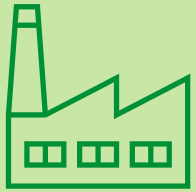
DECARBONISED ENERGY SUPPLY AT PAPER PRODUCTION SITES

A Decision Support Tool based on Mathematical Programming



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NEFI Conference – Technology Talk
Decarbonisation of the Paper Industry – Perspectives, Opportunities, and Innovative Solutions
Vienna, October 25th, 2024

This work and the corresponding project DekarPIO (Dekarbonisierung der Branche Papier- und Zellstoff-Industrie mittels mathematischer Optimierung) were initiated and funded by FFG (FFG, No. 907007).

INDUSTRIAL TRANSITION - THE ROLE OF OPTIMIZATION

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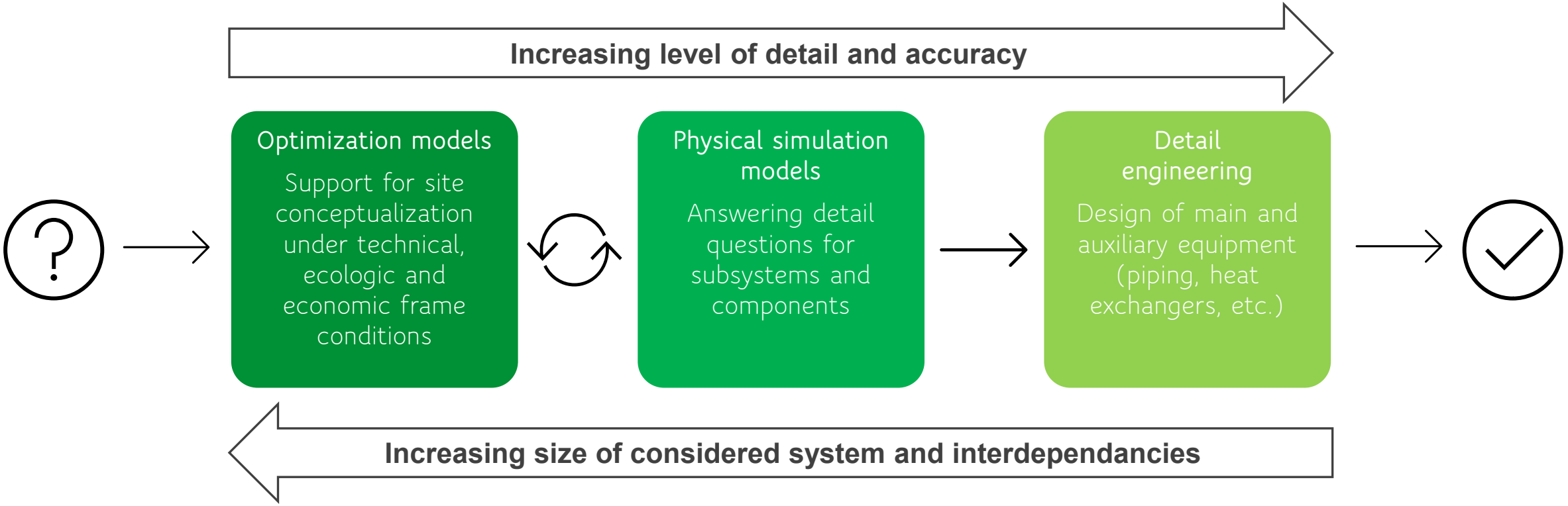
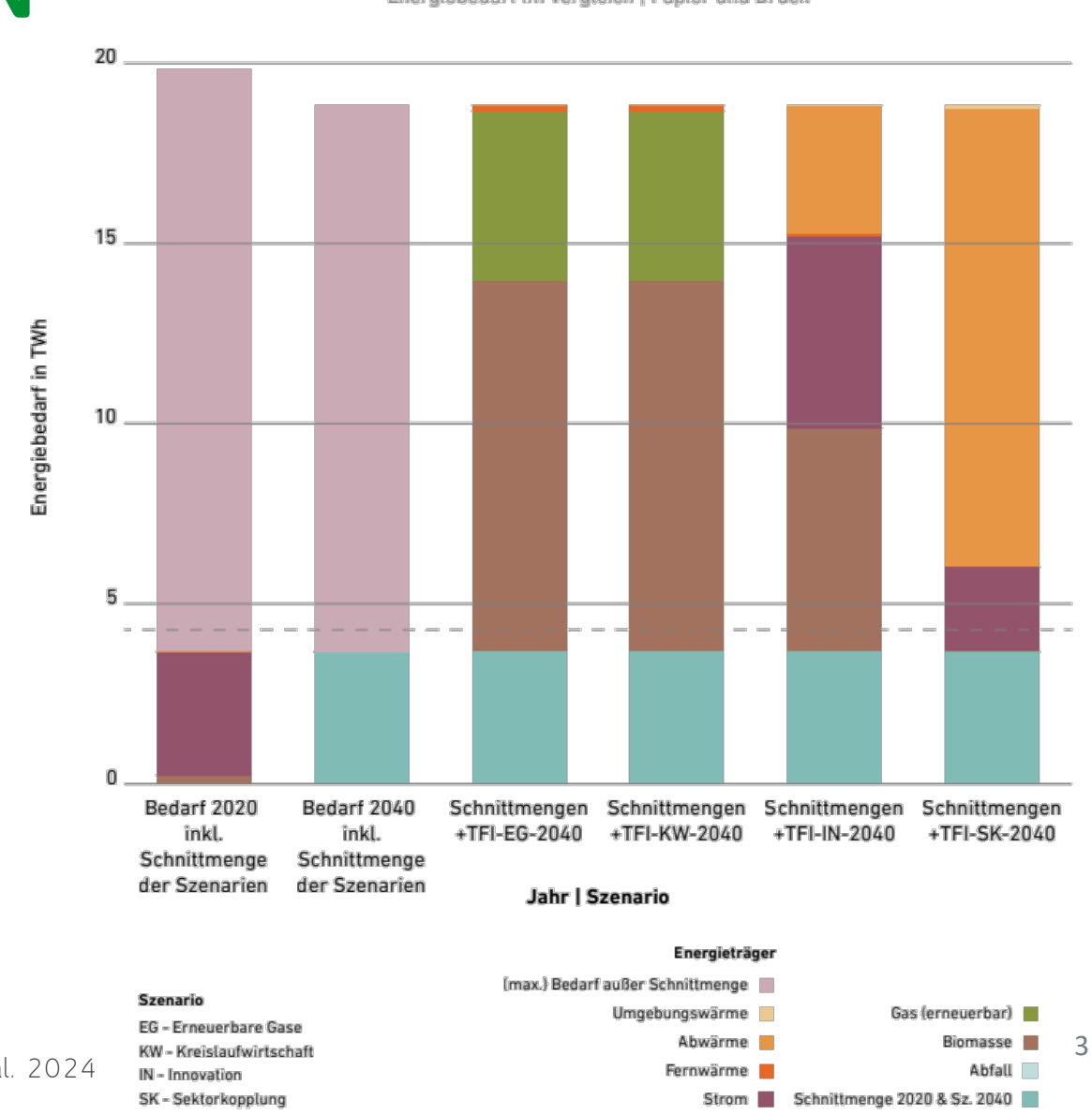
Interfaces to further methods supporting decision processes



STRATEGIES FOR INDUSTRIAL DECARBONIZATION

- Fuel change
  e.g. renewable gases, biomass, internal and external residual fuels (sludge, bark, biogas, etc.)
- Electrification
  e.g. power-to-heat boilers, (steam) heat pumps
- Increased recycling rates
  realizability depends on product (e.g. quality, hygienics)
- New processes
  efficiency potentials (e.g. heat recovery, control), disruptive new technologies (barrier of long machinery life-time)



Source: Schützenhofer et al. 2024

A DESIGN OPTIMIZATION MODEL FOR THE PULP AND PAPER SECTOR

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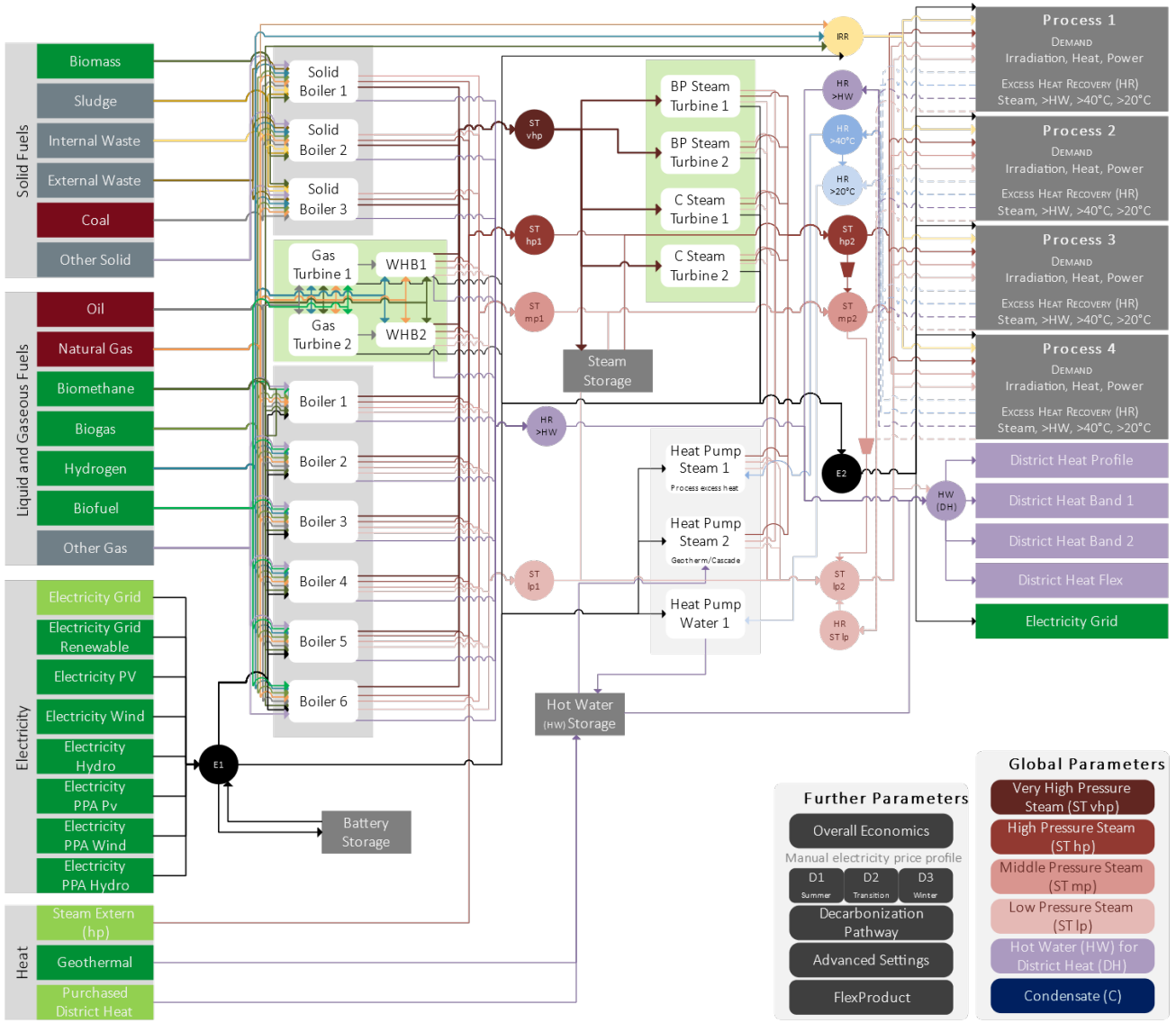
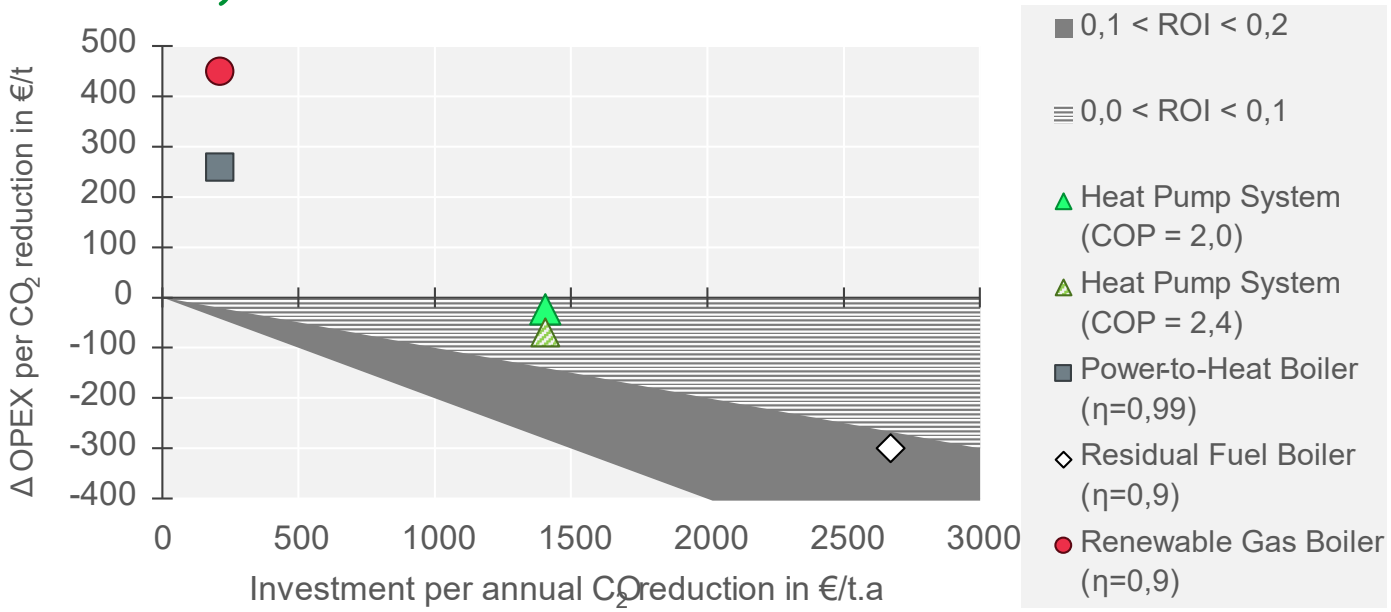
- A **user-friendly** but a still representative tool
- Simplified and applicable **for non-optimization experts**
- **Customizable** - realized with company specific user profiles and options to specify, parametrize and save specific configurations
- Initially configured for paper factories, also suitable for other types of production sites of this sector
- Technologies and fuels are chosen based on **current supply concepts** in the paper sector and **possible adaptions**



DECARBONIZATION „MERIT ORDER“

Electrification vs. Fuel Change (in new boilers)

- Comparison vs. reference
  natural gas-fired steam generator
- Focus
  heat provision
- Additional benefits (here not considered)
  - CHP readiness (boilers)
  - Water recovery (heat pumps)
- Different **(site-specific) prerequisites** cause different optimal solutions
  - Availibility of (long-term cheap) internal and/or (close) external residual fuels
  - Sufficient electric grid capacity and/or ideal combinations of direct power-purchase-agreements and on-site generation
  - Availibility of renewables gases

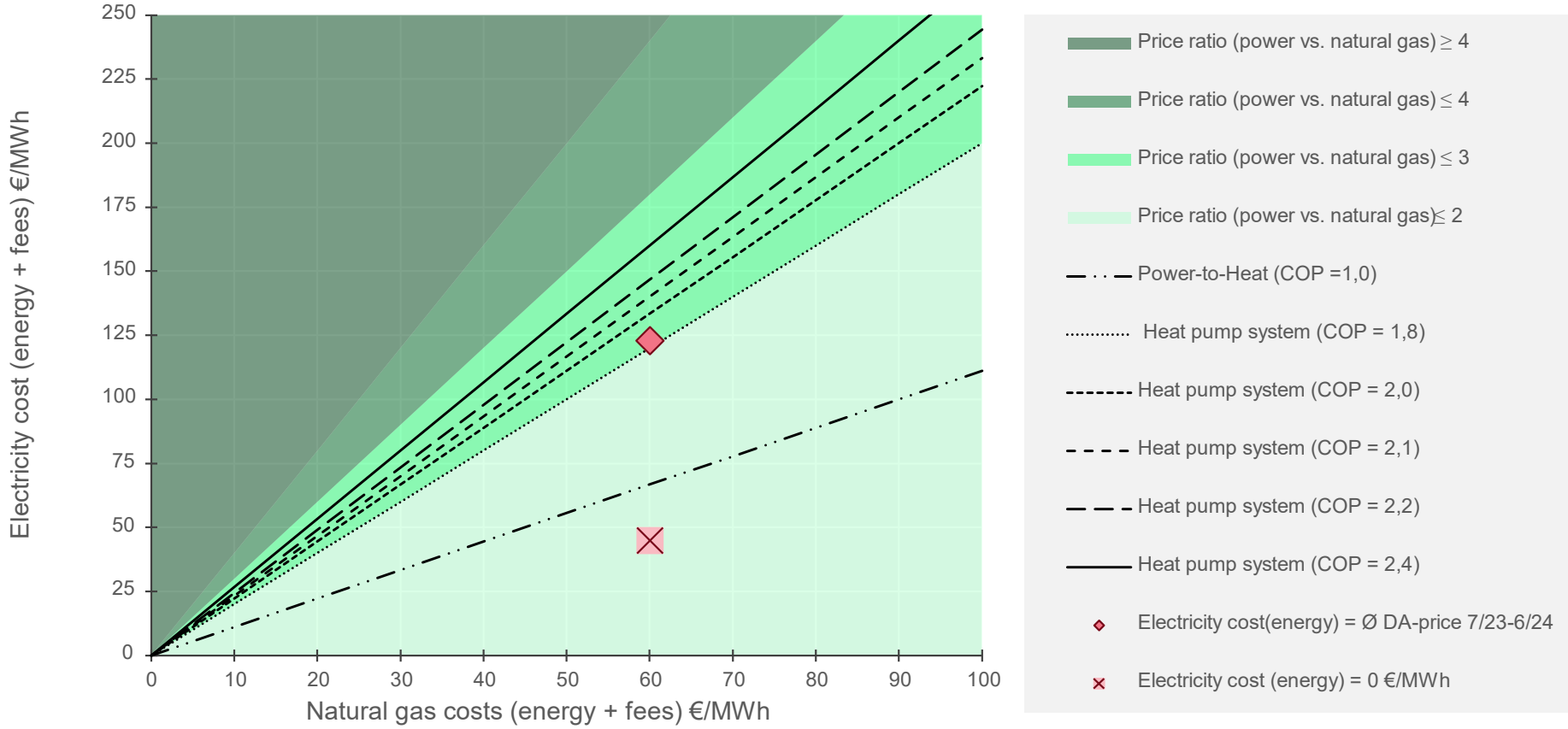


*Actual values depend of technology-specific parameters, for this analysis literature- based values were assumed

OPERATIONAL PERFORMANCE OF ELECTRICIFICATION STRATEGIES

Performance optimization for heat pump systems (increase of coefficient of performance)

- Adaption of steam temperature to actual needs
- Usage of high temperature sources (might not be available on-site)
- Provision of base-load
- Combination of closed loop heat pumps with steam compressors

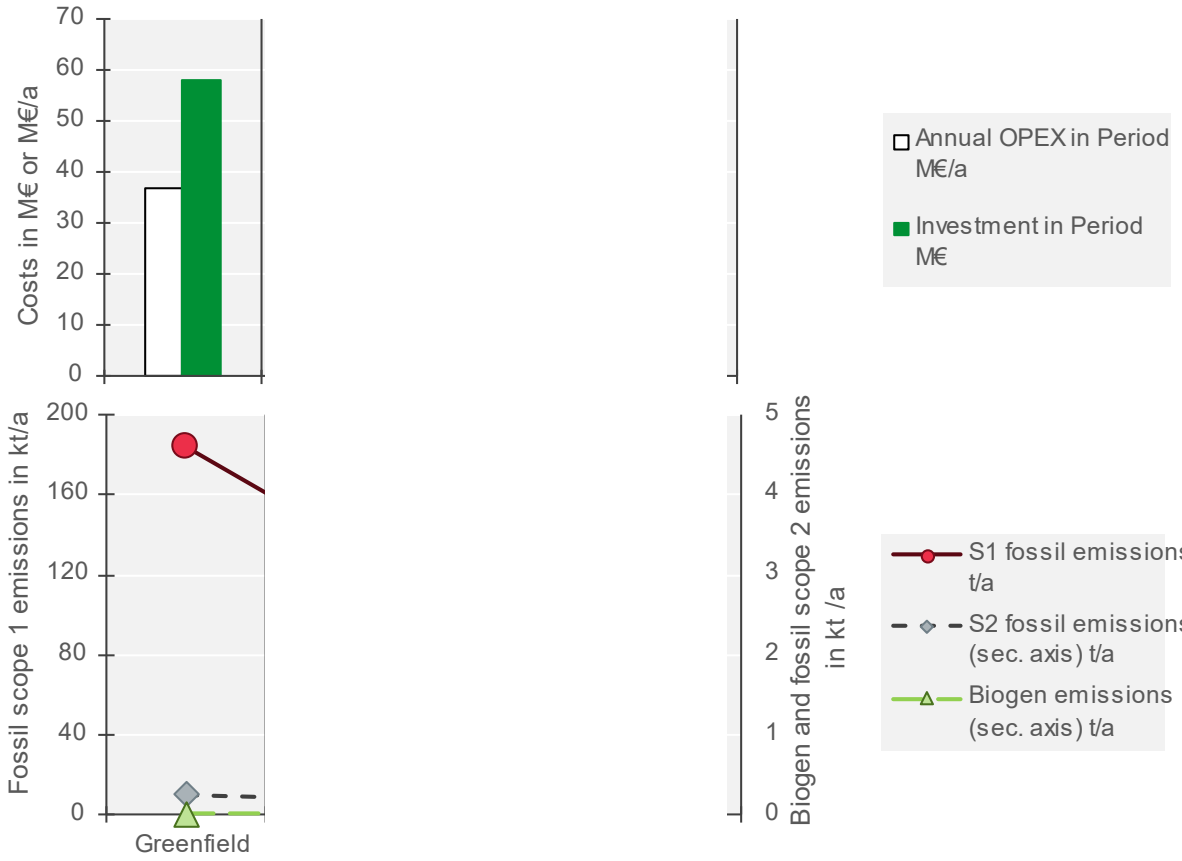


USE CASE FROM OPTIMIZATION TOOL

Generic paper mill with 300 kt/a production

- **Raw material** market pulp
- **Superstructure** includes various boilers (no residual fuel boiler), turbines, PV, heat pumps, etc.
- **Greenfield design (min Cost, no decarbonization)**
  - almost 100% on-site electricity generation
  - Gas turbine + boiler
  - Fossil fired boiler + steam turbine
  - PV
- **Towards a decarbonized „Net-Zero“ solution**:
  - Stepwise integration of steam generating heat pump supplied with industrial excess heat and renewable electricity

Visualization of generic decarbonization path

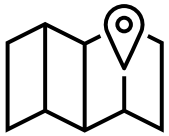


Results depend on „enabled and allowed“ structure!

CONCLUSIONS AND DISCUSSION

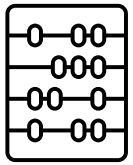
ACTUAL IMPLEMENTATION POTENTIAL OF TECHNOLOGIES IS SITE SPECIFIC

- Limitations such as space, logistics, local availibility and prices of non-grid-bound energy carriers, unused capacity of electric grid connection, or even legal boundary conditions



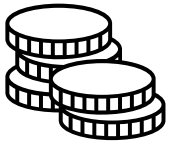
ADVANTAGES OF COMPREHENSIVE OPTIMIZATION MODEL

- First assessments of economic and ecologic performance indicators
- Scenario calculations in a reasonable time (seconds to minutes)



DECARBONIZATION

- Can cause significant increase of energy related costs and change the structure in the energy system (transition from producer to consumer)



THANK YOU

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LITERATURE

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