FME HighEFF

Centre for an Energy Efficient and Competitive Industry for the Future

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Abstract

This memo is presenting the results of the ongoing NEC projects CETES and BUSMod, given at the HighEFF Spring meeting in May 2020.

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1 Cost-efficient thermal energy storage for increased utilization of renewable energy in industrial steam production – CETES

2 Shared resources – The process towards collaboration

Cost-efficient thermal energy storage for increased utilization of renewable energy in industrial steam production – CETES

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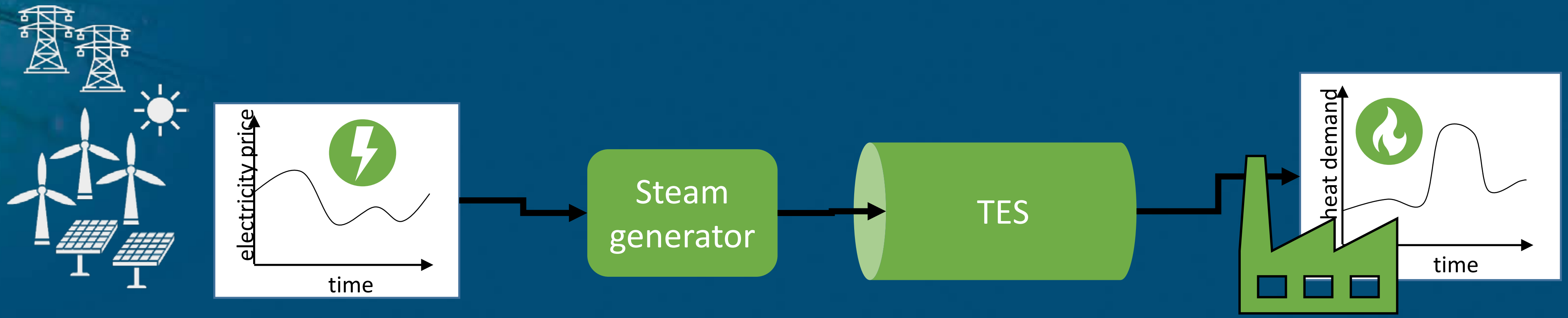
CETES – Why?

- Today **steam** production is mostly fossil based
- Share of **fluctuating energy sources** increases in future decarbonized, electricity driven energy systems
- **Active market participation** from industry required for stable and flexible electricity supply.

➔ <u>Thermal energy storage + Power-to-Heat enables renewable-based steam production.</u>



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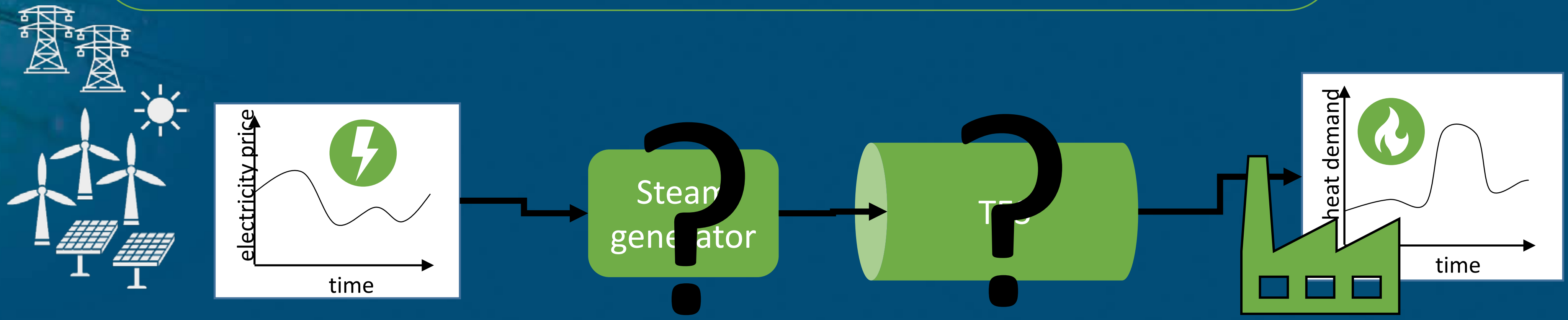
CETES – Why?

- TES + P2H can **decrease energy costs** by shifting the electricity consumption to low-cost periods.
- **Short payback time** and profitability are key criteria for investment decisions

➔ **Problem:** How can we identify the most cost-efficient TES system?

Considering:

– Technical restrictions
– Available conversion technologies and
– Time-dependent energy prices and process demand



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CETES – What?

CETES is developing methods to enable cost-efficient usage of fluctuating renewable energy sources in steam production:

- Identify the most cost-efficient storage technology
- Find the optimal storage size
- Optimize operation

In addition, the cost-optimal P2H conversion technology is selected for the individual case.

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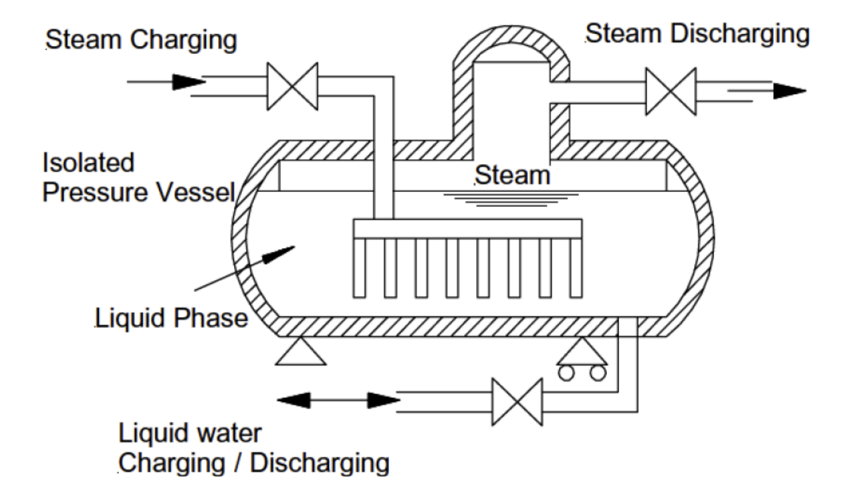
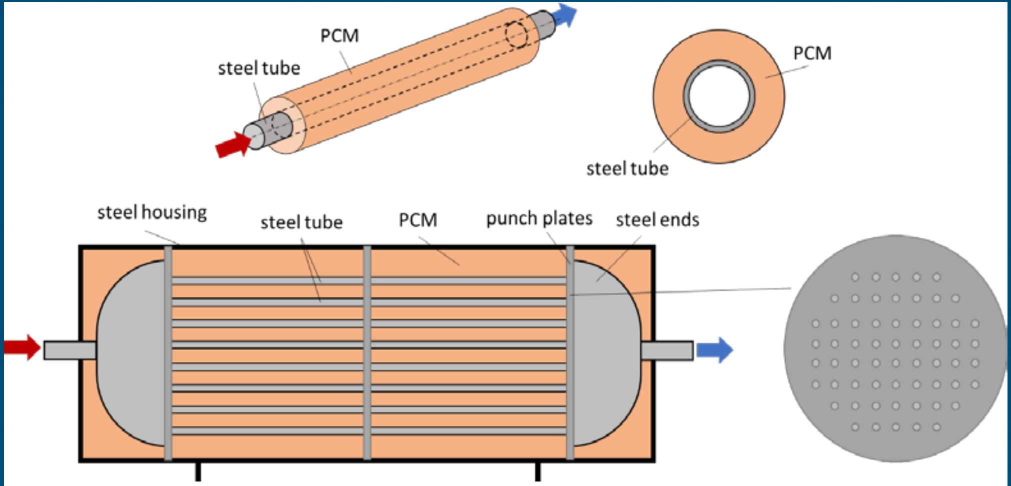
CETES – Storage Technologies



Ruth's steam accumulators



Latent Heat Thermal Storages (LHTS)

Molten salt storages

Concrete storages

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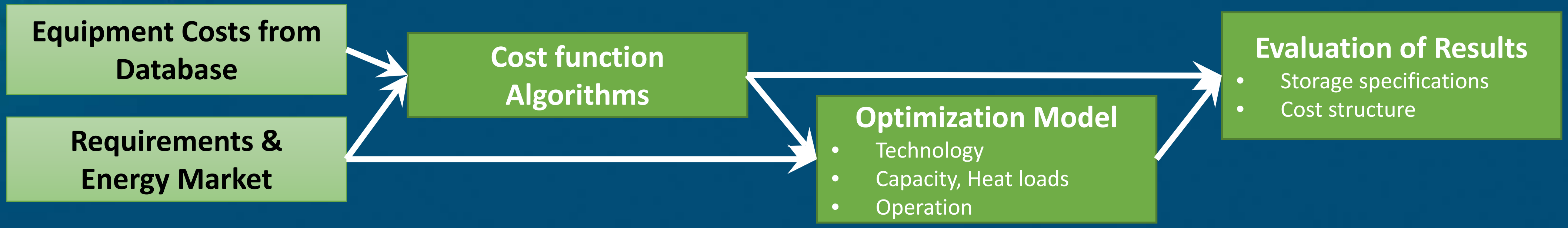
CETES – How?

- **Costs** are based on equipment costs from **database**
- **Cost functions** are established for
  - … **each storage technology** for
  - … **each individual use case**
  - considering relevant cost drivers
- **Optimization model** uses cost functions to identify optimal technology, size and operation in terms of **capacity & heat load profiles**
- **Results** from optimization are **evaluated**
  - Storage specifications
  - Cost structure



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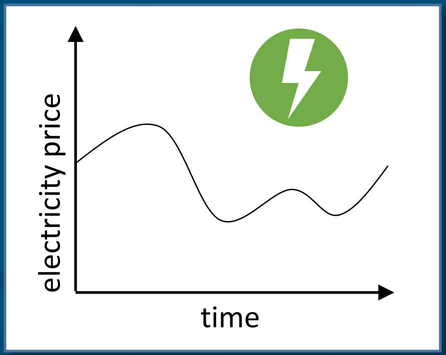
CETES – How?

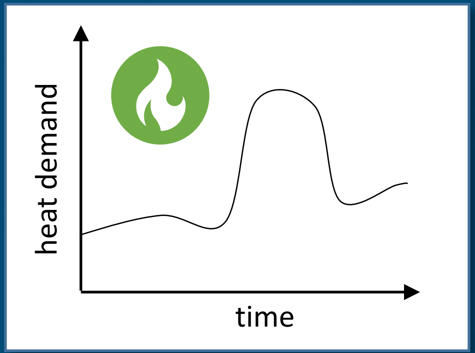
Equipment costs from Database:

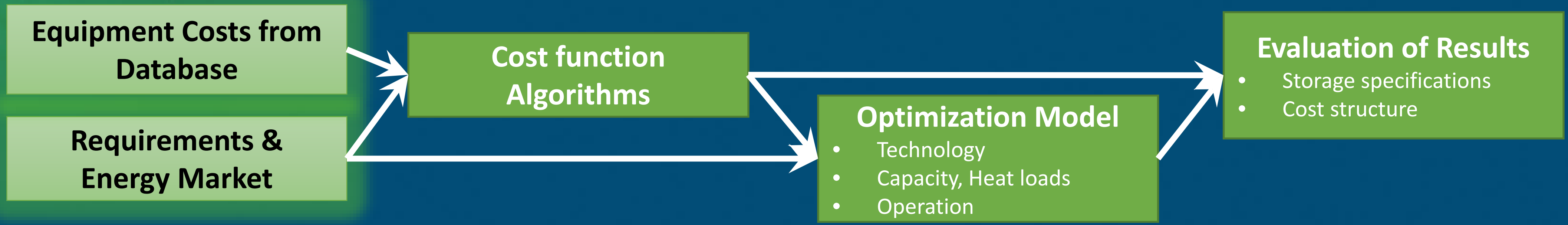
- Piping,
- Vessels, Tanks,
- Valves,
- Instrumentation,
- Insulation,
- Pumps, Motors,
- Storage Material,
- …

Requirements & Energy Market:

- Steam demand (temperature, heat flow)
- Energy markets (fluctuating energy prices)







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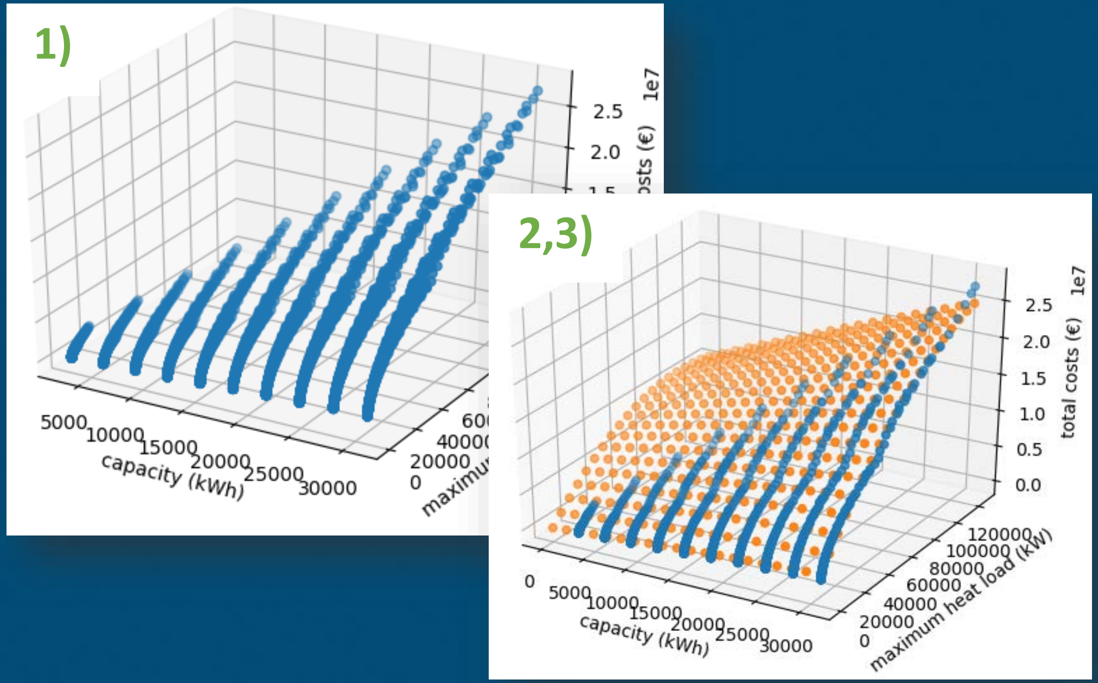
CETES – How?

Cost function algorithms:

1. Calculate costs for lots of different storage configurations → Datapoints
2. Eliminate suboptimal datapoints (if necessary)
3. Linear / Polynomial fit for optimal datapoints

$$costs = f(capacity, heat\ load)$$



Equipment Costs from Database

Requirements & Energy Market

Cost function Algorithms

Optimization Model
- Technology
- Capacity, Heat loads
- Operation

Evaluation of Results
- Storage specifications
- Cost structure

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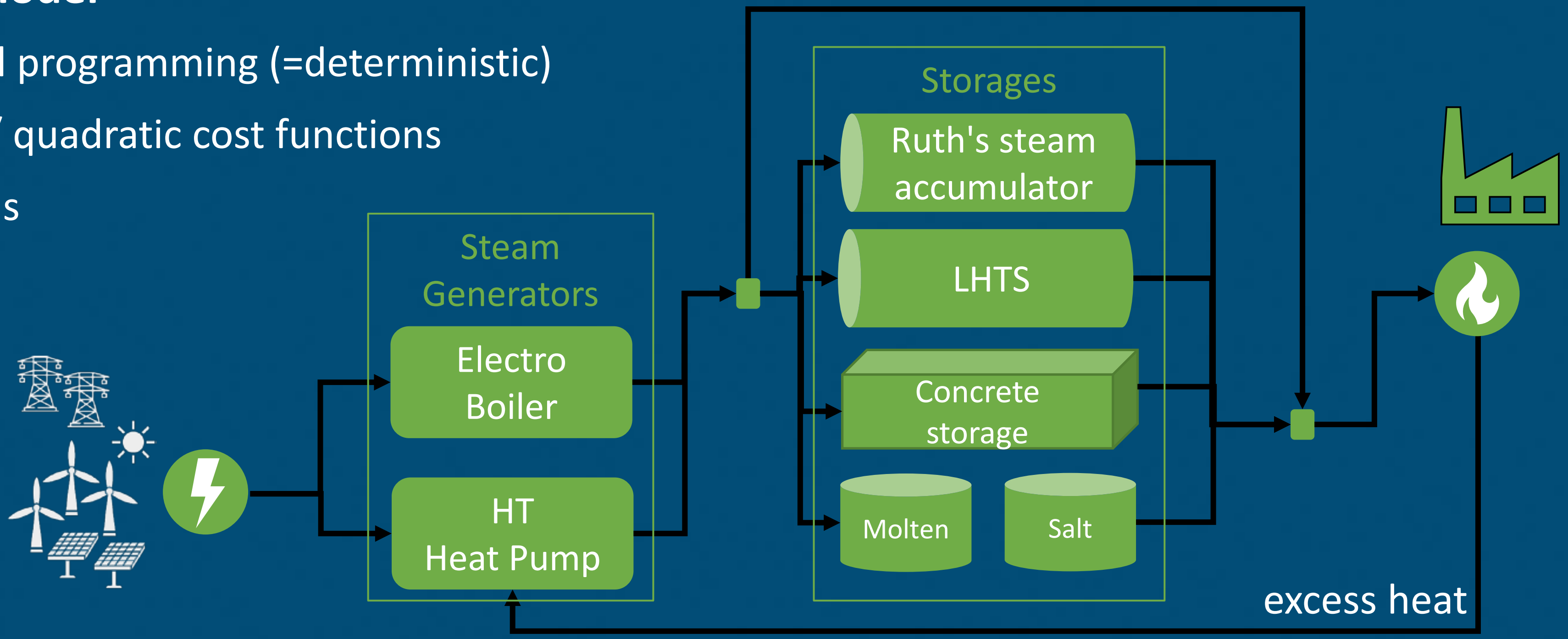
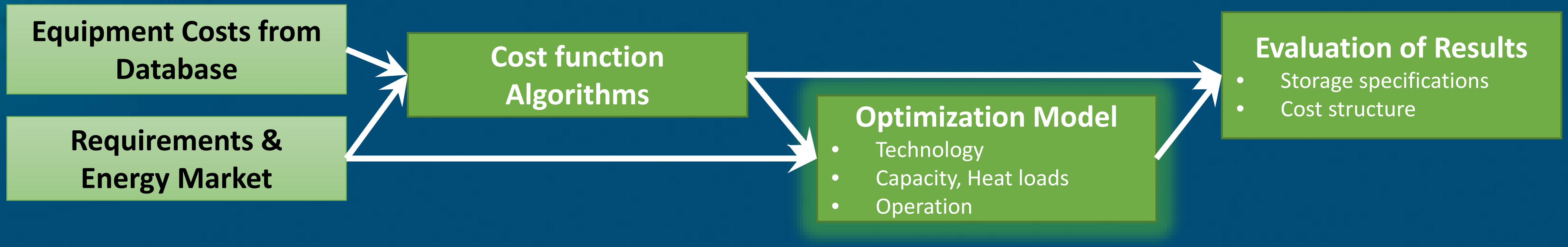
CETES – How?

Optimization Model

- Mathematical programming (=deterministic)
- (Non-)linear / quadratic cost functions
- Simple models
- Fast to solve





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CETES – How?

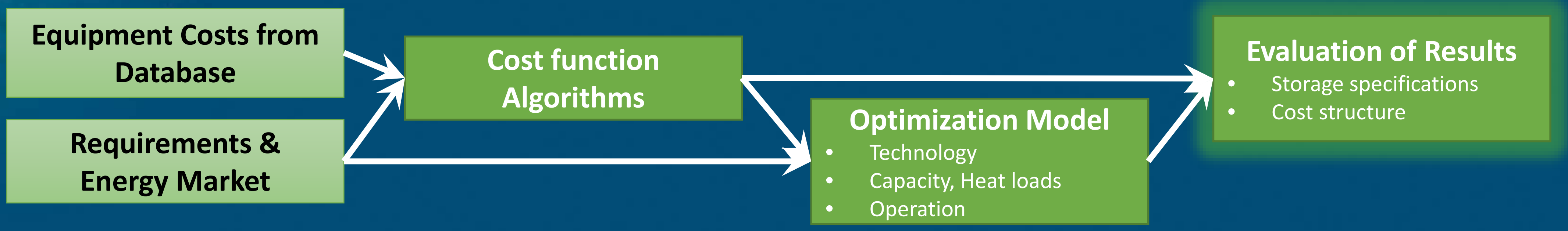
Evaluation of Results

The outputs of the optimization model are

- Storage capacities,
- Maximum heat loads and
- Optimal operation (Load profiles)

No details for the individual equipment such as piping, vessel geometry etc.

➔ **Details** are calculated using **cost function algorithms**



CETES – Example 1

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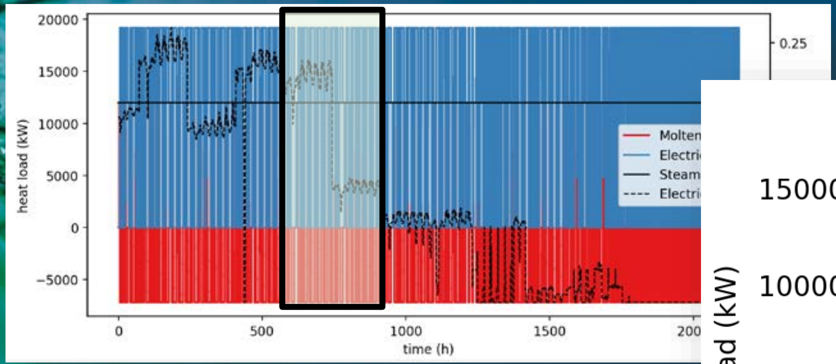
Bayer process for producing alumina from Bauxite

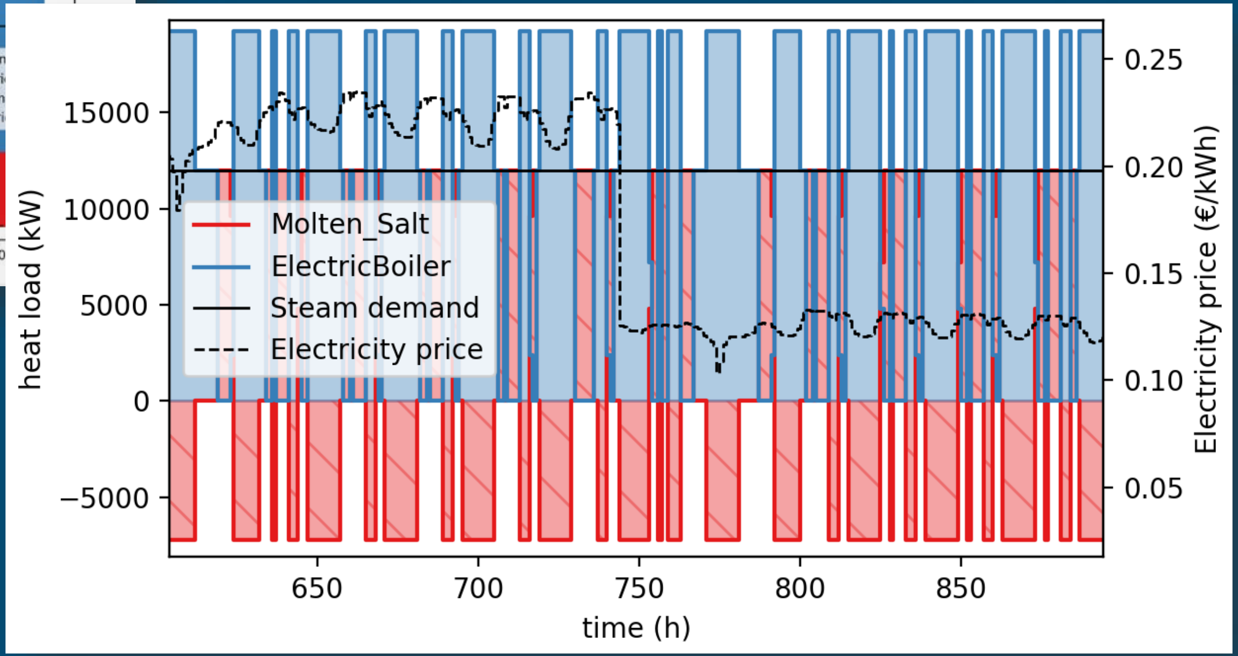
Constant steam demand: 12 MW – 200°C saturated steam

Steam generation temperature: 250°C

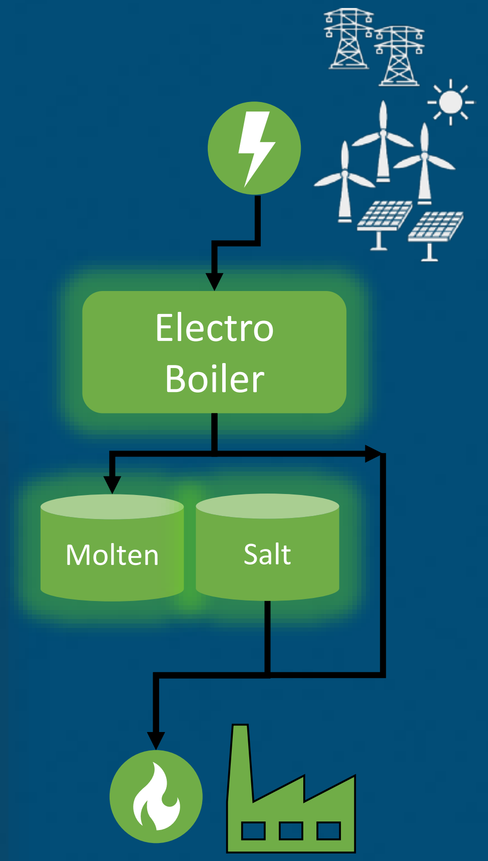
Temperature range for storage integration: 200-250°C

Spot-market prices (Brazil – January - March 2020)





Optimal System



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CETES – Example 2

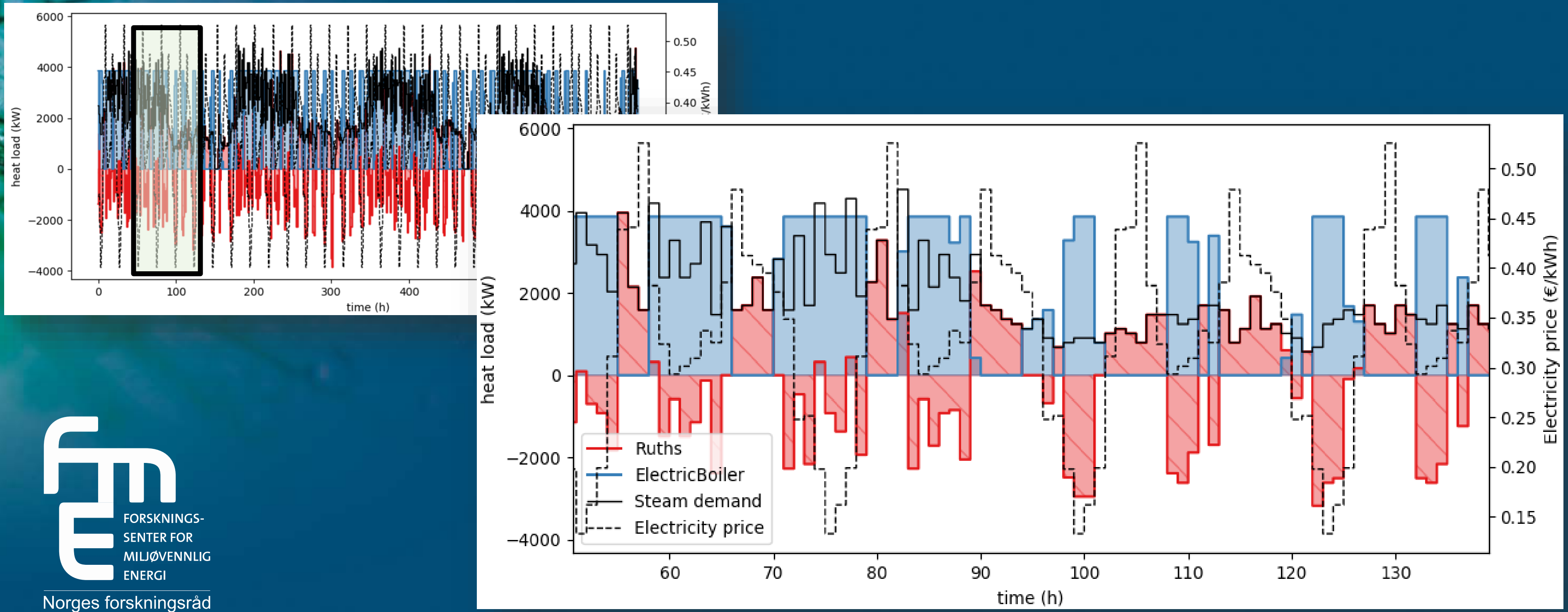
Brewery

Varying steam demand: 150 °C saturated steam

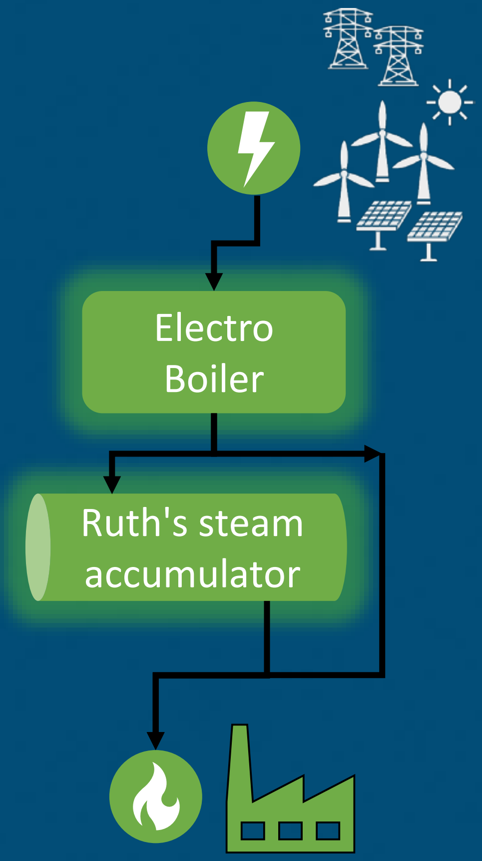
Steam generation temperature: 200 °C

Temperature range for storage integration: 150-200°C

Spot-market prices (Austria, 22.01.2020, repeated for each day)



Optimal System



CETES Spin-Off

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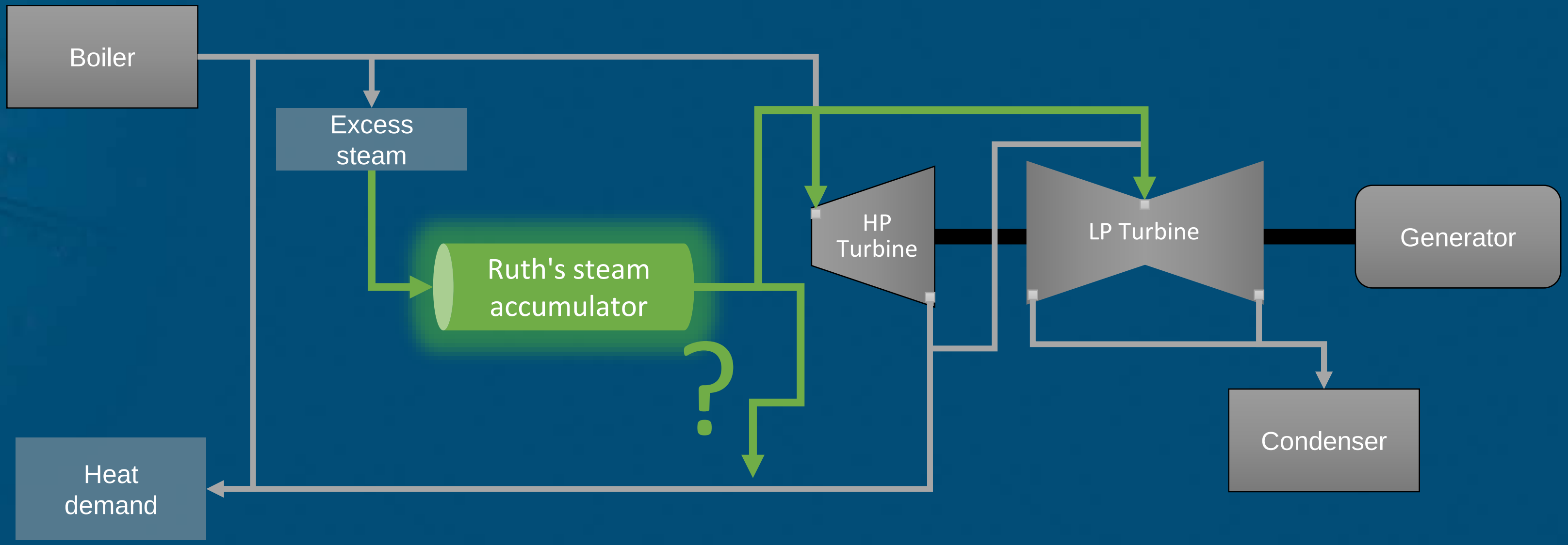
Storage of excess steam in **ELKEM plant Thamshavn** (HighEFF Task 3.3.6):

Excess steam spikes can be stored and fed into

- HP Turbine
- LP Turbine
- LP steam distribution for heat supply

➔ Trade-off between gains from power generation and storage size/costs



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CETES Conclusion / Current status

Current work:

- Finalizing consistent cost basis for all technologies
- Evaluation module for optimization results
- Identification of demo cases (different requirements)
- Publication on CETES methodology

Industrial applications:

- Cost evaluation for molten salt storages @ Hydro Alunorte
- Use of excess steam @ ELKEM Thamshavn (HighEFF Task 3.3.6)

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Thank you very much!
Questions?

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Shared resources – The process towards collaboration

HighEFF Annual Consortium Meeting 2020

Shared resources – NTNU Samfunnsforskning AS

Lucia Liste, Gudveig Gjøsund, Asle Gauteplass, Catharina Lindheim

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Goal

How can we contribute to increase the number of established energy- and resource collaborations?

Inspire HighEFF members – and others – to creative thinking when searching for new energy collaborations, and by this increase the number of such collaborations.

Focus on “low hanging fruits” - assuming compatible partners.

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Handbook structure

- Introduction
  - Background
  - From challenges to enablers
  - From business models to collaborative contract strategies
- About energy and resource collaborations
  - Important dimensions at early stage
  - Important enablers
- A guideline to establish and operate energy- and resource collaborations
  - Five steps towards collaboration
- Appendixes
  - Elaborating findings and relevant topics

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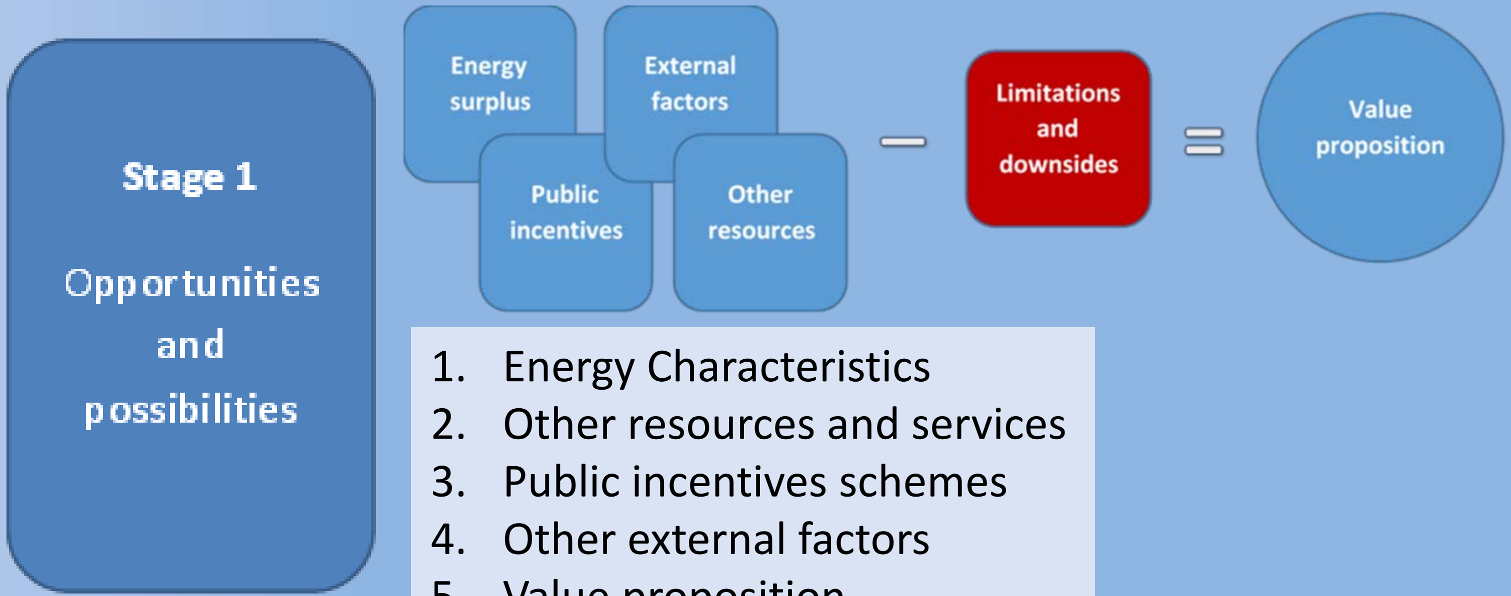
Process – step by step



1. Energy Characteristics
2. Other resources and services
3. Public incentives schemes
4. Other external factors
5. Value proposition

Stage 0 Fundamental preparation and considerations (continuous work)

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Process – step by step

Stage 1

Opportunities and possibilities

Stage 2

Mapping of potential stakeholders

1. Main partner(s)
2. Other stakeholders

Establish dialogue

Stage 0 **Fundamental preparation and considerations (continuous work)**

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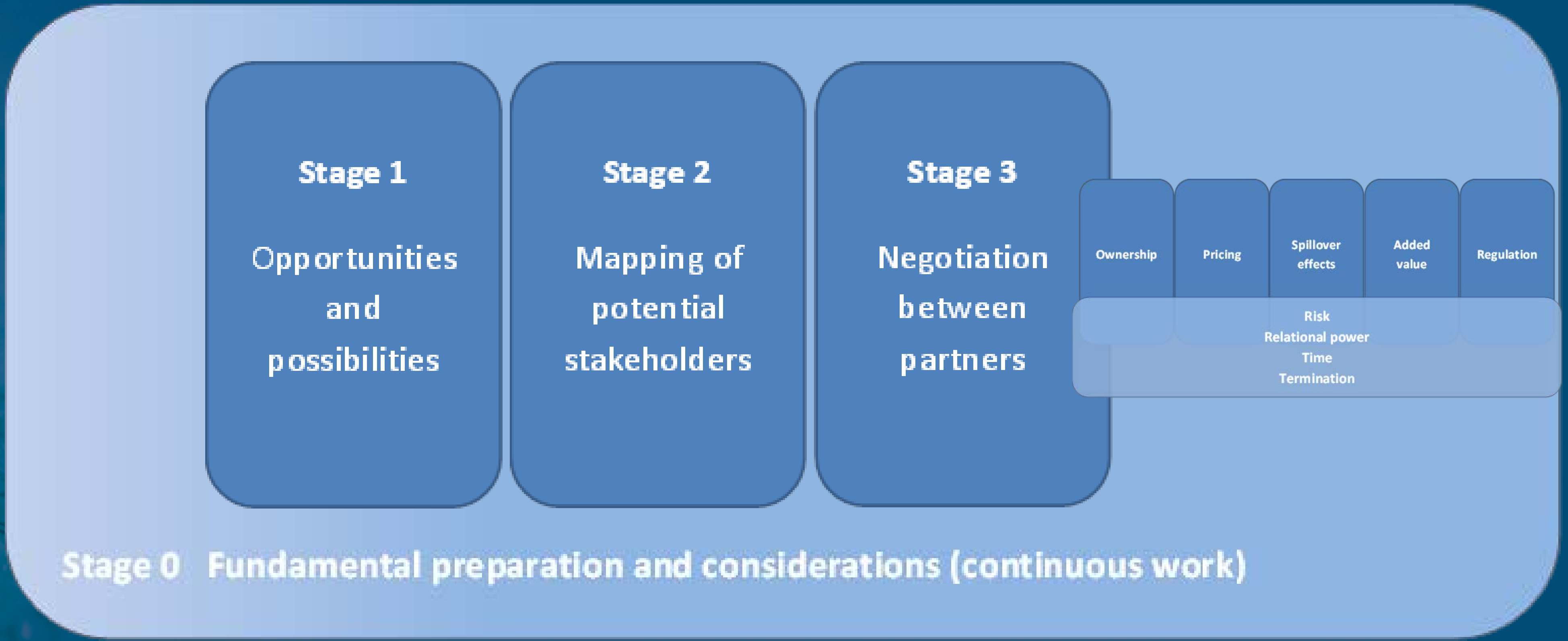
Process – step by step



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Process – step by step

Stage 4

Implementation and operation

What is important for the partners to achieve a successful implementation and operation of the energy and resource collaboration?

- Understanding
- Anchoring
- Commitment

Stage 0 Fundamental preparation and considerations (continuous work)

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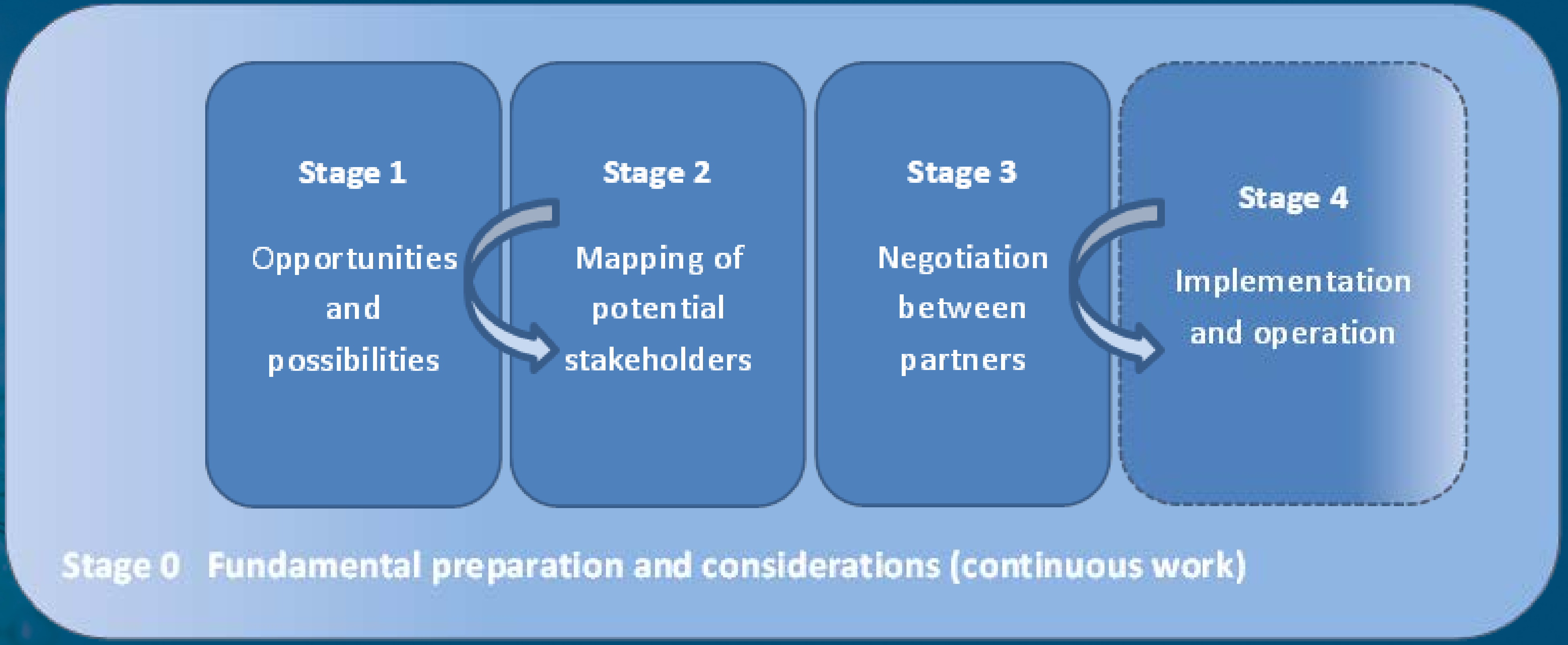
Process – step by step



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Thank you for your attention!
Any questions?

If you would like to provide input to the handbook, please contact

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