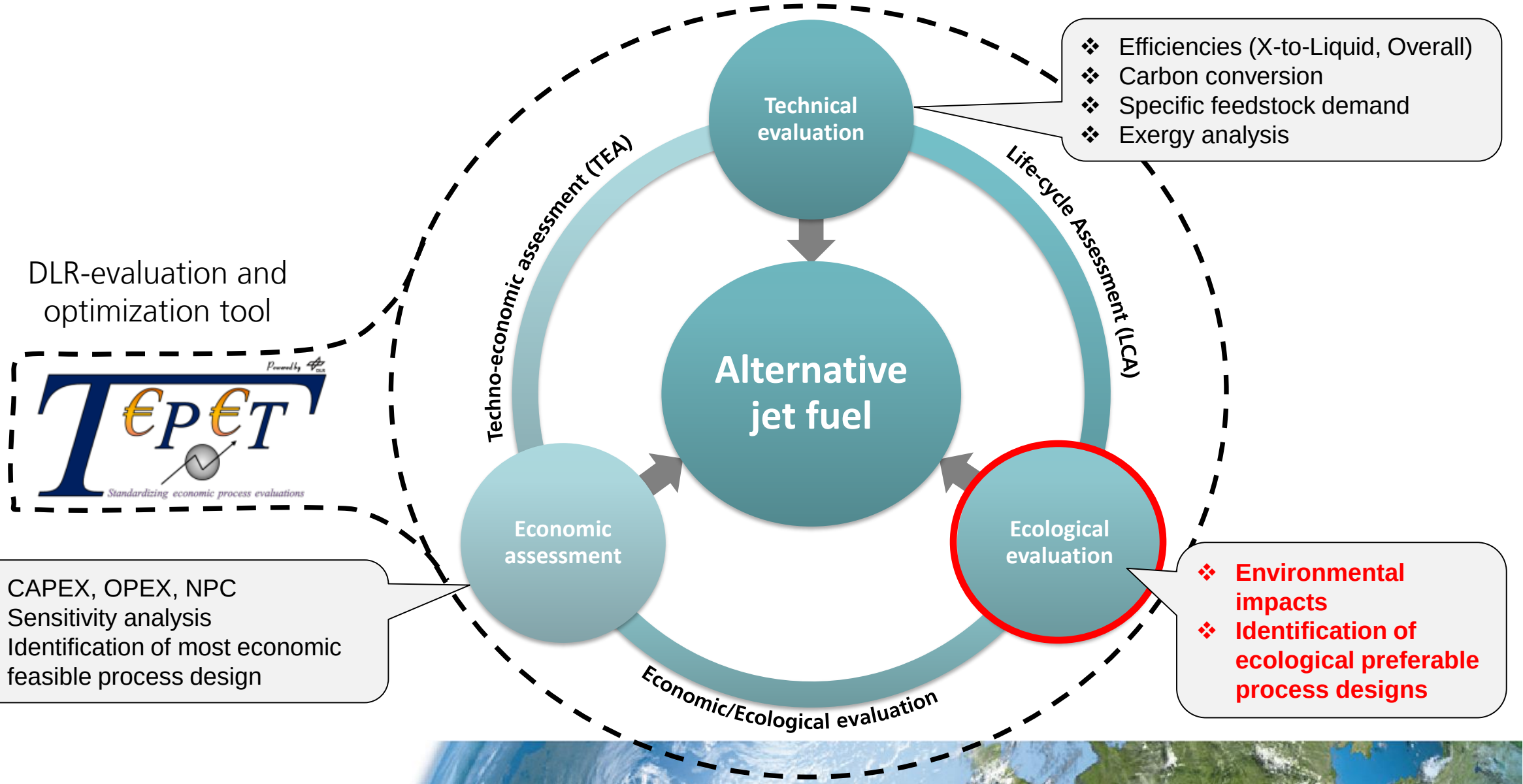

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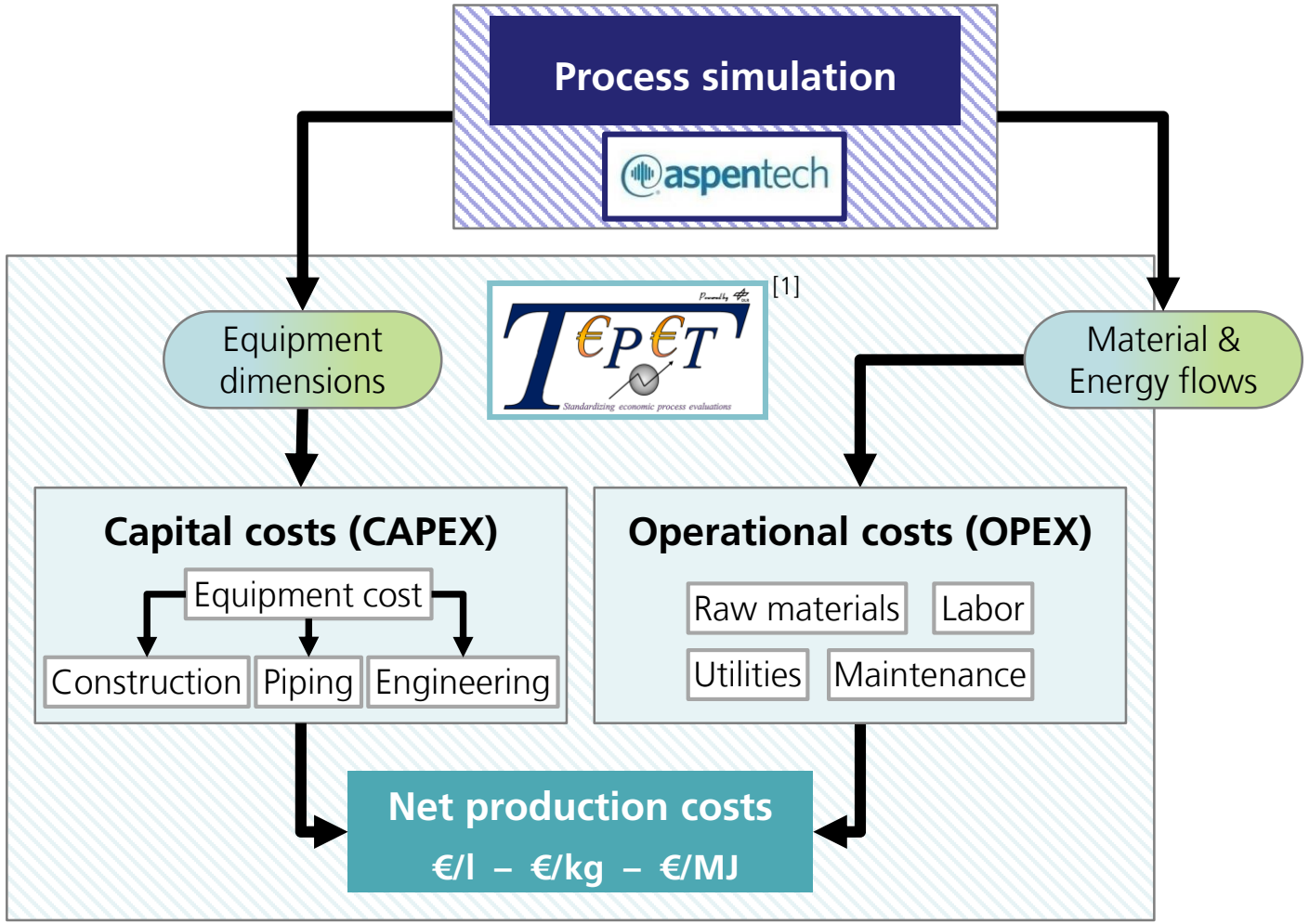
# LCA – Optimized integration in existing assessment system




- Adapted from **best-practice chem. eng. methodology**
- Meets AACE class 3-4, Accuracy: **+/- 30 %**
- **Year specific** using annual CEPCI Index
- Automated interface for **seamless integration**
- Easy sensitivity studies for **every** parameter
- Learning curves, economy of scale, …

[1] Albrecht et al. (2016) - A standardized methodology for the techno-economic evaluation of alternative fuels – A case study, Fuel, 194: 511-526
[2] Mutel (2017) - Brightway: An open source framework for Life Cycle Assessment, Journal of Open Source Software, 2(12): 236

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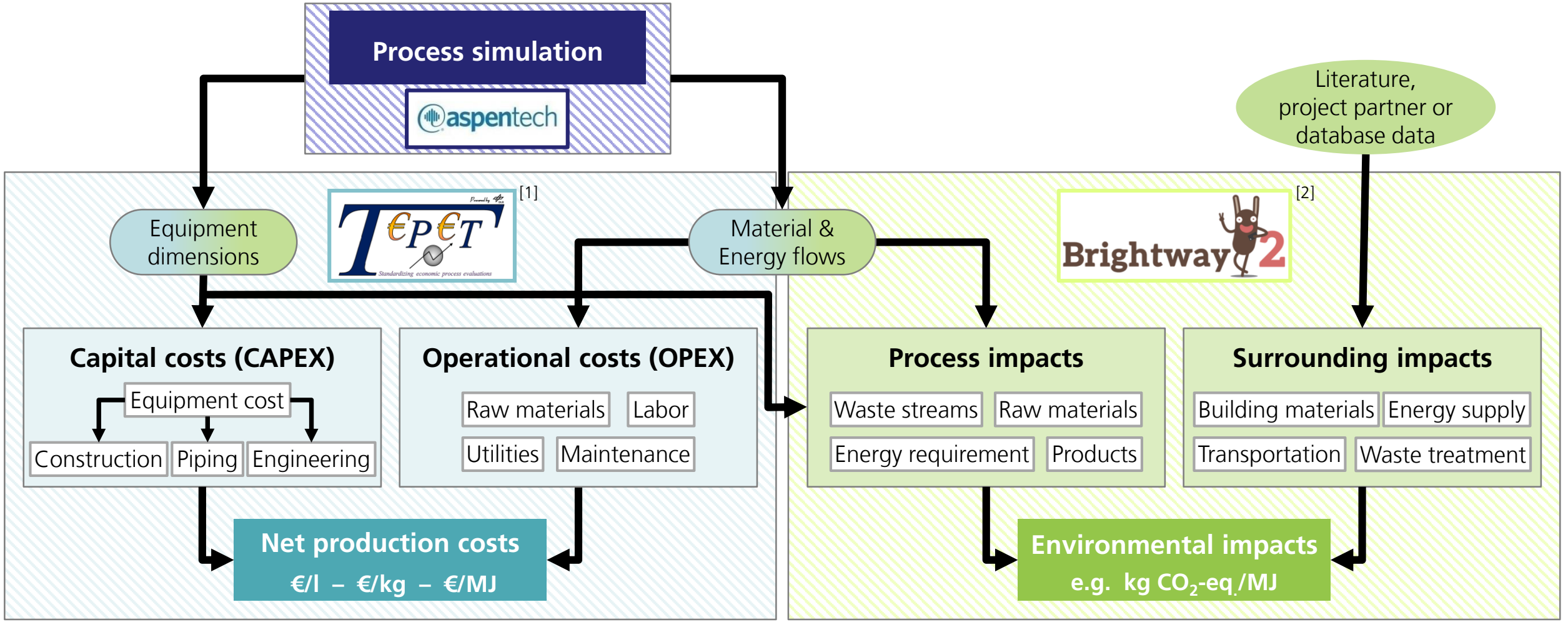


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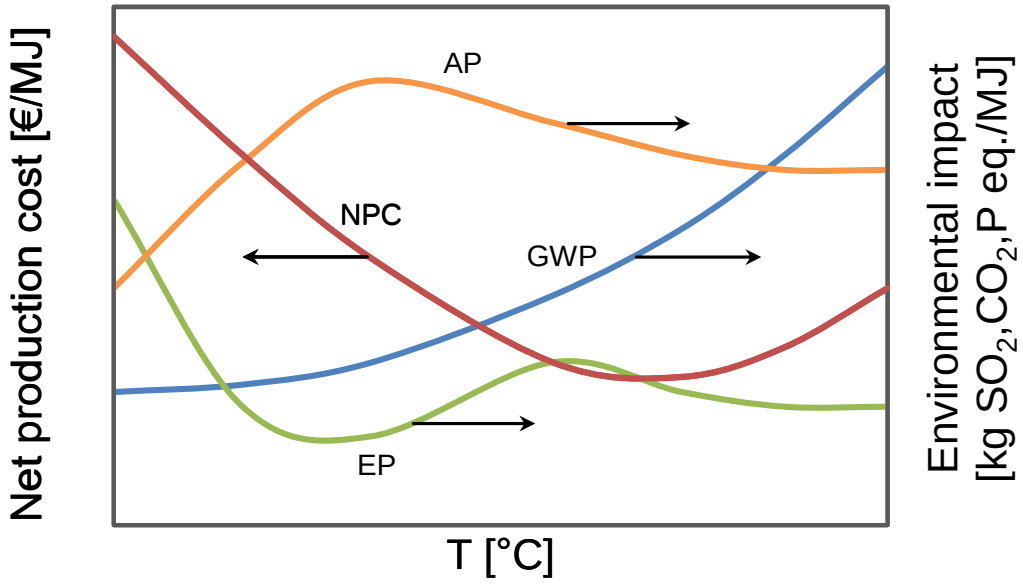
# Process simulation based LCA

- Environmental impact of FLEXCHX biofuel?
- Does the environmental assessment change the outlook on winter vs. summer mode?
- What is the environmentally optimized process configuration?

➢ Answers through process simulation based LCA

AP – Terrestrial acidification potential ($SO_2$ eq.)
GWP – Global warming potential ($CO_2$ eq.)
EP – Freshwater eutrophication potential (P eq.)




Schematic view of the net production cost (NPC) and environmental impacts in dependency to a particular process parameter (e.g. gasifier, reformer temperature etc.)

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# National Case studies for Finland, Lithuania and Germany

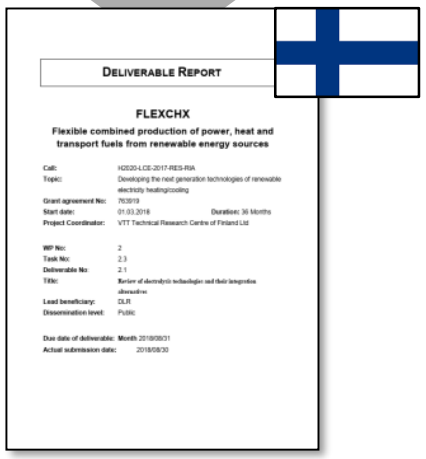
**Country specific market conditions**: Labor cost, district heating/power market, biomass price & availability

HELEN

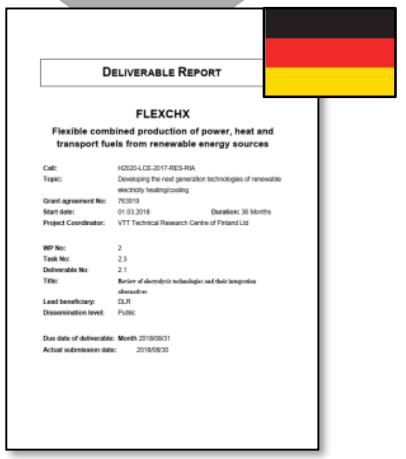
LITHUANIAN ENERGY INSTITUTE

DLR

**Investment cost estimates** DLR








**National economic feasibility studies**

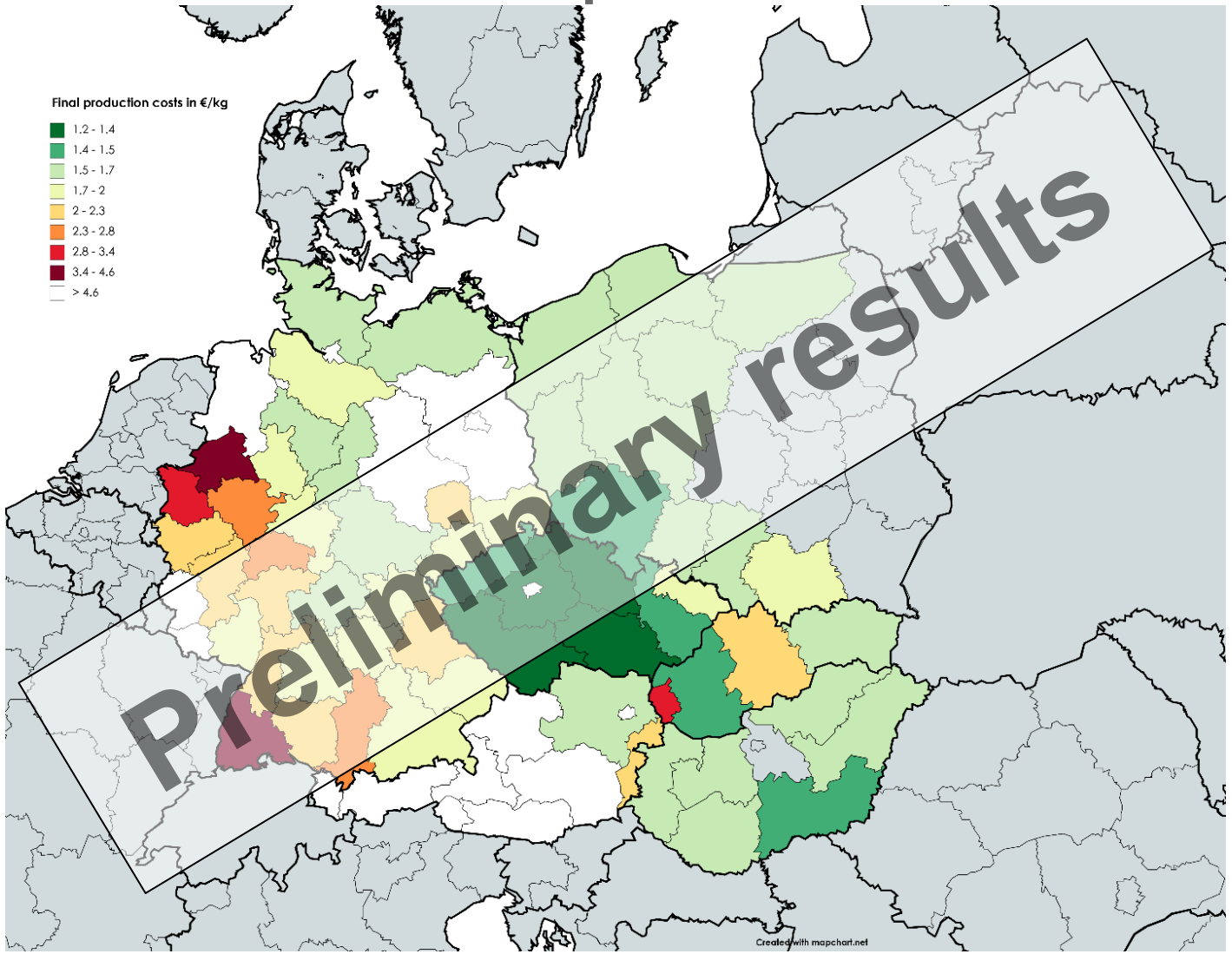
DLR

COMSYN project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727476

# Roadmap for Central-European business case: Example COMSYN

## Final production costs

- Assumptions:
  - Straw as biomass feedstock
  - Product refining at Litvinov ORLEN UniPetrol refinery
  - 20 years of plant life time
  - 10 % interest rate
  - 8260 h/a operation
  - 10 workers per shift



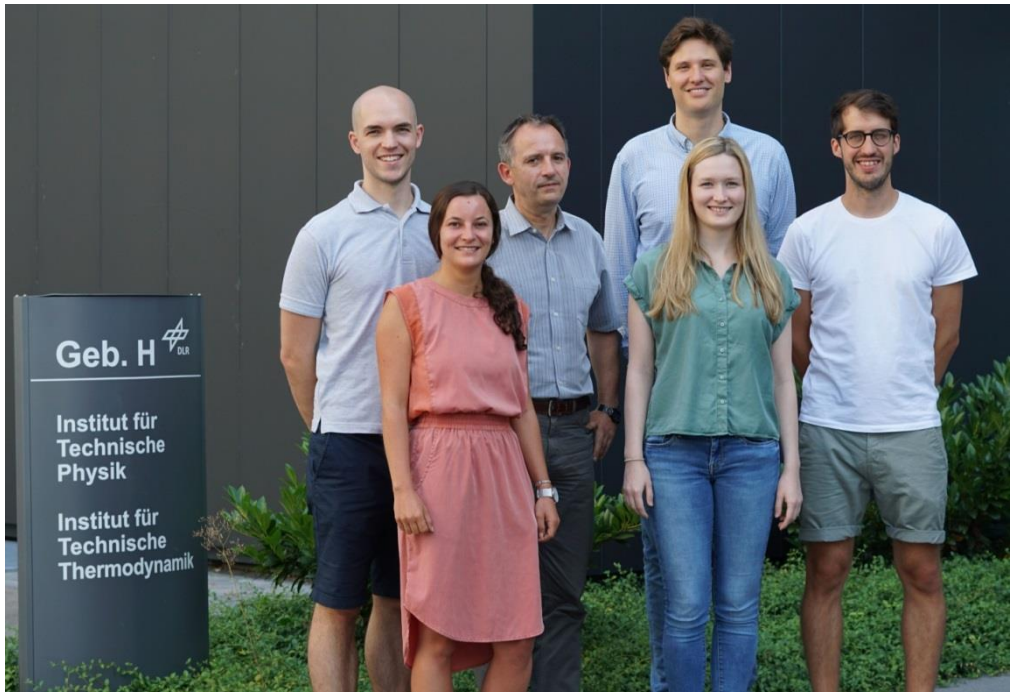
# Conclusion and outlook

- The **techno-economic analysis tool TEPET** enables an automated cost+performance evaluation of multiple process configurations and operating regimes
  - Successfully applied in multiple projects
  - Standard TEA tool in the national research initiative Energiewende im Verkehr [1]
- FLEXCHX process model incorporates **unit models based on project partner's experimental data**
  - Fuel efficiency: **≈ 57 % in** Summer (25 MW) and Winter **≈ 60 %** in Winter (50 MW)
  - 50 MW plant: Summer operation mode attractive @ renewable electricity price **< 20 €/MWh**
- **TEPET tool** was extended for **automated process simulation based life cycle assessment**
- Flexible input data for **individual national case studies** provided

Outlook:

- **National case studies** for **Finland** (Helen), **Lithuania** (LEI) and **Germany** (DLR)
- **Techno-economic analysis publication**
- **LCA results publication** planned

[1] https://www.dlr.de/vf/desktopdefault.aspx/tabid-2974/1445_read-52897




# THANK YOU FOR YOUR ATTENTION

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Research Area Techno Economic Assessment

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