COMSYN

Techno-economic Analysis and LCA
DLR's participation in COMSYN

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German Aerospace Center (DLR)

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Stuttgart/Karlsruhe

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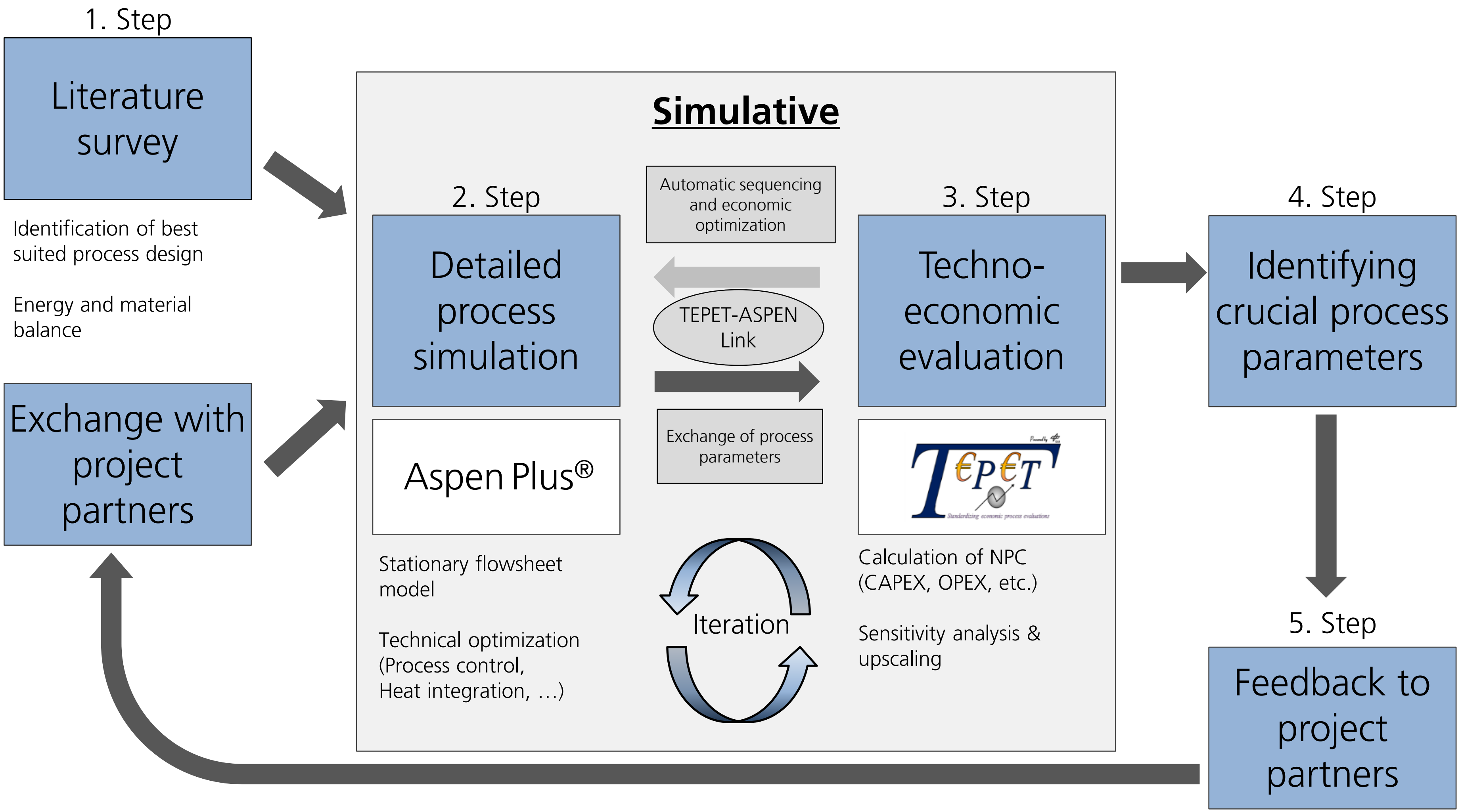
DLR Methodology



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Economical Analysis: Standardized Method

AACE Recommended Practice Class III + IV (Expected Accuracy: ±30%)

Process simulation results

Unit sizes

Energy/ Material flows

aspentech

TEPET

Capital costs
- Equipment costs
- Piping and installation
- Service facilities
- Engineering

Operational costs
- Raw materials
- Utilities
- Maintenance
- Labor

Net production costs (NPC) [€/l]

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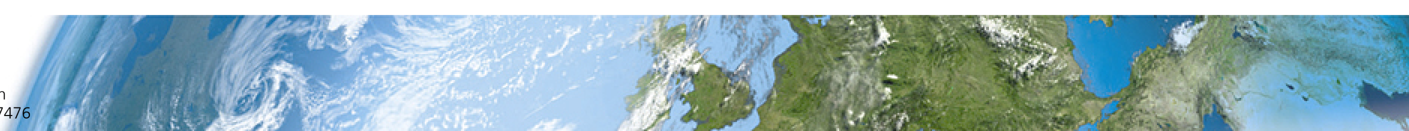

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- Equipment costs
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- Service facilities
- Engineering

Equipment costs for chemical plant size:

- Standard equipment (compressors, pumps, heat exchangers): Chemical engineering data from Peters, Timmerhaus, West[1]
- Non-standard equipment (reactors, electrolyzers): Literature survey, commercial offering

[1] Peters M., Timmerhaus K., West R., Plant design and economics for chemical engineers, 2004

Net production costs (NPC) [€/l]

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Economical Analysis: Standardized Method

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Process simulation results

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- Year-specific (2016) raw material prices and by-product revenues for Germany (stock market, market surveys)
- Labor costs based on German labor market

→ Adaptation for additional markets required

Operational costs

- Raw materials
- Utilities
- Maintenance
- Labor

Net production costs (NPC) [€/l]

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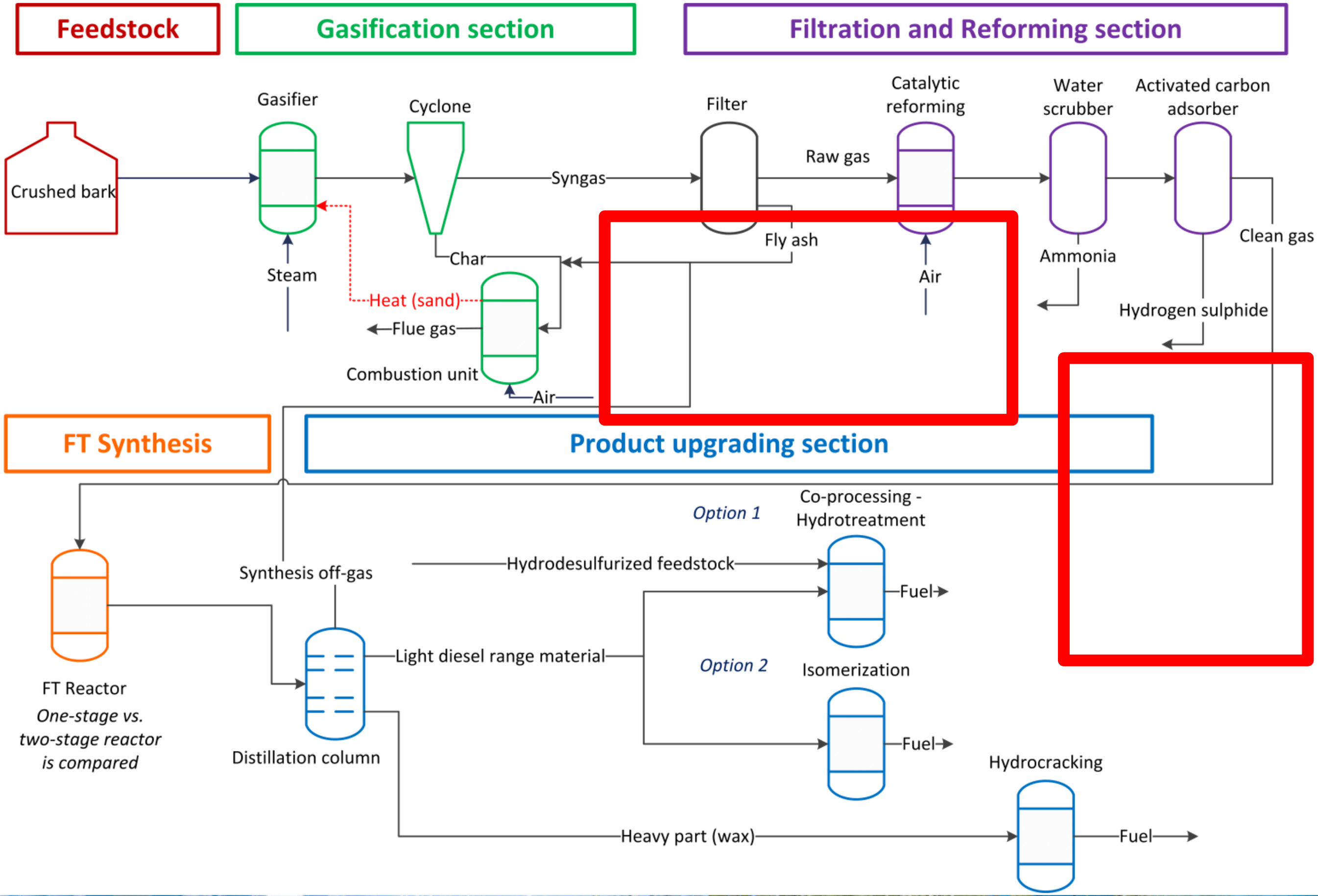
COMSYN task - process simulation
Flexible flowsheet model

3 example cases for the process improvement:

- 1st case
  Base case (see chart)
- 2nd case
  CO_2 removal
- 3rd case
  Allothermal reforming



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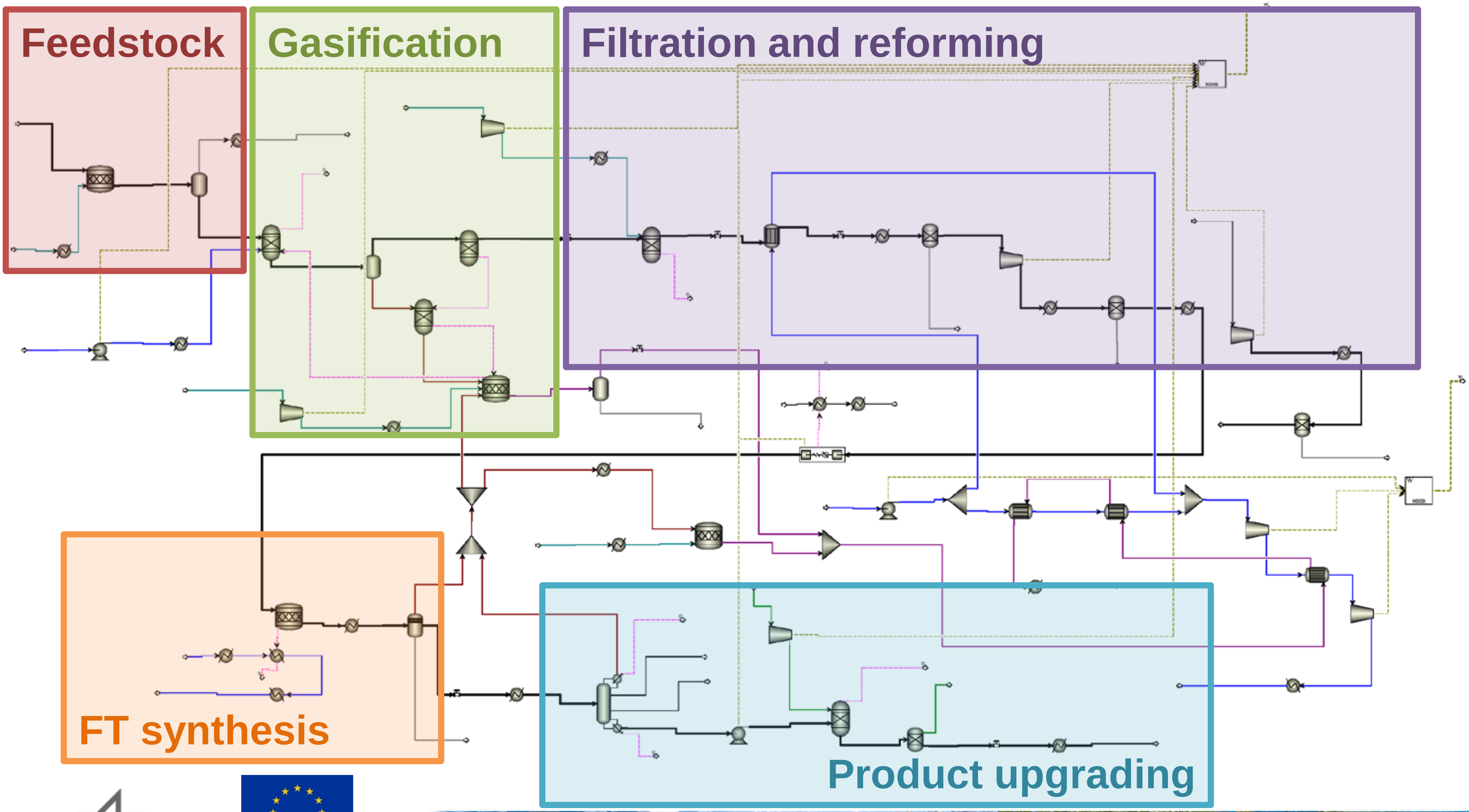
Aspen Plus Simulation – Base Case



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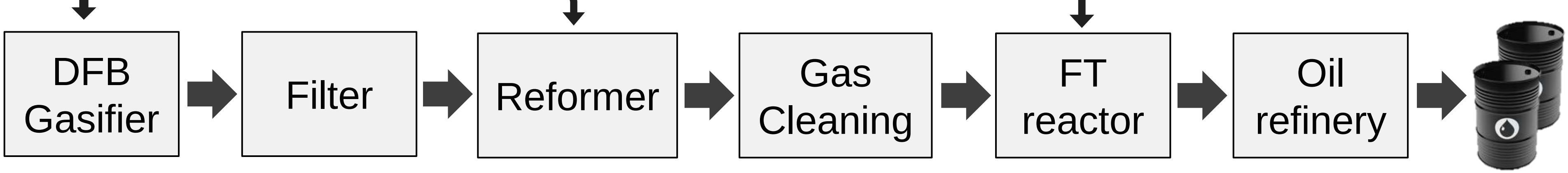
Simulation results

Preliminary data

- Dual fluidized gasifier @ 780°C and 1.5 bar
  - Autothermal/allothermal Reformer @ 900 °C and 1.3 bar
    - FT reactor @ 230 – 250°C and 20 – 30 bar
      - First results modelled with: chain growth probability (α): 0.81
        CO conversion: 75 %



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Simulation results with preliminary data
Overview

- Input: 20 t/h biomass (98 MW_{th})

	Units	Case 1 Base case	Case 2 CO_2 removal	Case 3 alloth. reformer
Power consumption	MW_e	**9.8**	**8.1**	8.4
FT-product	t/h	2.7	2.7	3.2
(LHV = 44 MJ/kg)	MW_{th}	32.7	32.8	39.1
Efficiency (BtL)	%	**30.4**	30.9	**36.8**
En. Efficiency	%	76.7	76.8	79.3
Carbon usage	%	21.9	21.9	26.2

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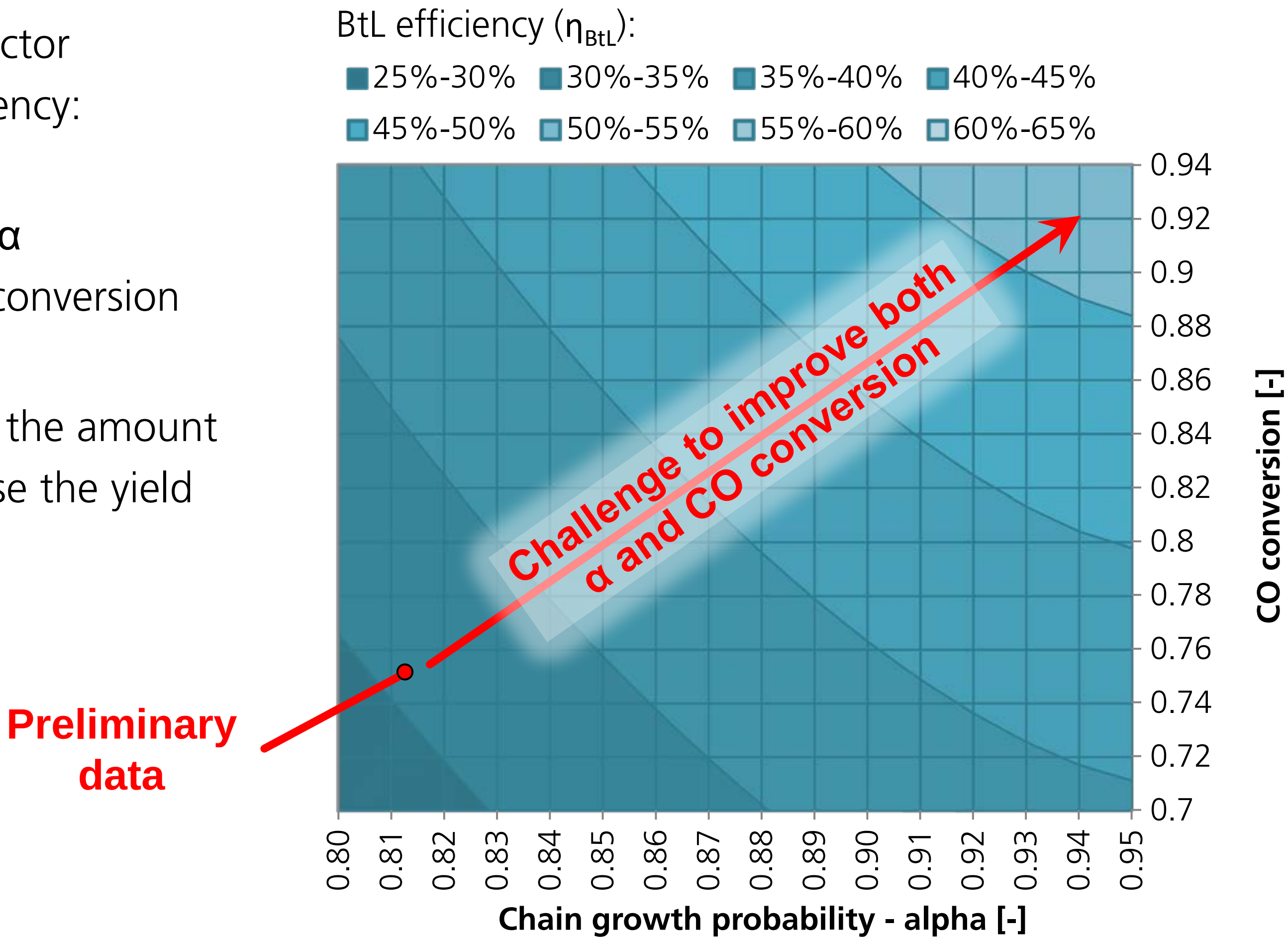
Case 1 – Base case results:
Investigating of the impact of the FT operating conditions

Strong impact of FT reactor conditions on BtL efficiency:

- η_{BtL} increases with…
  … increasing ASF α
  … increasing CO conversion

Both parameter reduce the amount of FT-tailgas and increase the yield of FT-waxes



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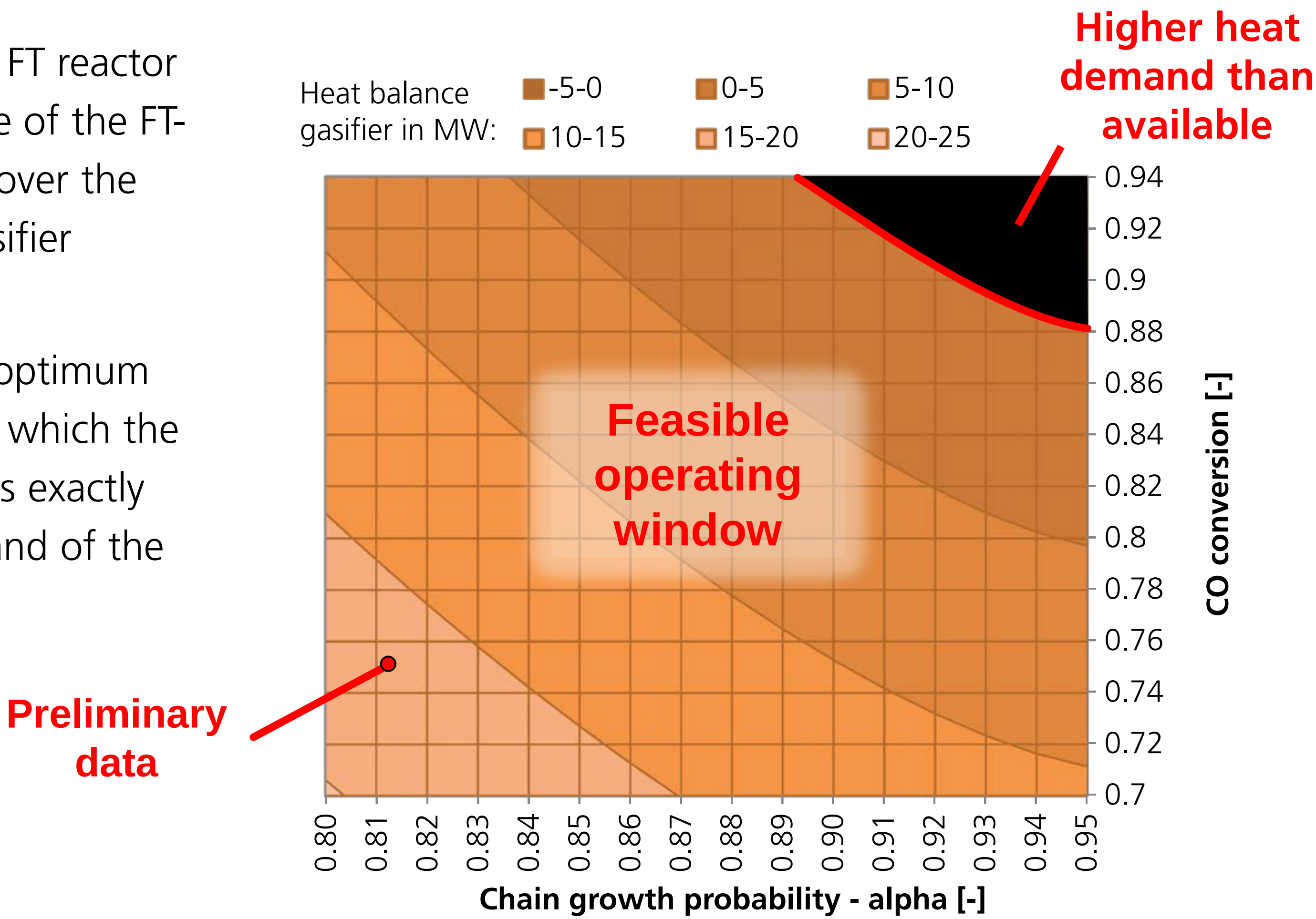
Case 1 – Base case results:
Investigating of the impact of the FT operating conditions

Process conditions limit FT reactor optimization since some of the FT-tailgas is necessary to cover the required heat in the gasifier

The red line marks the optimum operating conditions at which the energy flow of FT-tailgas exactly matches the heat demand of the gasifier



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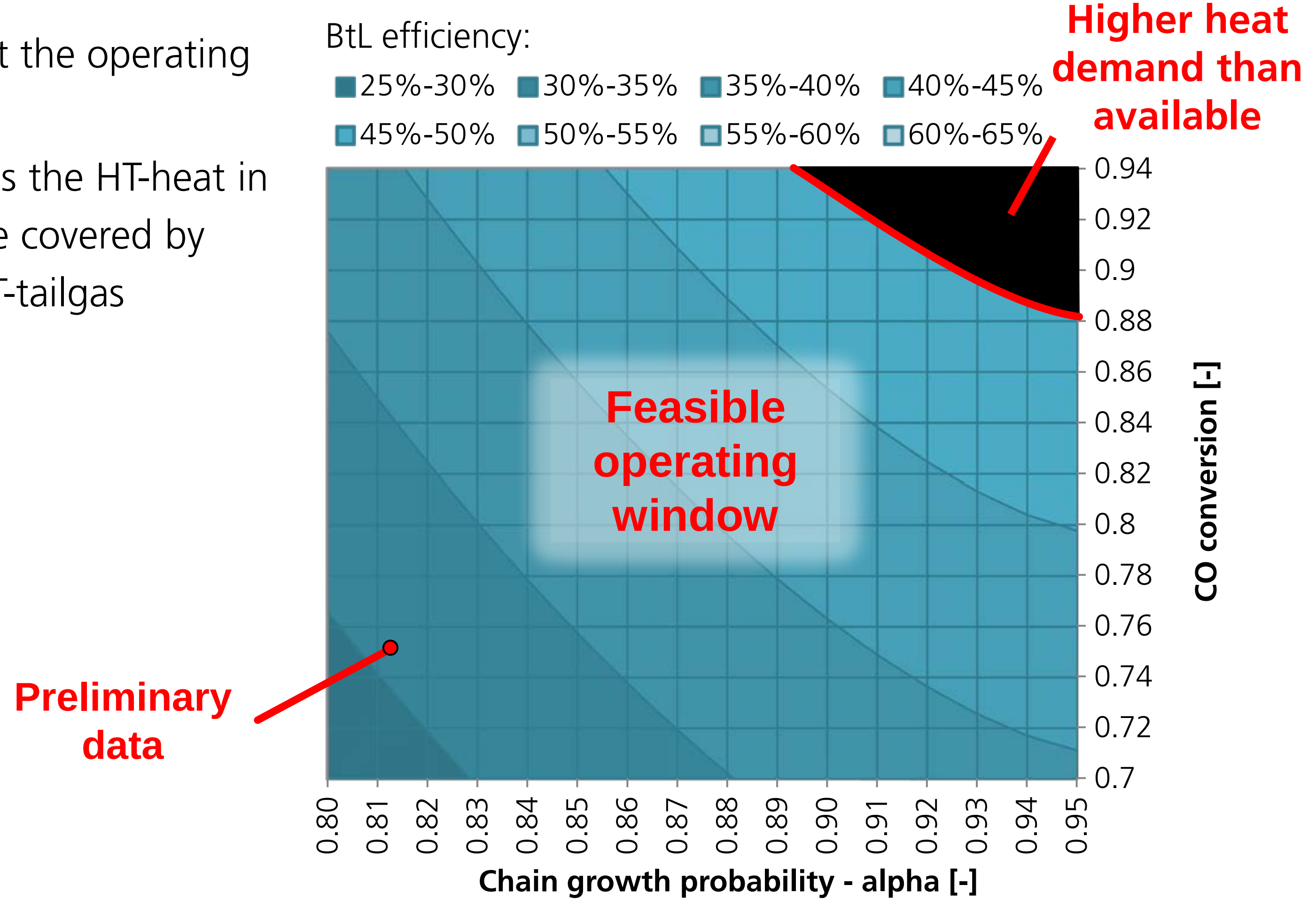
Case 1 – Base case results:
Investigating of the impact of the FT operating conditions

System restrictions limit the operating window:

In the COMSYN process the HT-heat in the gasifier needs to be covered by burning some of the FT-tailgas



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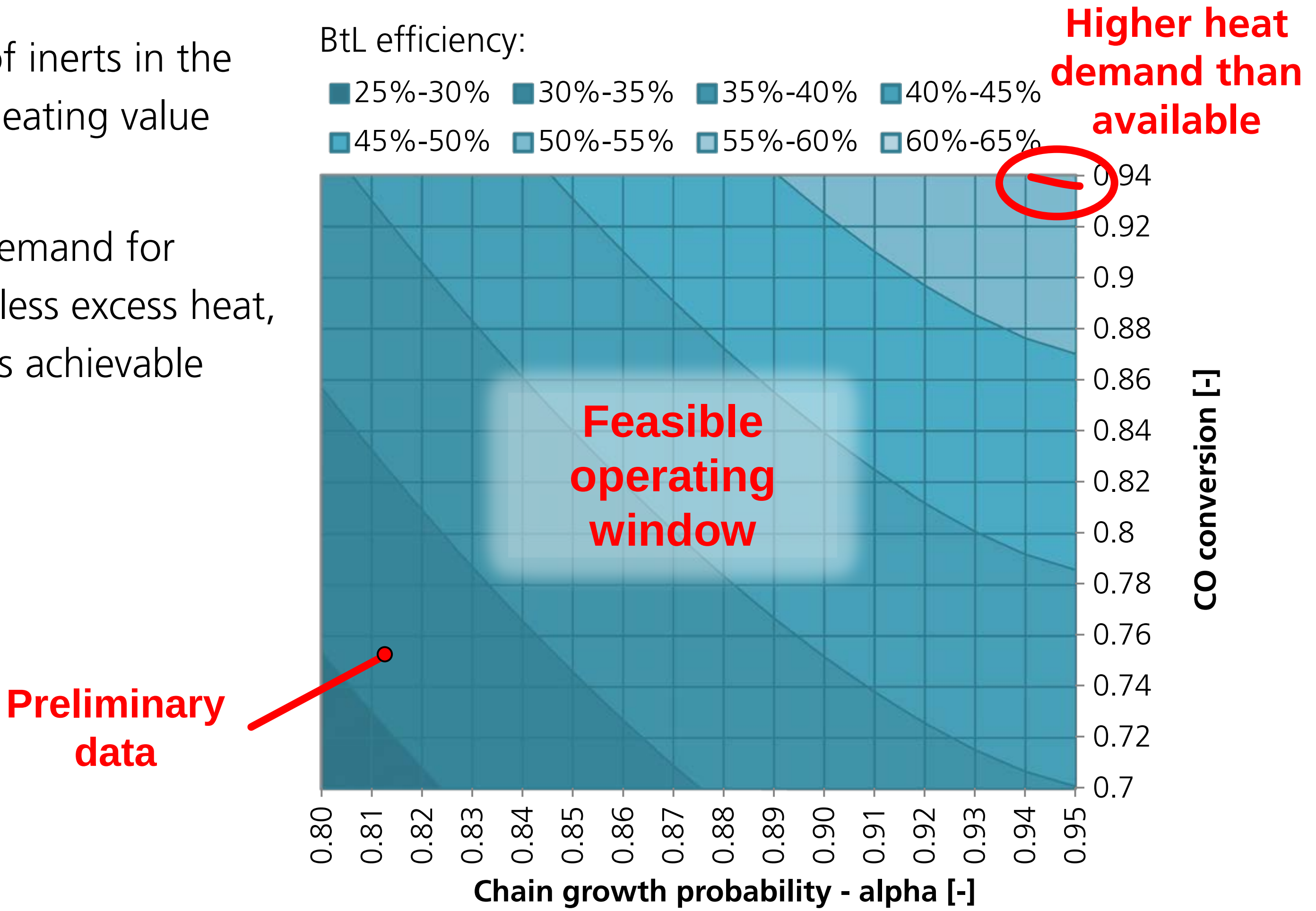
Case 2 – CO_2 removal:
Investigating of the impact of the FT operating conditions

Reducing the amount of inerts in the FT-tailgas increases its heating value

→ Lowering the heat demand for the gasifier leads to less excess heat,
➔ higher efficiencies achievable



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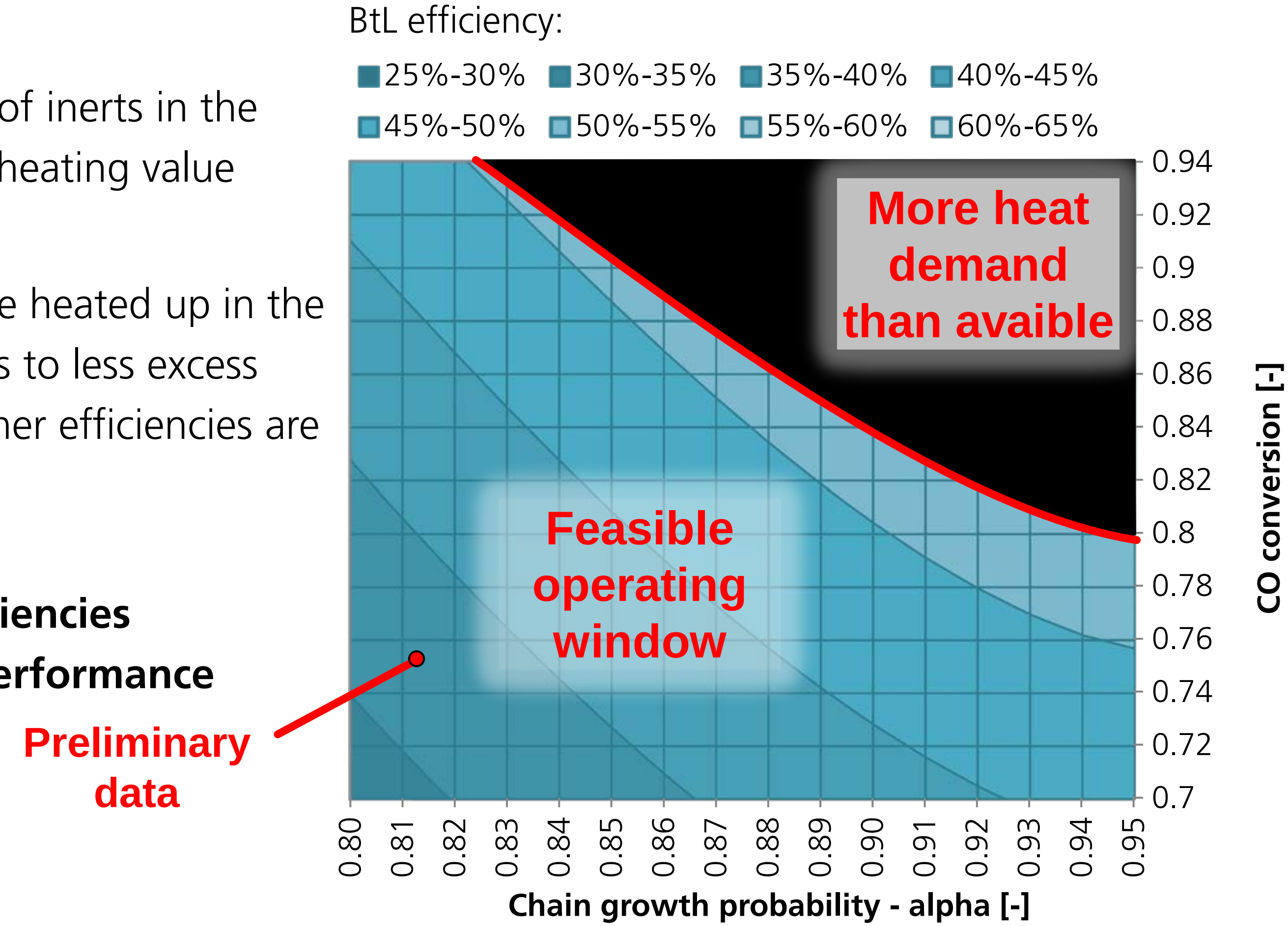
Case 3 – allothermal reformer:
Investigating of the impact of the FT operating conditions

Same effect as before:

Reducing the amount of inerts in the FT-tailgas increases its heating value

→ Less gas needs to be heated up in the gasifier, which leads to less excess heat, therefore higher efficiencies are achievable

→ Case 3 allows very **high BtL efficiencies at moderate FT performance**



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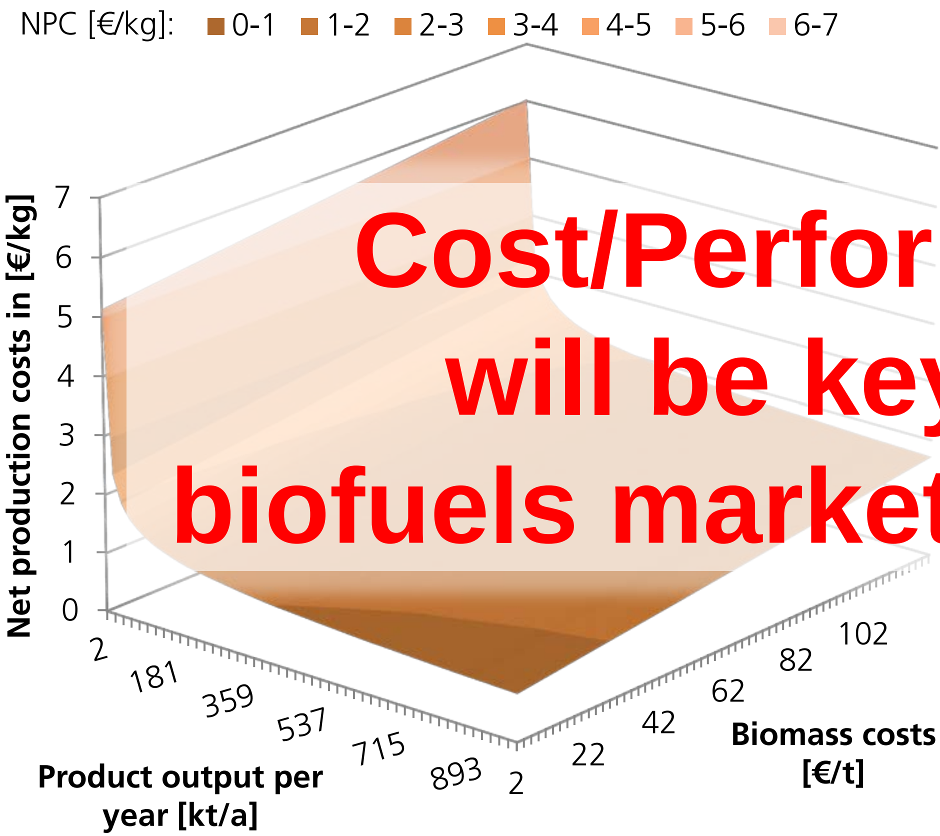
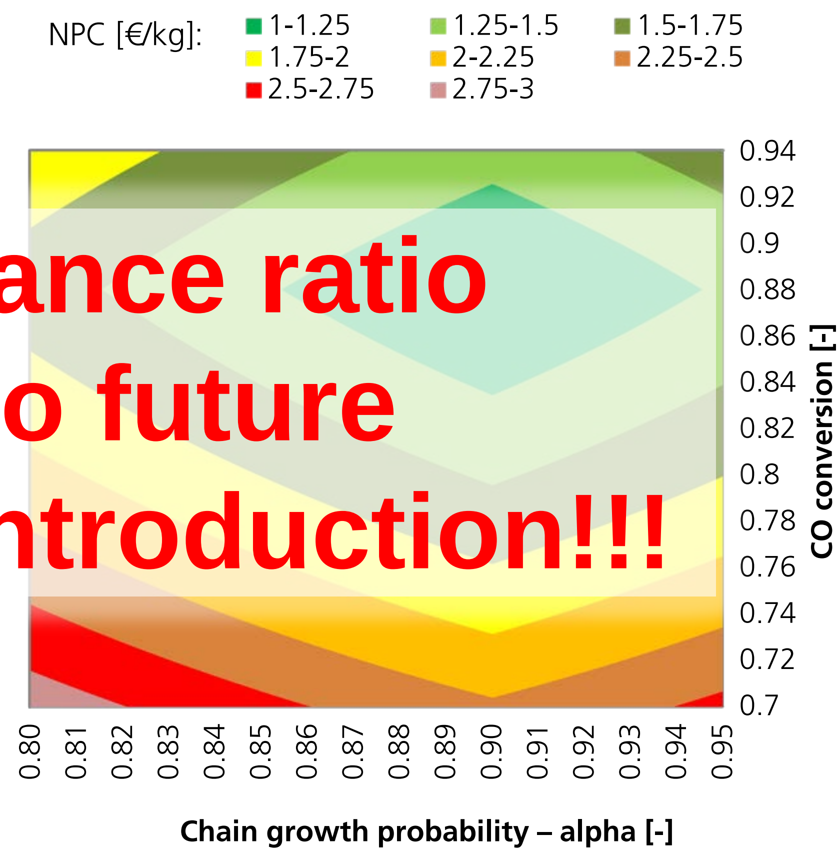
Outlook 1: Cost estimation





Cost/Performance ratio will be key to future biofuels market introduction!!!

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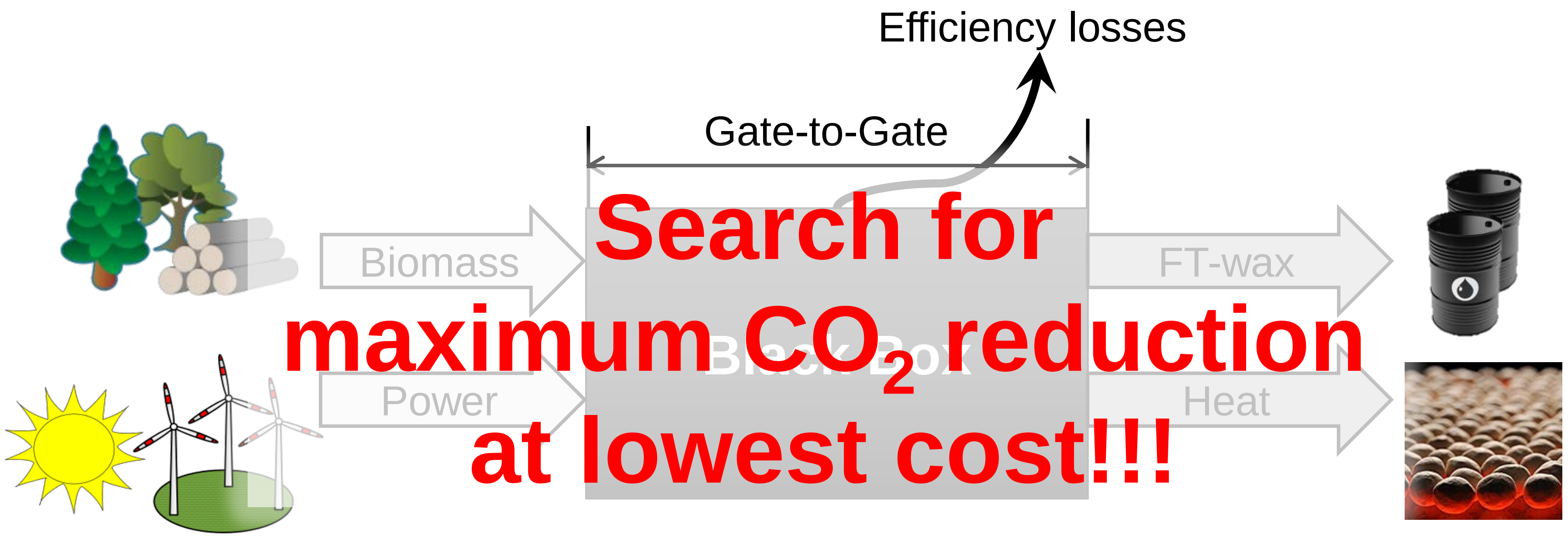
Outlook 2: Life cycle analysis



- Assigning ecological impact (e.g. CO_2, CH_4, NOX,…) to material and energy streams
- Ecological footprint for products and by-products and comparison between process options

→ mitigation potential/costs for e.g. GHG emissions (CO_2-equivalent), CO_2 emissions (reference?)

$$CO_2 - Abatement\ costs\left[\frac{€}{t_{CO_2}}\right] = \frac{Difference\ in\ fuel/heat/H_2\ costs}{CO_2 - emission\ reduction}$$

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Outlook 3: Ongoing Dissemination

- **2nd workshop in Czech Republic, 2019**
  - raise your interest to VTT
- **3rd workshop in Finland, 2020**
  - TBD
- **COMSYN summer school, 2021**
  - Ph.D. student gathering across Europe

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Thank you for your attention!

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