Thermal Energy Storage for Cost-Effective Energy Management and CO_2 Mitigation

Energy Storage Europe Conference

Düsseldorf, 13 March 2019

Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)

German Aerospace Center

Institute of Engineering Thermodynamics | Thermal Process Technology

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Background

This presentation comprises an overview of the methodologies and results of the IEA ECES Annex 30.

- Duration: July 2015 through June 2018
- 7 workshops held over the 3 years
- 4 national conferences held (DE, JP, ES, FR)
- Public report on the Annex 30 results:

  Application of Thermal Energy Storage in the Energy Transition – Benchmarks and Developments

- Three additional Annex 30 documents and a scientific publication

Final meeting of Annex 30
18 June in Cologne, Germany

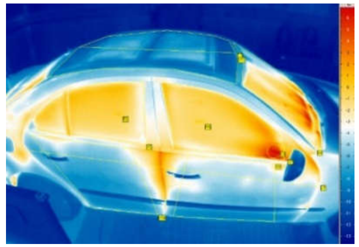
Annex 30 – Objectives and Outcome

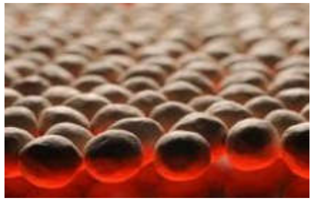
The general **objective** was to advance the implementation of thermal energy storage technologies.

The **outcome** is a **methodology** to evaluate and quantify the benefit of integration of thermal energy storage systems into processes to

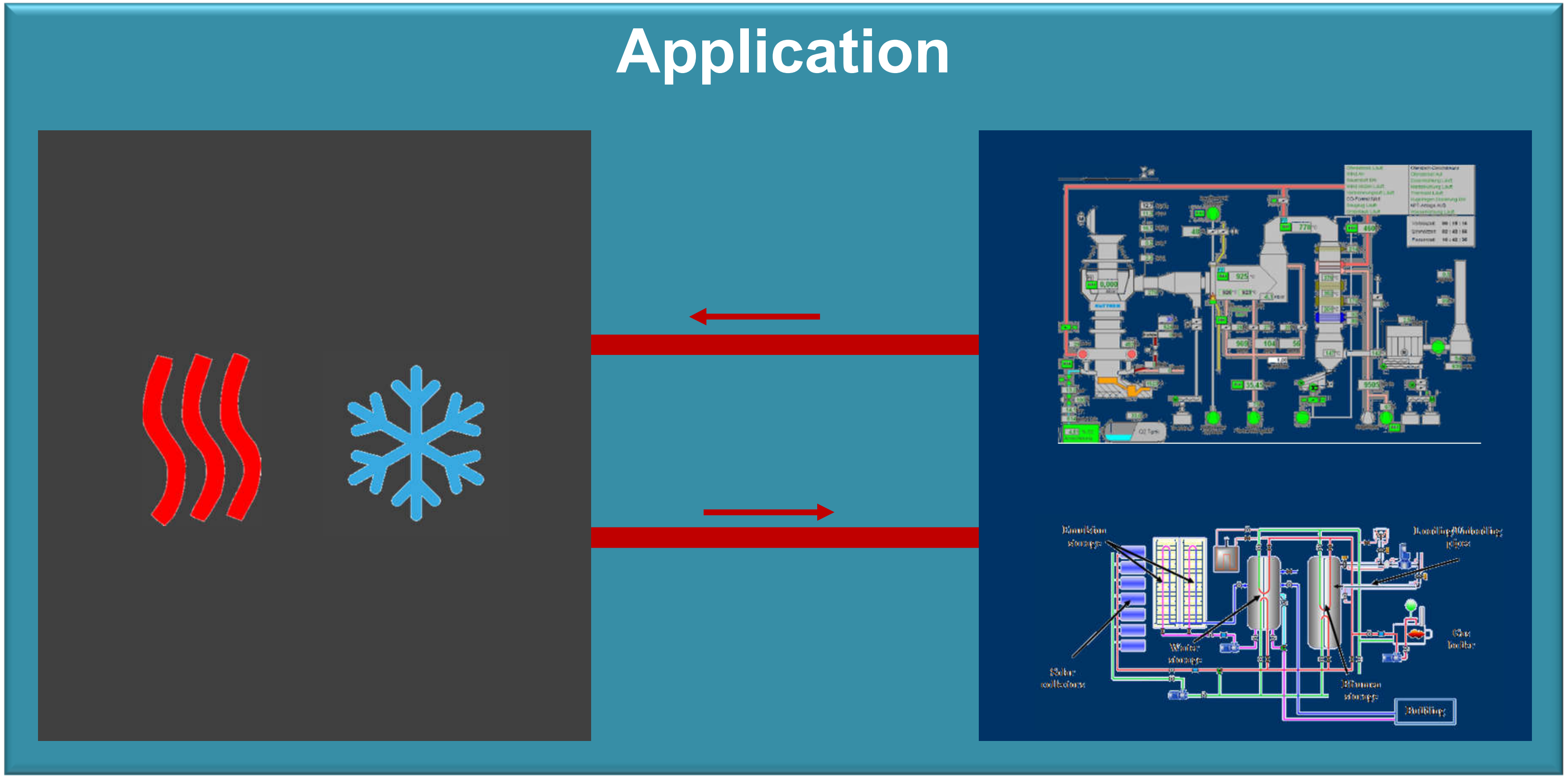
- increase efficiency,
- gain flexibility and
- advance the uptake of renewable energy technologies.

Methodology applied to cases in **district heating, non-residential buildings, industrial processes, power plants and vehicles**.





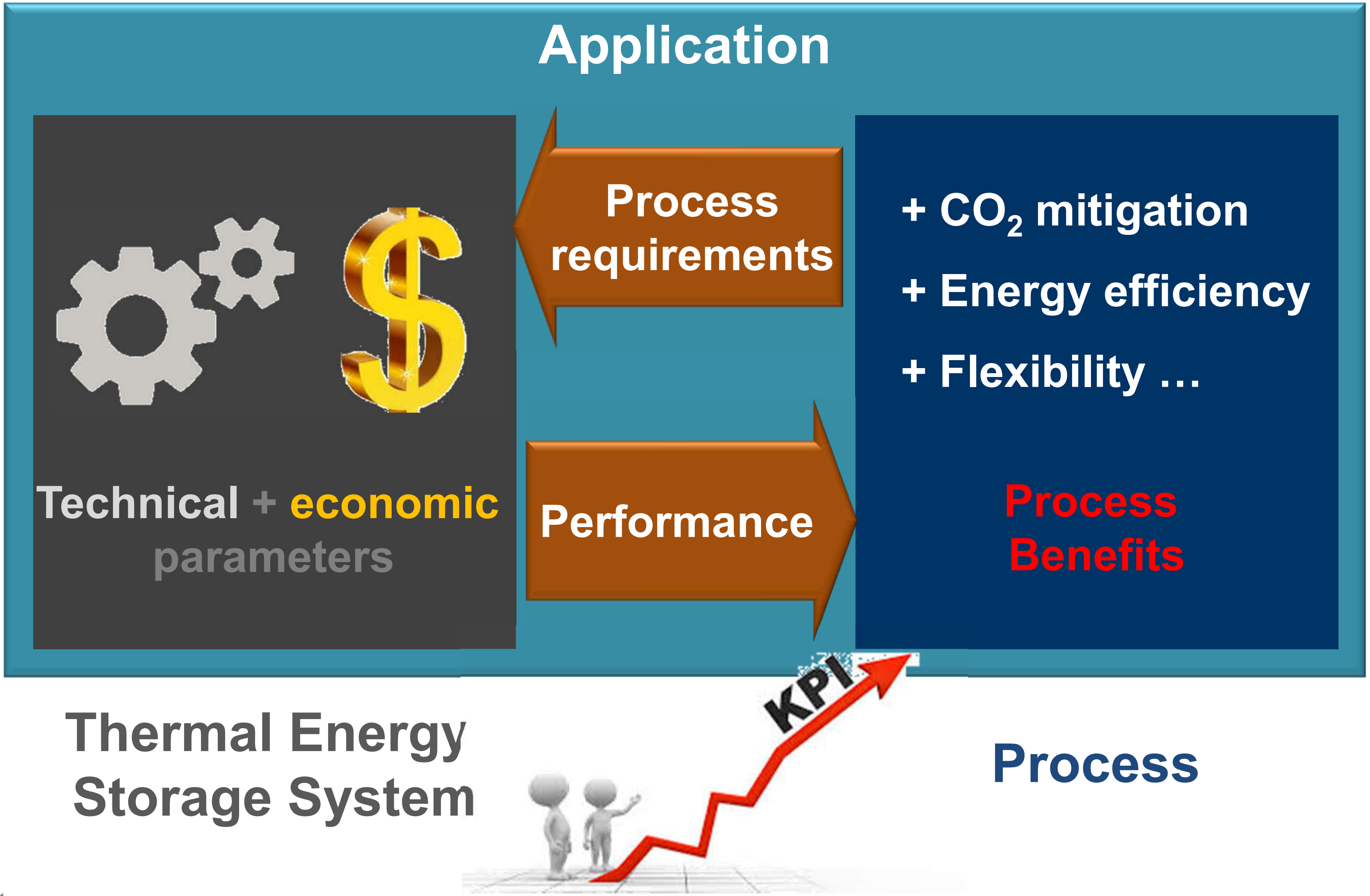
Process with integrated thermal storage



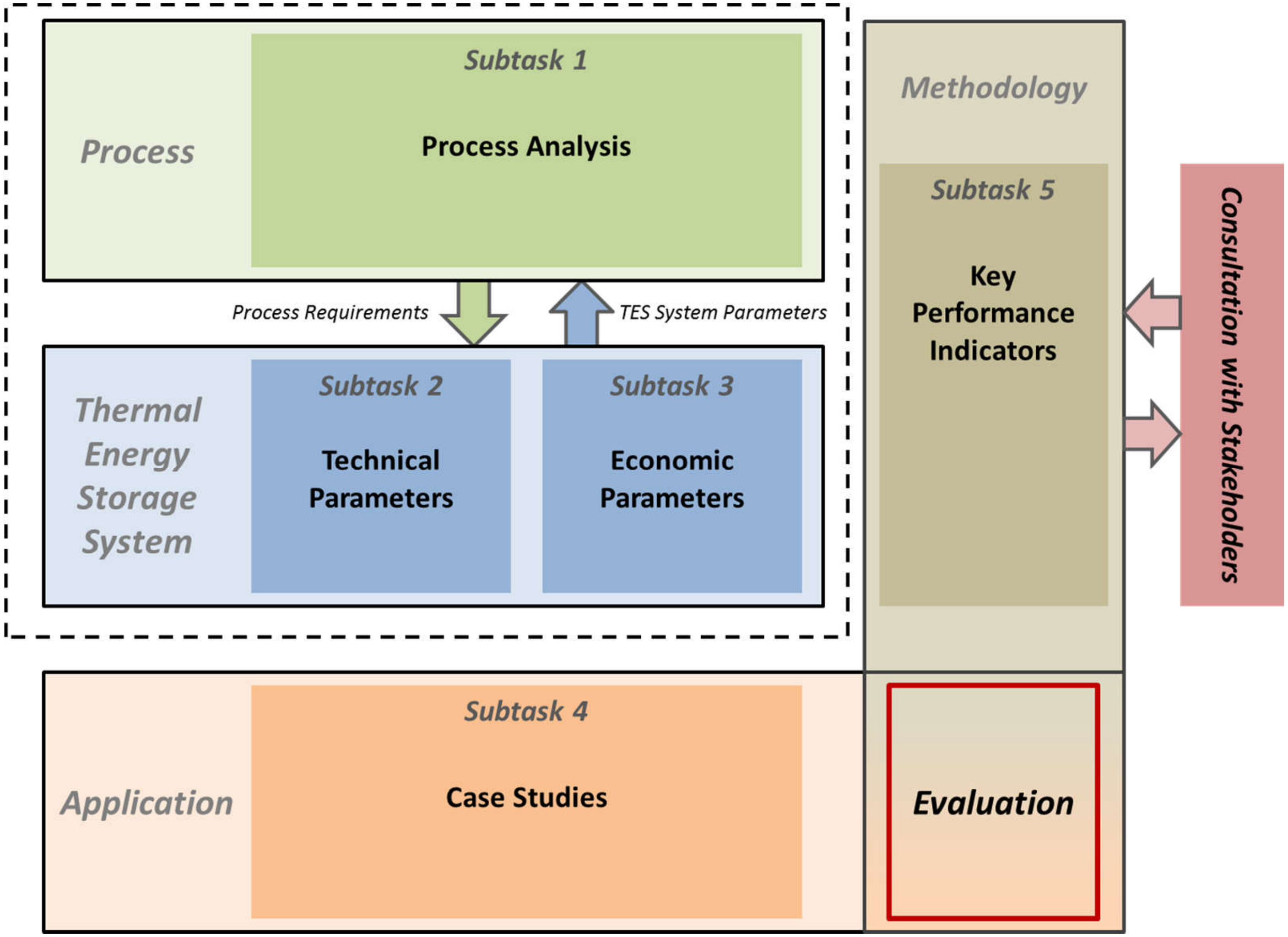
Thermal Energy Storage System

Process

Analysis of process with integrated thermal storage

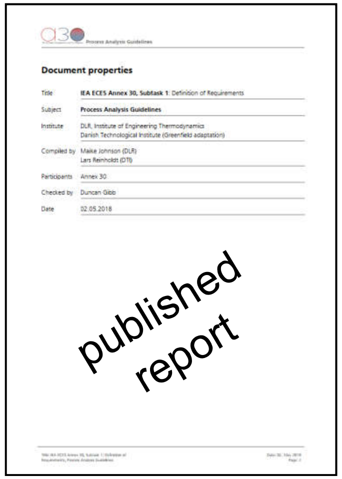


Annex 30 – Structure

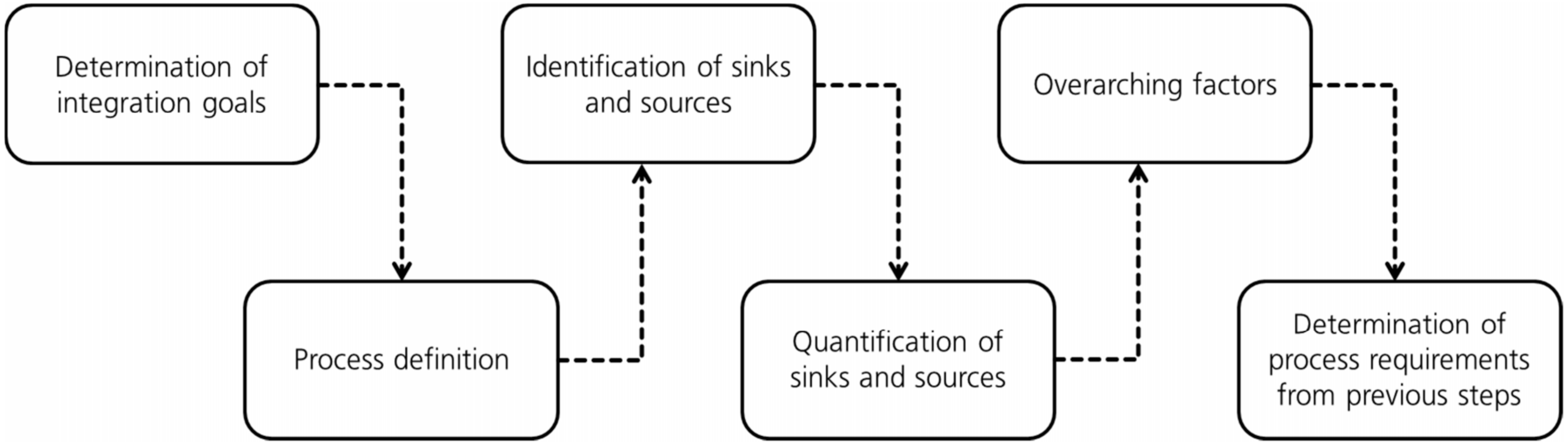


Subtask Results

Subtask 1 – Process Analysis (Maike Johnson, DLR)



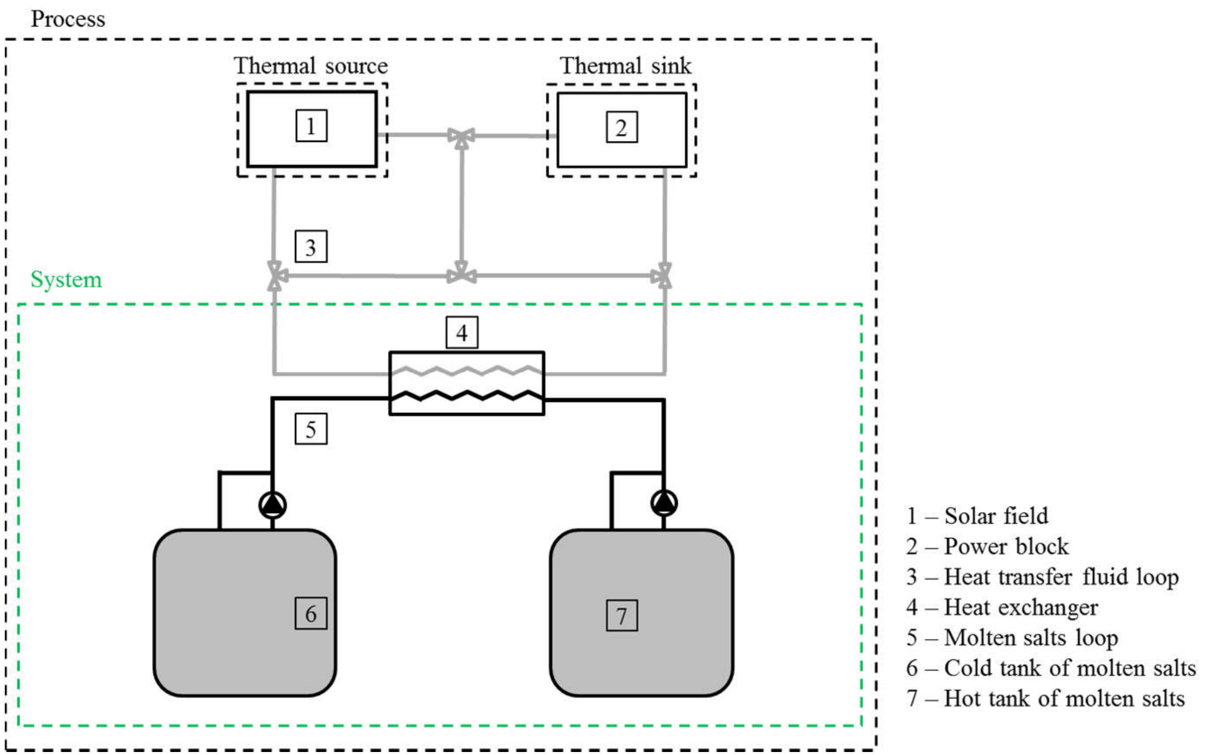
- Methodology with 6 analysis steps:
  1) Determination of integration goals
  2) Process and boundary definition
  3) Identification of thermal sinks and sources
  4) Quantification of thermal sinks and sources
  5) Analysis of overarching factors
  6) Determination of process requirements from previous steps



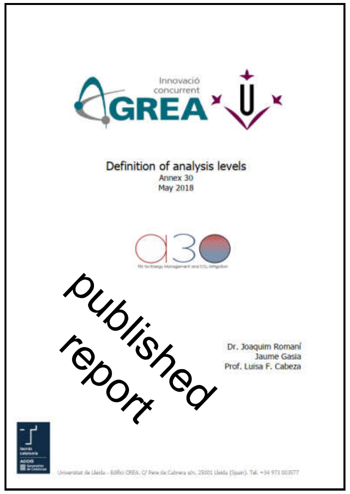
Subtask Results

Subtask 2 – Technical Parameters (Luisa F. Cabeza, UdL & Yukitaka Kato, TT)

- Creation of definition of system boundary for thermal energy storage



Definition of the system boundary as applied to an example of indirect storage in concentrating solar power.



Subtask Results

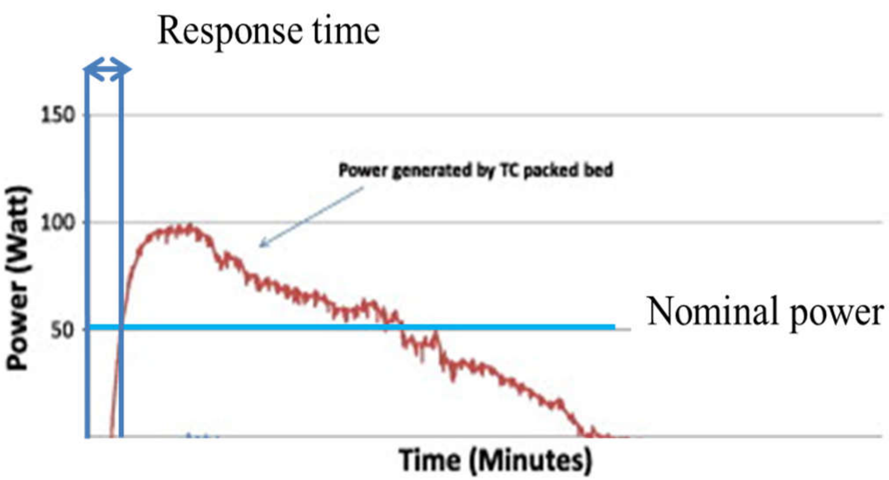
Subtask 2 – Technical Parameters (Luisa F. Cabeza, UdL & Yukitaka Kato, TT)

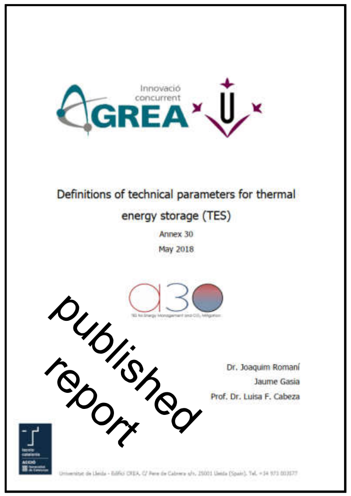
- Creation of definitions for 7 technical parameters of thermal energy storage

Example

Definition of Response time ($ReTi_{sys}$):

Interval of time between the moments in which the discharge request is issued and the moment the TES system reaches the nominal power ($P_{nom.sys}$).





Subtask Results

Subtask 3 – Economic Parameters (KTH, assumed by DLR)

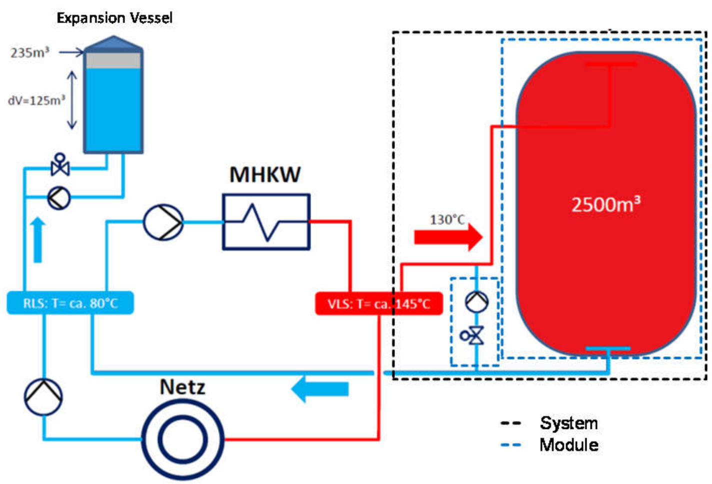
- Application of the bottom-up cost calculation methodology (SCC_{real}) from Annex 29 to collected case studies in Annex 30.
  - $SCC_{real} = INC/ESC_{sys}$

- Expansion to include bottom-up costs based on nominal power as well (SPC_{real}).
  - $SPC_{real} = INC/P_{nom.sys}$

Subtask Results

Subtask 4 – Case Studies (Richard Gurtner, ZAE Bayern)

- Collection and evaluation of 49 “real-world” cases of TES in applications.
- Validation of technical information for these cases and preliminary analysis within different application fields (e.g. technical parameters, system boundary).
- Comprehensive collection and validation of cases on district heating and cooling as reported in the Annex 30 public report.

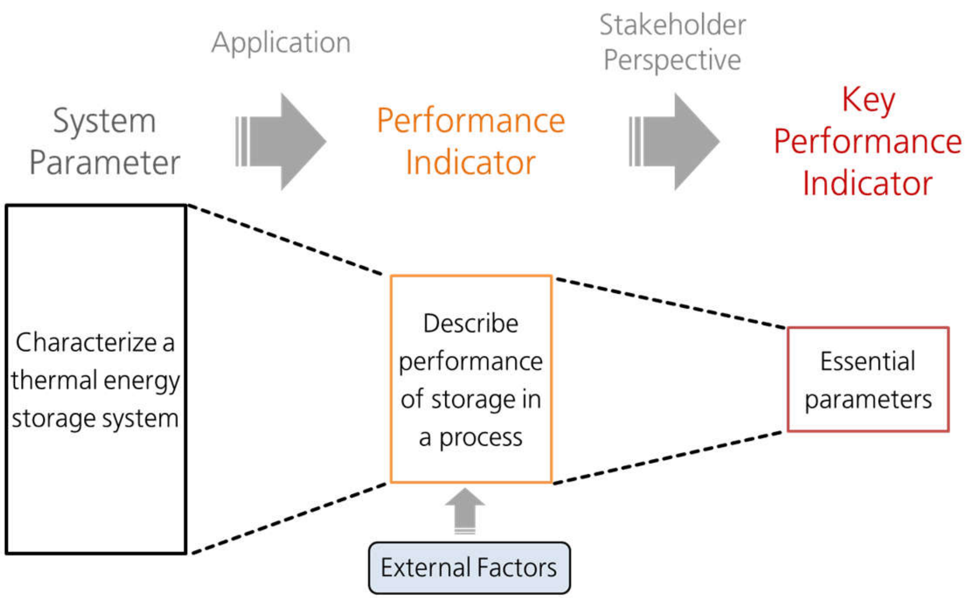


Images: City of Potsdam (L)
City of Ulm ®

Subtask Results

Subtask 5 – Key Performance Indicators (Duncan Gibb & Antje Seitz, DLR)

- Development of an analysis methodology for thermal energy storage integrated in an application.
- Methodology takes into account the most important system parameters, external factors and considers a stakeholder perspective to provide an analysis for the benefits of a TES system integrated into an application.



Evaluation

- Four of the most relevant sectors for integration of thermal energy storage systems investigated:
  - district heating
  - non-residential buildings
  - industrial processes
  - power plants
  - (application field of vehicles is also touched)

Example: Non-residential Buildings

- Most technologies use **low-temperature latent heat/PCM** (4 – 80 ºC).
- A low- to mid-range TRL level can be found (**TRL 3 – 8**). Some systems are being tested in a real environment, others are earlier-stage concepts.
- More interest is being shown in this sector, however complex technologies remain **pre-commercial**. Benchmarks are large-scale snow and ice storage.
- **R&D work** focuses on material development, system design, and system integration in processes (schools, office buildings).
- TES integration has delivered the following **benefits/KPIs**:
  - Time shift of heat/cold from lower energy needs at sink to higher energy needs
  - Subsequent peak shaving and downsizing of heating/cooling equipment
  - Improved performance of installed system components (CHP, chiller)
  - Reduction in greenhouse gas emissions

Example: Non-residential Buildings

Non-exhaustive representation of each sector and technology.

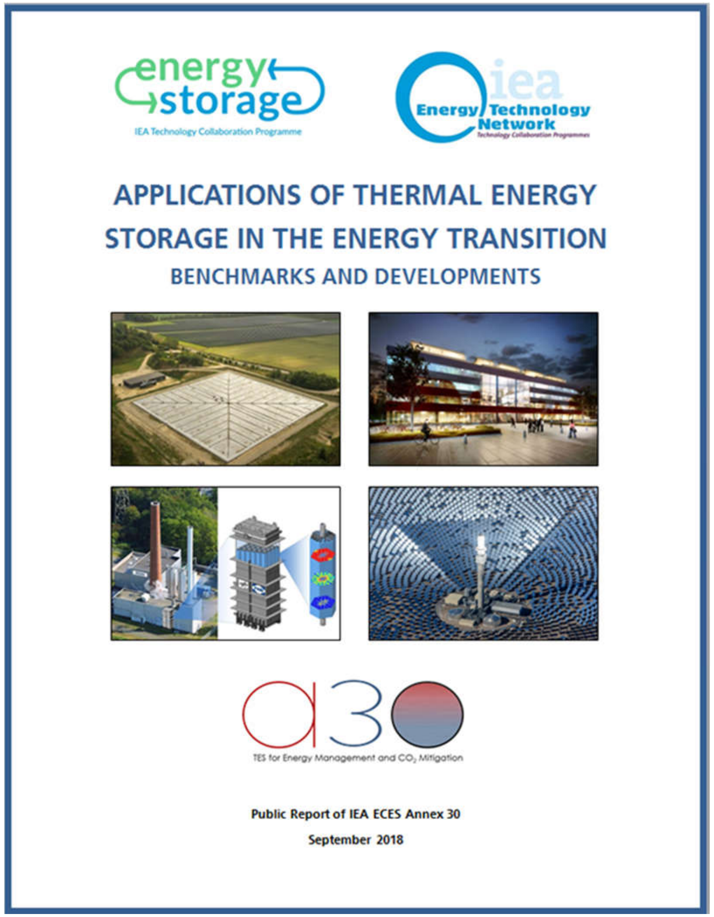
	Cold storage	Heat storage
T_{min} (°C)	-7 – 7	20
T_{max} (°C)	7 – 18	80
SCC_{real} (€/kWh)	0.8 – 3.3	ca. 103
ESC_{sys}	0.3 – 11 MWh (R&D) 0.49 – 10 GWh (Benchmarks)	
Cycle freq.	1/day to 1/year (seasonal)	
Response time	Immediate to 1-2 minutes	

Working lab office in Johanneberg Science Park (Akademiska Hus)

Storage bricks of phase change material (SINTEF Energy Research)

Public Report

- 23 participating institutions from
- 16 active countries
  - Members: BE, CA, CH, CN, DE, DK, ES, FR, IT, JP, NL, NO, SE, TR, UK
  - Observers: A



Thank you!

More information:

https//www.eces-a30.org

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