Termodagen 2022
- Samspel i energisystemet -

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Energimyndigheten

Session: Cirkulära flöden för ett resurseffektivt energisystem

Circular Techno-Economic Aspects of Thermal Energy Storage

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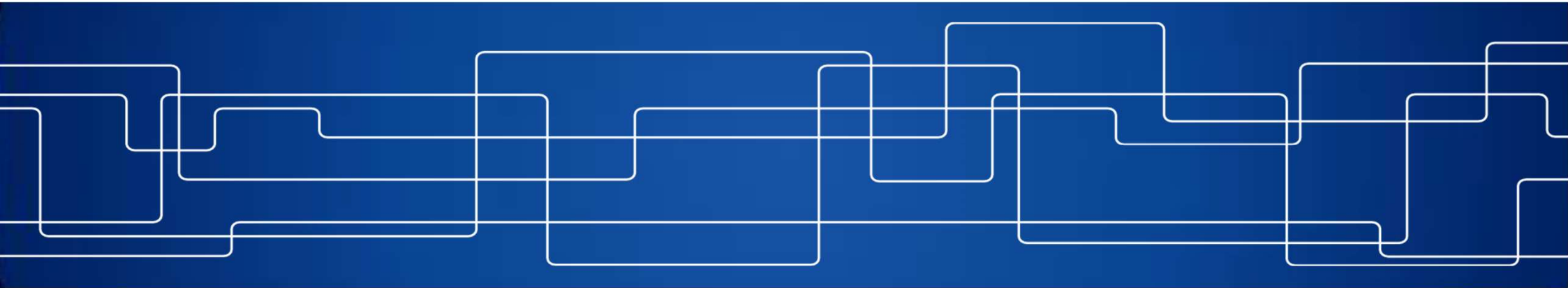

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1. Thermal Energy Storage Group at KTH

- Material Characterization
- Component Testing
- System Integration and Setups
- Underground Energy Storage with Borehole and Aquifer

Swedish Energy Agency

iea ECES

Annex 24, 28, 30, 33, 35, 41

PUMP HEAT

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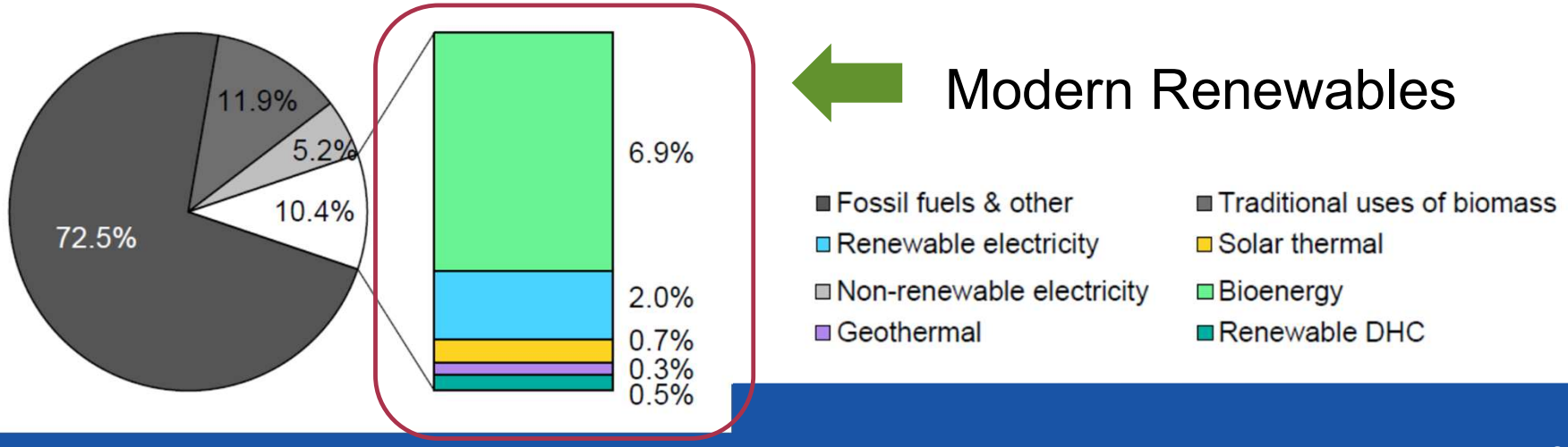
energy storage
IEA Technology Collaboration Programme

Horizon 2020 Programme

2. Motivation for Thermal Energy Storage

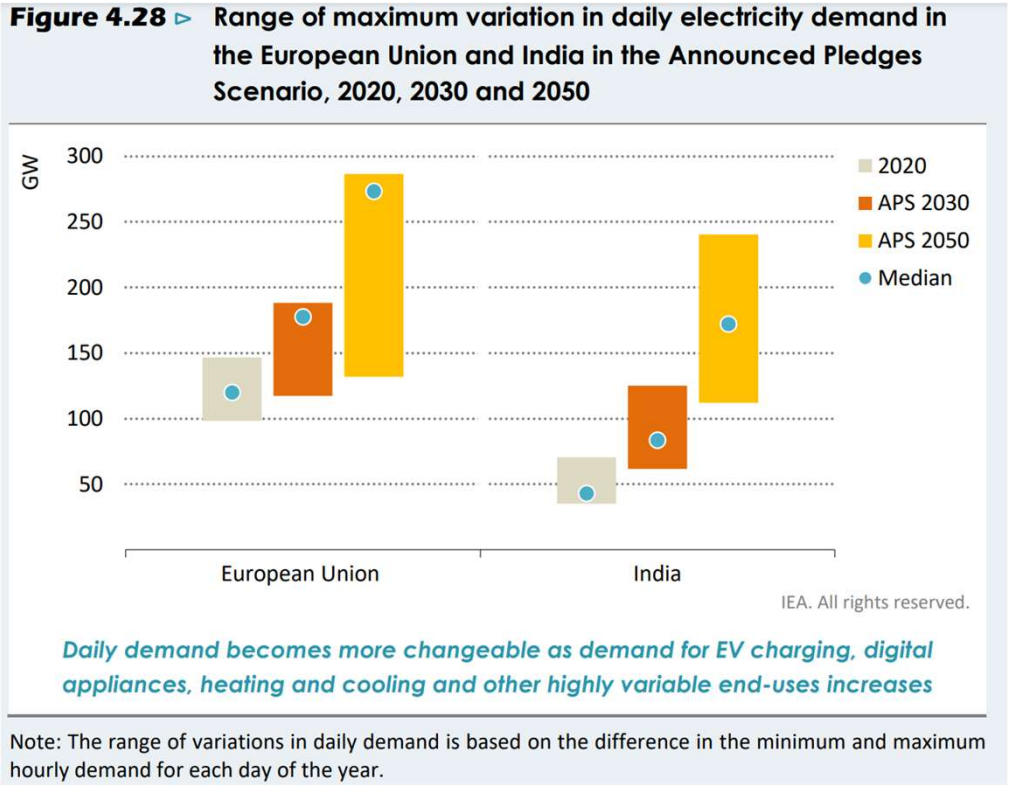
- Half of global energy demand is in the form of heat
- 50% in industries and 47% in building space/water heating
- only 22% is renewable based
- 78% non renewable causes 40% global CO_2 emission

→ Need for energy system efficiency and renewable penetration



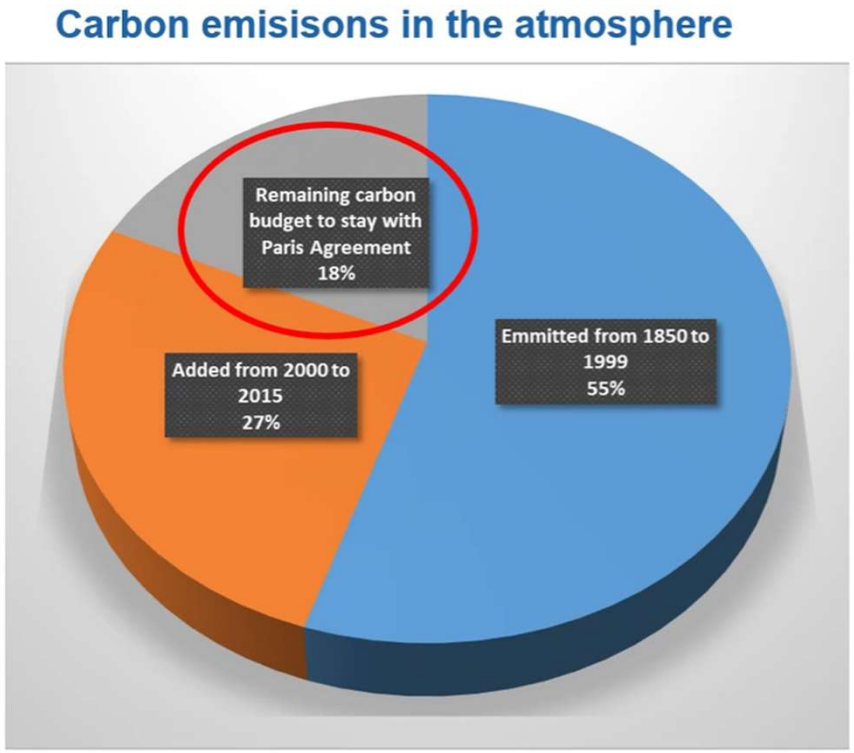
IEA, Renewables, 2020

2.1. High Variation in Energy Demand and Price



World Energy Outlook 2021, IEA

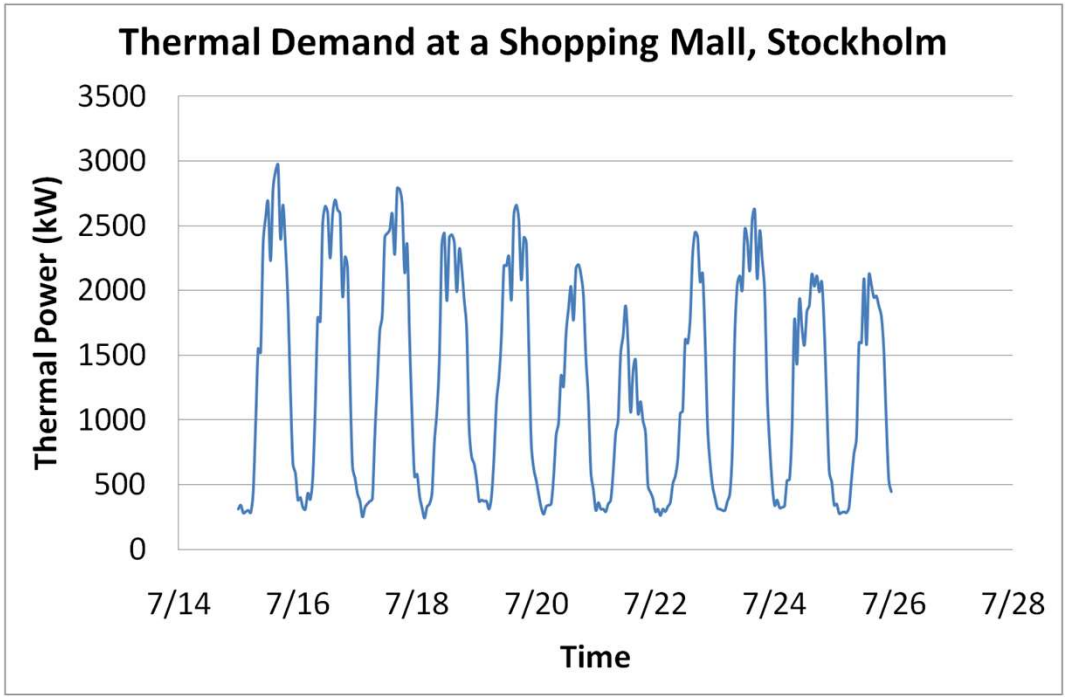
2.2. Meeting Paris Agreement?

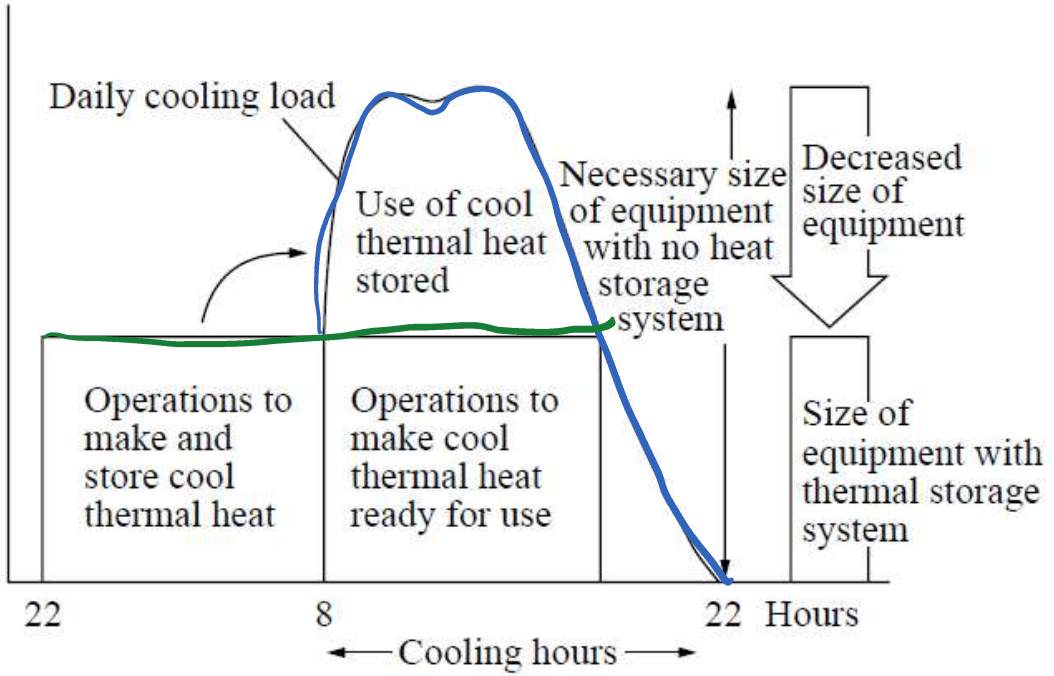


A fast energy transition is urgently needed

- Low carbon renewable energy sources (development and integration)
- Production of low carbon energy carriers
- Decarbonisation of final uses of energy
- Implement flexibility in the energy networks by:
  - ❑ Storing energy
  - ❑ Inter-converting the different energy carriers
  - ❑ Smart management of the energy networks
  - ❑ Implement demand side control

2.3. Why Energy Storage?



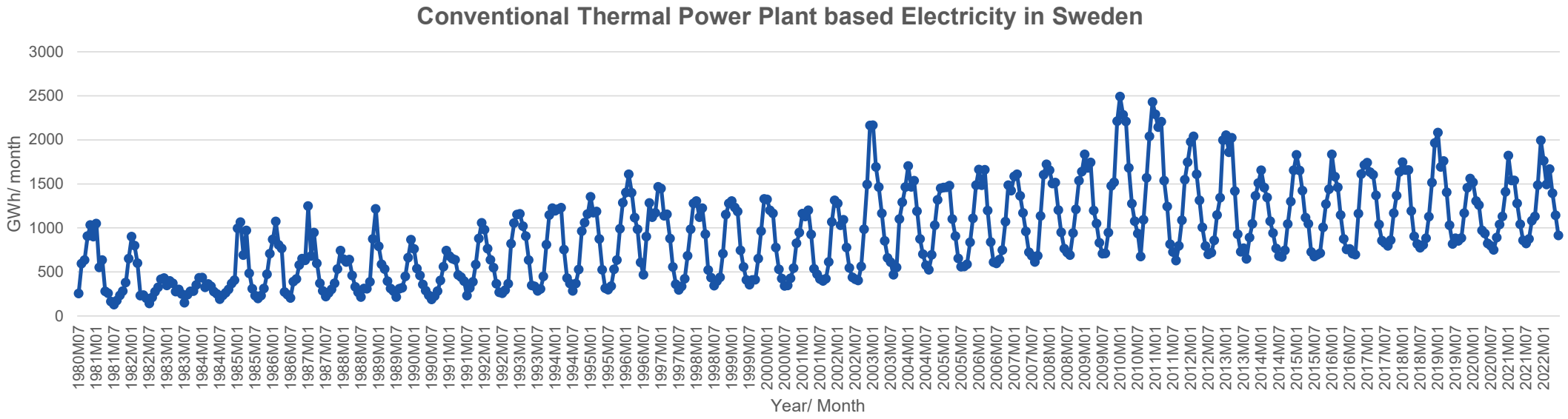


Operation Pattern of Thermal Storage System

Source: TEPCO

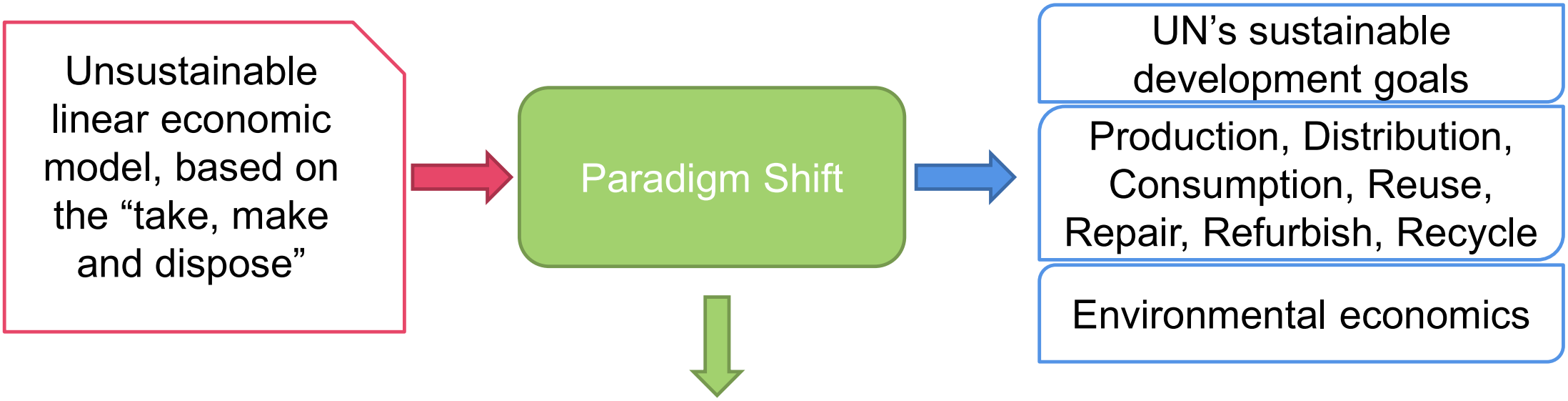
2.4. Marginal Electricity in Sweden

- 3 GW fossil fuel based electricity generation capacity.
- 2021 Jul- 2022 Jun: 15.7 TWh total conventional thermal based power with 2.2 TWh non-renewable fossil fuel power generation.

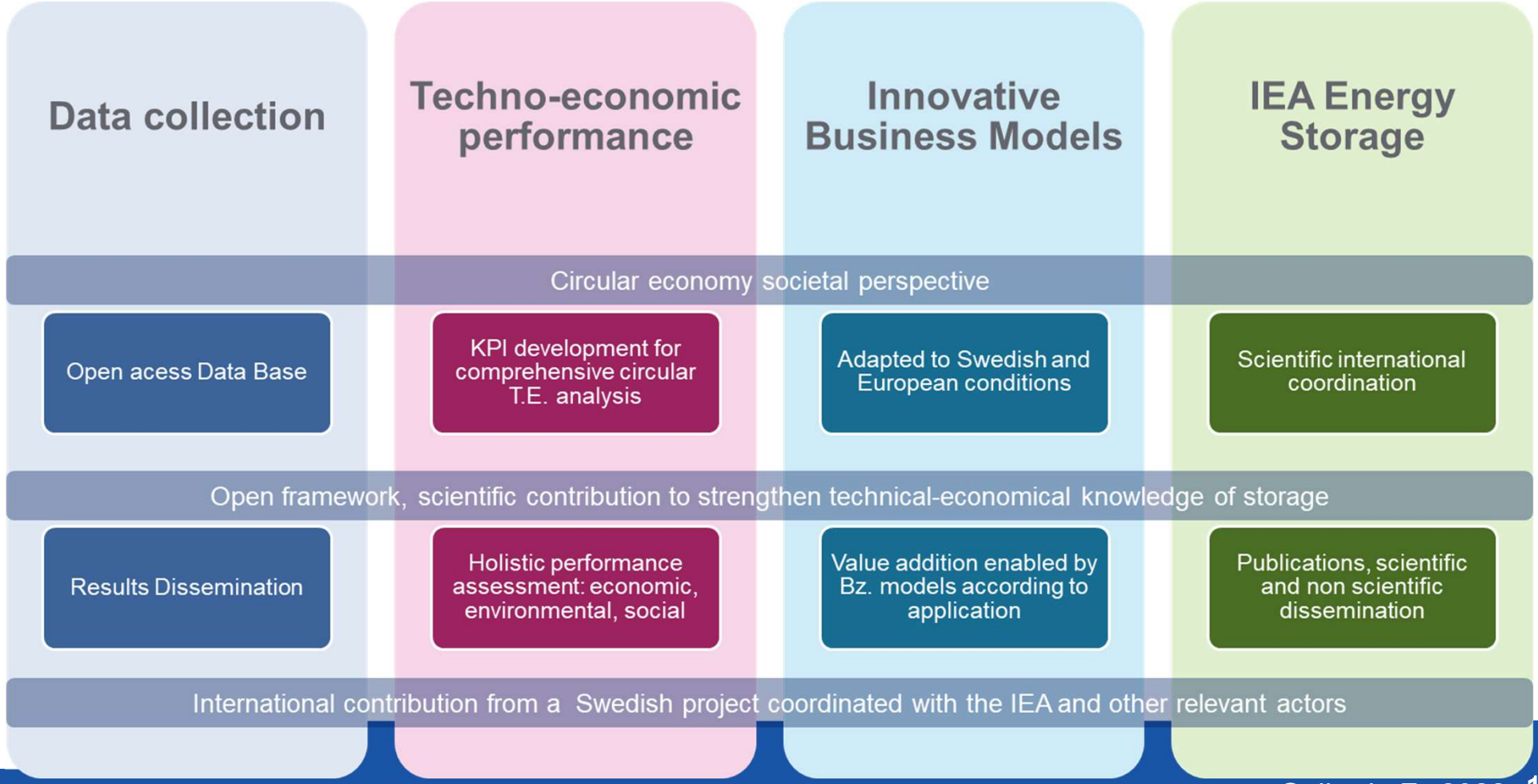


ENTSO-E, 2022; Chiu and Martin, 2011

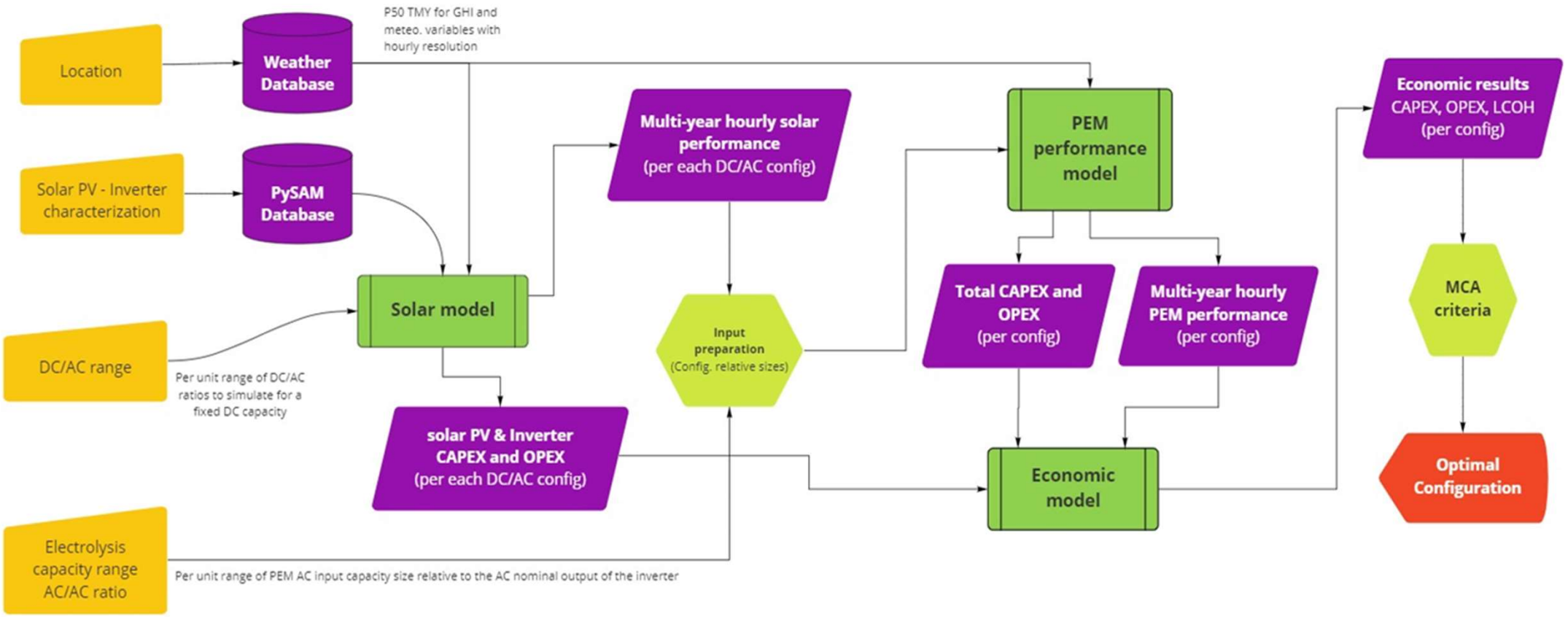
2.5. Moving Towards Circular Economy



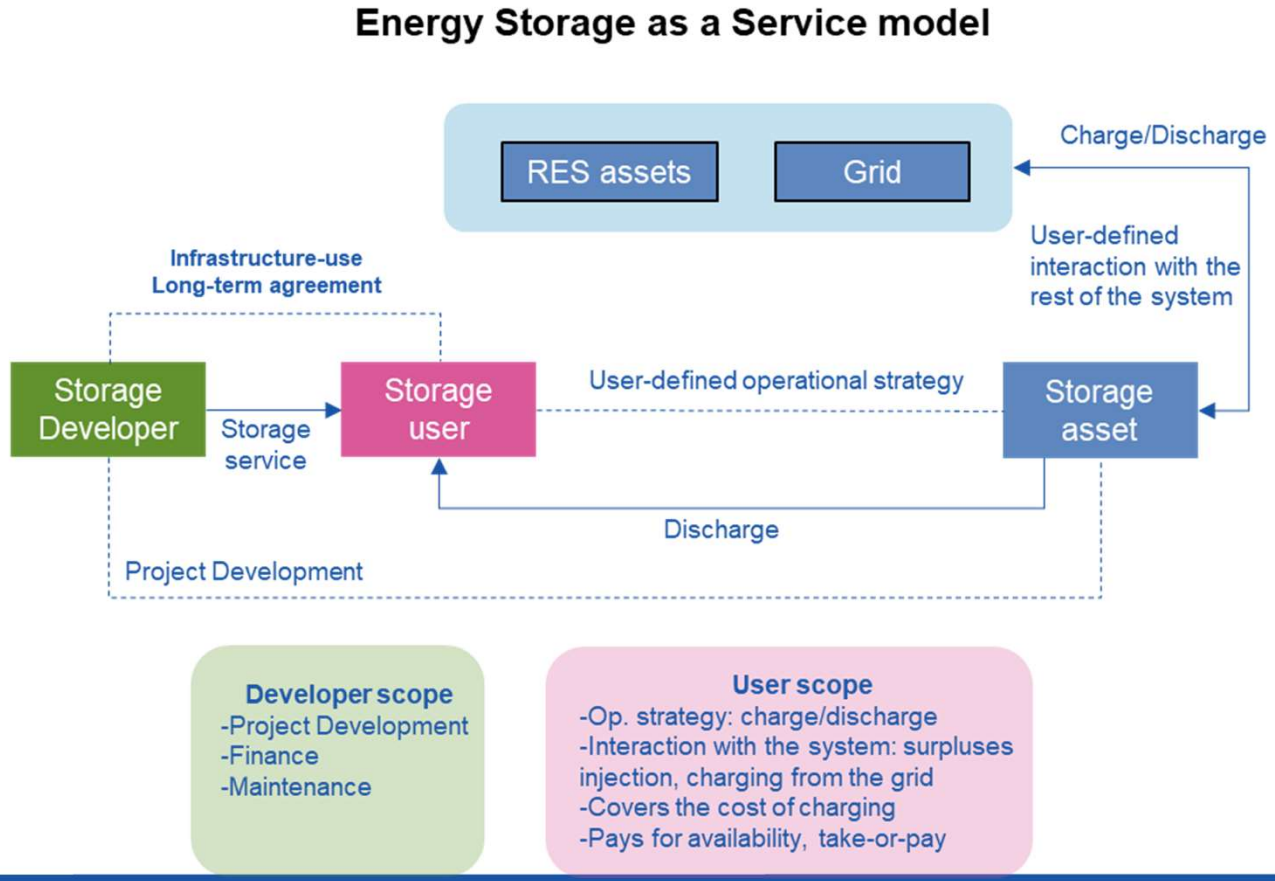
3. Circular Techno-Economy in IEA ECES TASK 41



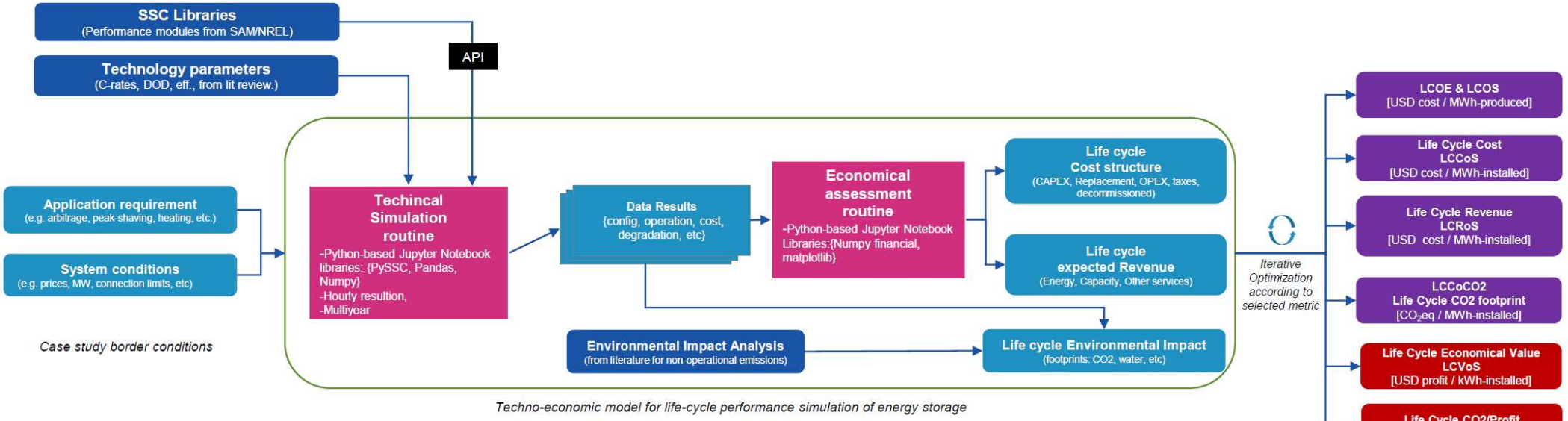
3.1. Sizing Optimization



3.2. Novel Business Model



3.3. New Metrics for Storage



Techno-economic model for life-cycle performance simulation of energy storage

DATA | Process | Process

External libraries/Lit. review

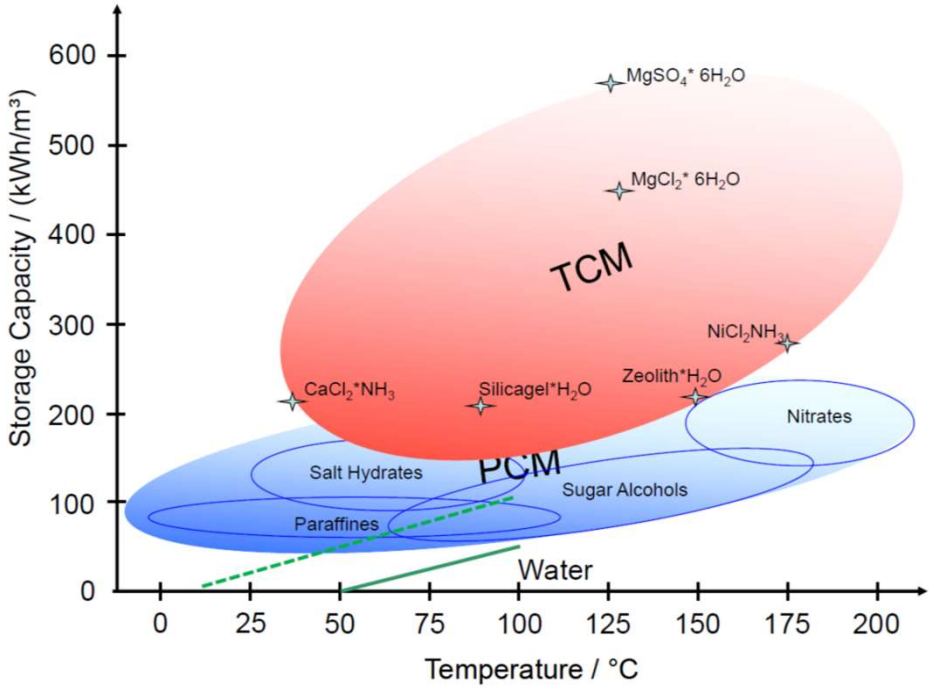
Conventional KPIs

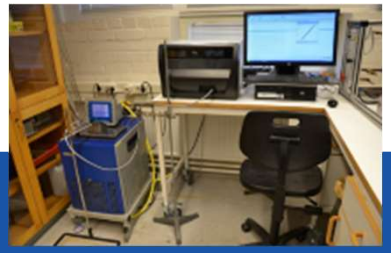
Proposed KPIs

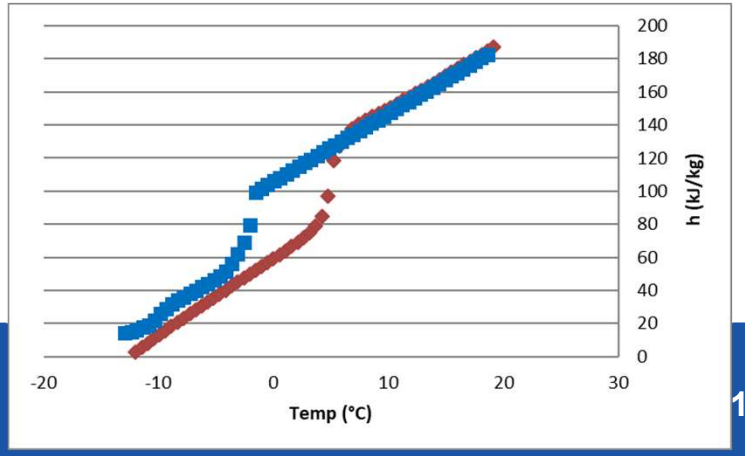
Applications and case studies intended:

- Optimization: LCVoS vs LCOE: configuration results and implications
- Sensitivities: e.g. carbon footprint tax scenarios, sector coupling alternatives, etc.
- Optimal technology selection

3.4. Thermal Storage Materials





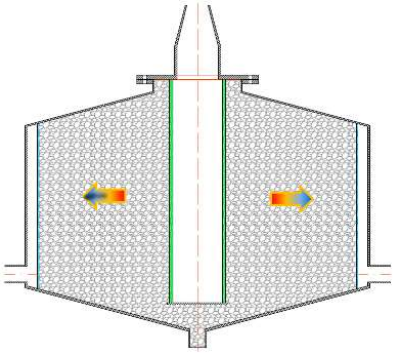


Hauer, A. 2012; Chiu et al. 2019.

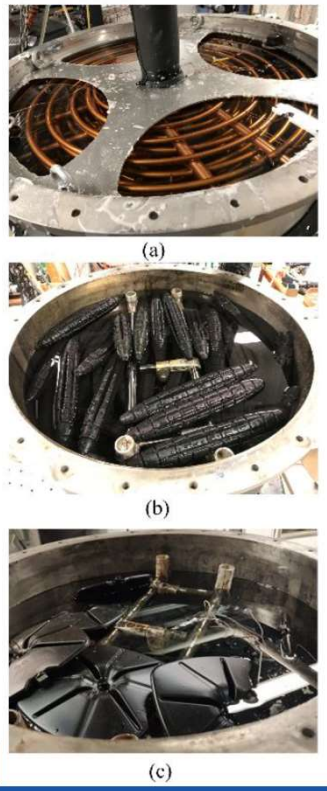
3.5. Component Design

Macro-Encapsulation

Packed Bed

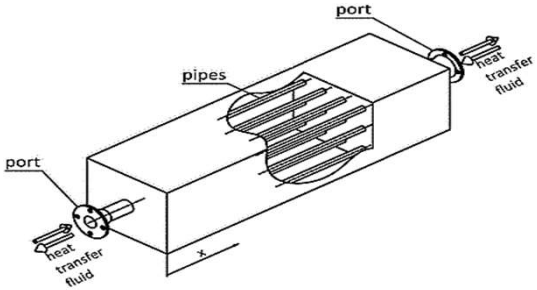


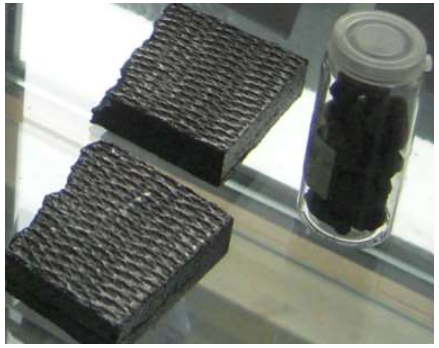
Submerged HX



Bulk Storage

Encapsulation





Foam and Matrix

Pouches

Source: Climator, Swerod, PCM Products, Trevisan S, Mahadar S. T. Barz, W. Zauner

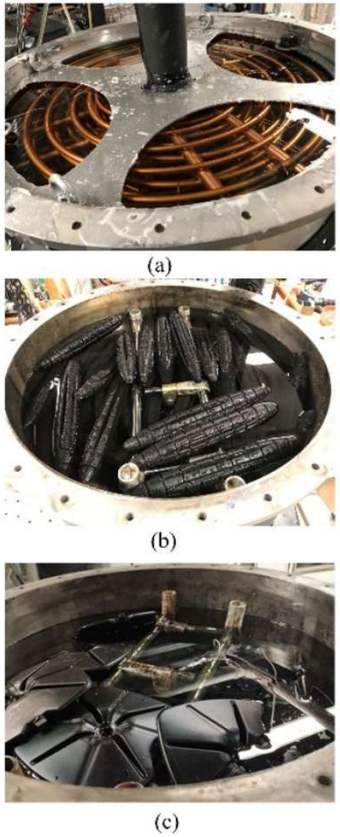
3.6. Thermal Storage Performance Indicators

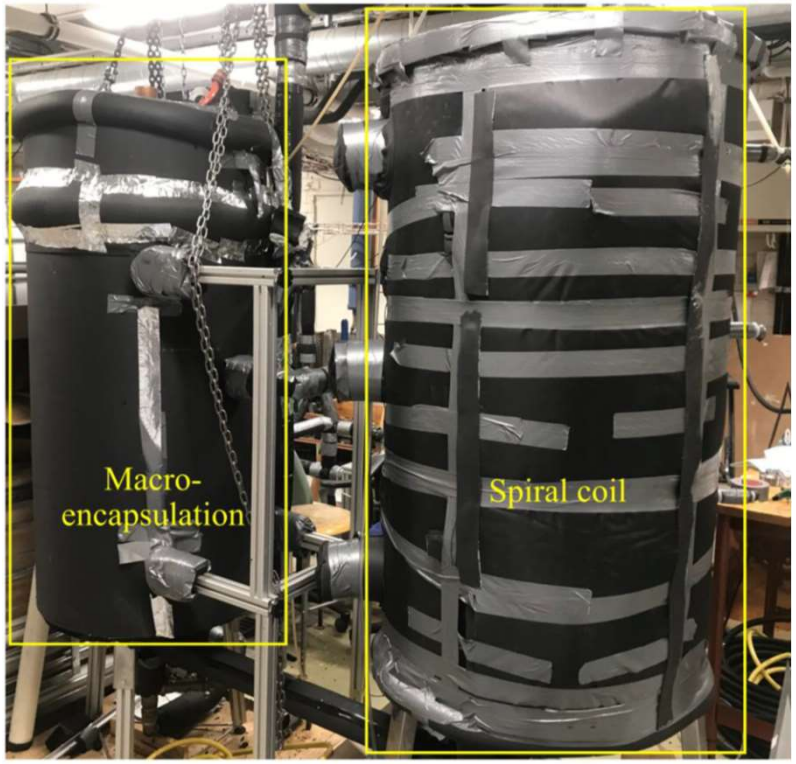
- Capacity
- Power Rate
- Efficiency in Terms of Heat Loss
- Storage Period
- Operating Temperature
- Physical Size
- Lifetime
- Number of Cycles
- Monitoring and Control strategy
- Environmental, Social, Economic, Political Aspects

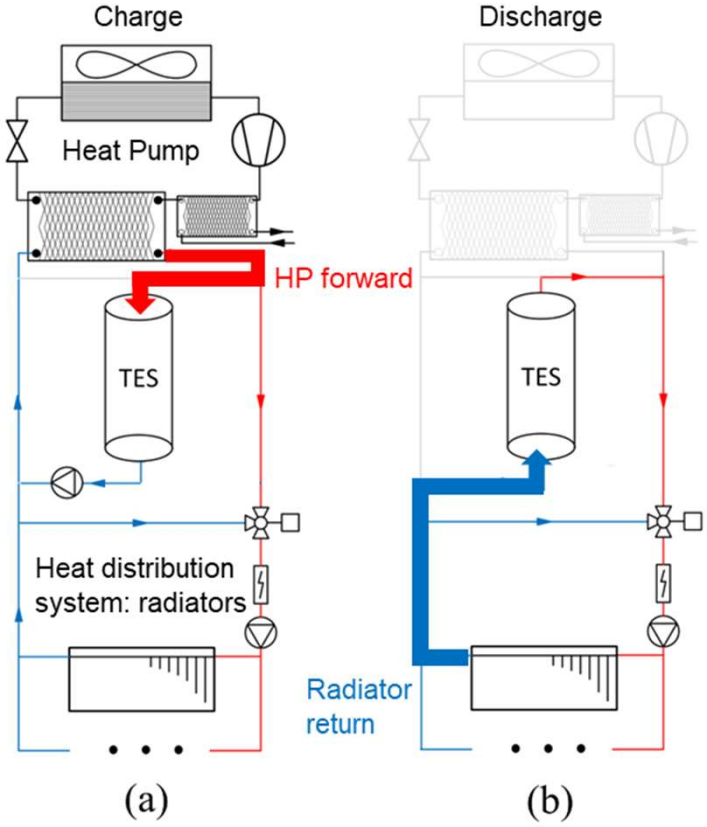
Performance Indicators

- Life Cycle Cost
- Levelized Cost of Energy
- Net Present Value
- Life Cycle Assessment
  - Carbon Footprint
  - Impact on Health, Ecosystem, Environment

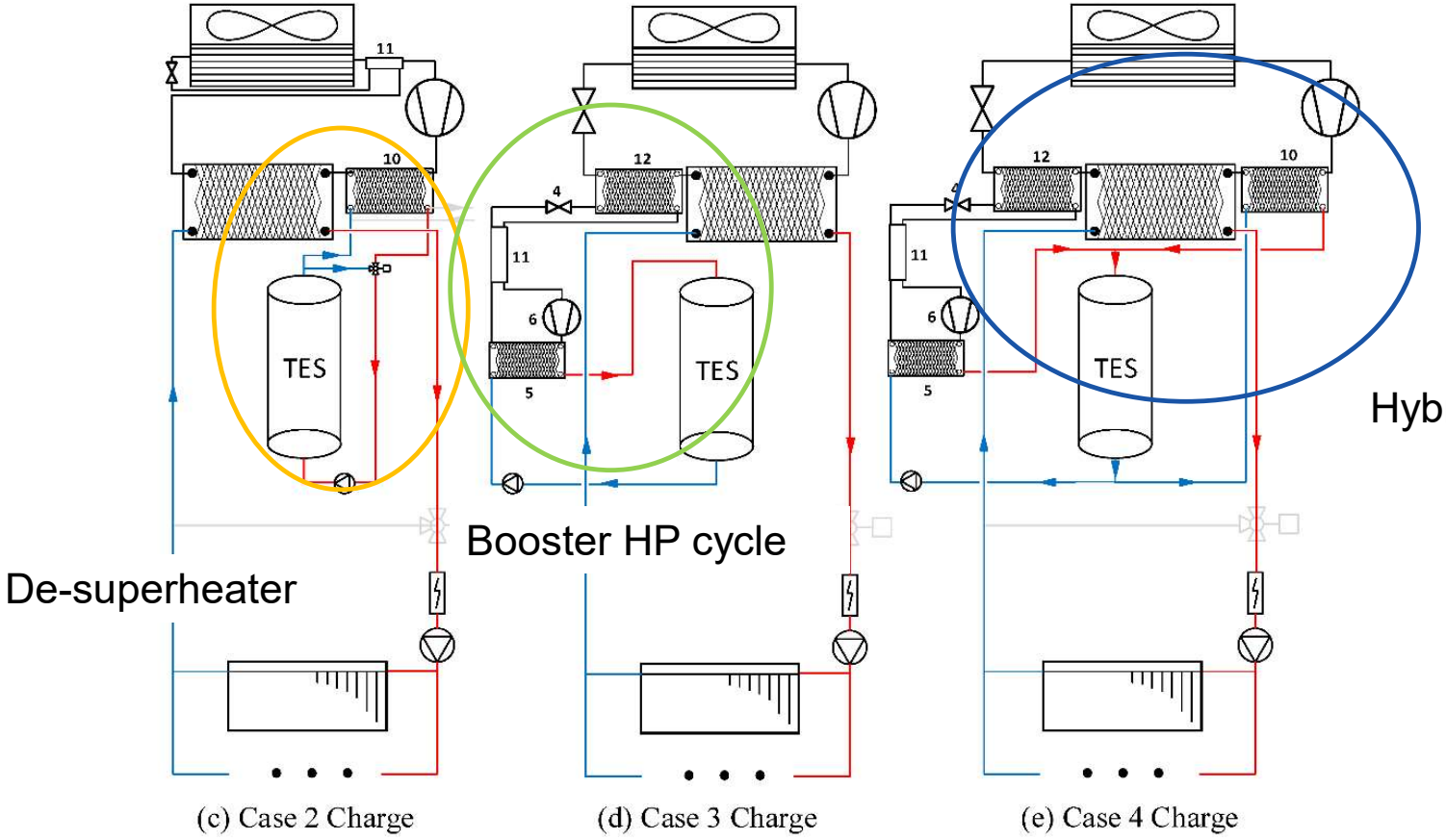
Example: Thermal Energy Storage for Heating Ventilation and Air Conditioning







Example: Thermal Energy Storage for Heating Ventilation and Air Conditioning



4. Future Research Focus

Material:

- Environmentally friendly and cost effective thermal storage materials

Component:

- Robust and high performing storage designs

System:

- Concept validation and demonstration
- Techno- economic optimization for system integration

Economic, social and environmental benefits are the deterministic factors for successful implementation of energy storage systems.

Circular Techno-Economic Aspects of Thermal Energy Storage

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Oct 20th, 2022

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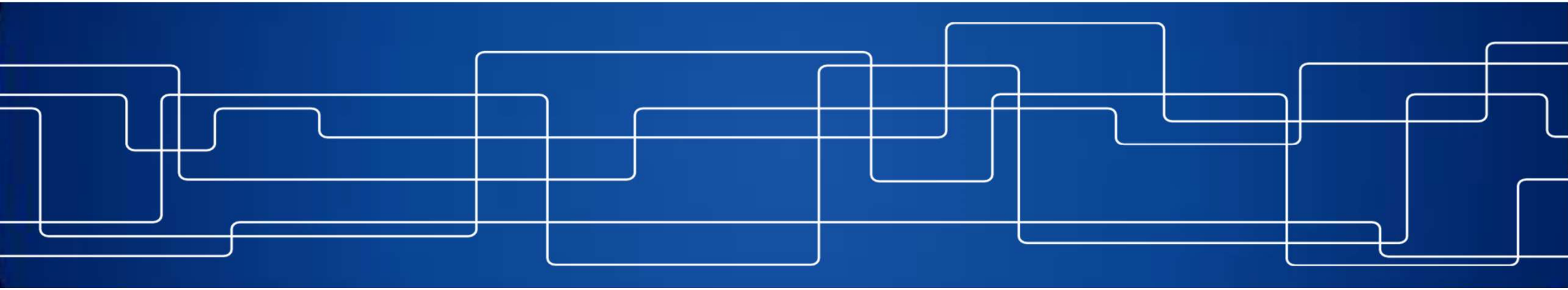
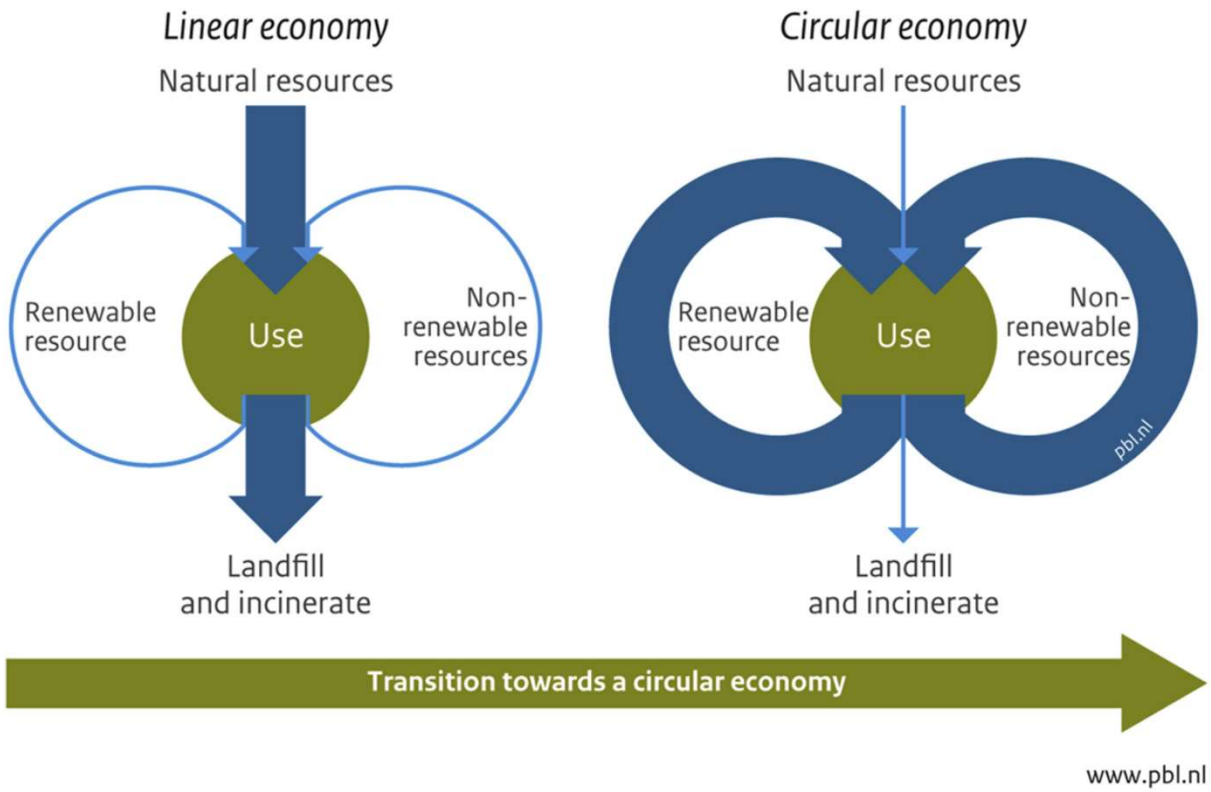


Linear to Circular Economy

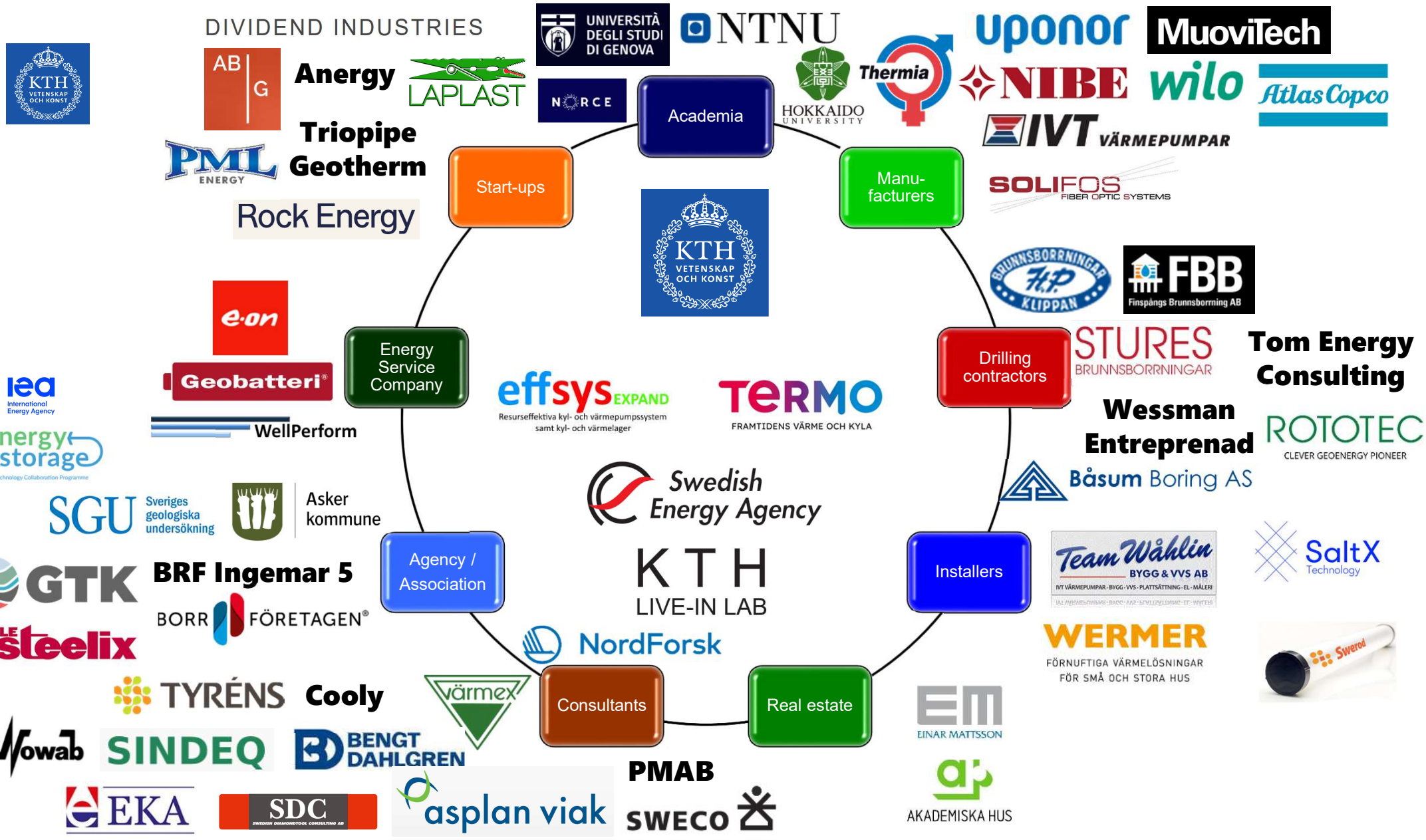


Maximize ecosystem functioning and human well-being

Maximize the service produced /…/ by using **cyclical materials flows**, **renewable energy sources** and **cascading energy flows**

Creation of (techno-) **economic value**, creation of **social value** and value creation in terms of the **environment**

Murray A, et al. 2017, Korhonen J, et al. 2018, van Buren N, et al. 2016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Triopipe
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