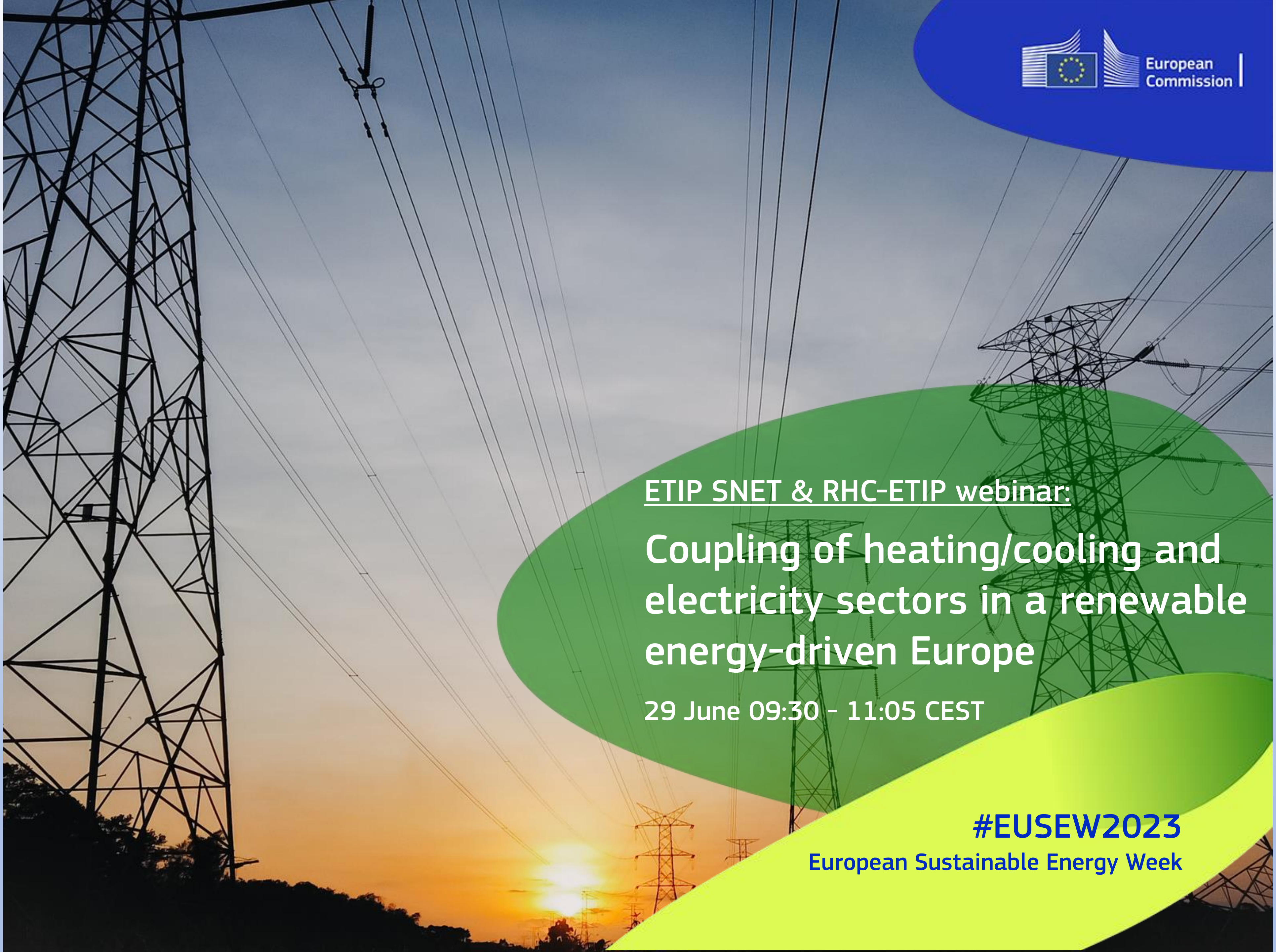

European Commission
ETIP SNET & RHC-ETIP webinar:
Coupling of heating/cooling and electricity sectors in a renewable energy-driven Europe
29 June 09:30 - 11:05 CEST
#EUSEW2023
European Sustainable Energy Week

Coupling of heating/cooling and electricity sectors in a renewable energy-driven Europe

	Topic	Speakers
9:30-9:50	Introduction and Presentation of ETIP SNET and ETIP RHC Joint White Paper “Coupling of Heating/Cooling and electricity sectors in a renewable energy-driven Europe”	• Alexander Wiedermann
	Sessions	
9:50-10:05	Session I: Technological potentials and barriers	• Ralf-Roman Schmidt • Caroline Haglund Stignor • Olaf Bernstrauch
10:05-10:15	Session I: Q&A	ALL
10:15-10:35	Session II: Thermal storage as an enabler of system integration and sector coupling	• Antonio Iliceto • Albana Ilo • Olaf Bernstrauch • Javier Urchueguia
10:35-10:45	Session II: Q&A	ALL
10:45-11:00	Session III: Skills needed for sector coupling	• Christian Holter • Albana Ilo
11:00-11:05	Closing remarks	• Alexander Wiedermann

Coupling of heating/cooling and electricity sectors in a renewable energy-driven Europe

	Topic	Speakers
9:30-9:50	Introduction and Presentation of ETIP SNET and ETIP RHC Joint White Paper: "**Coupling of Heating/Cooling and electricity sectors in a renewable energy-driven Europe**"	• Alexander Wiedermann

Introduction and Presentation of ETIP SNET and ETIP RHC Joint White Paper "Coupling of Heating/Cooling and electricity sectors in a renewable energy-driven Europe"

Speaker:

ALEXANDER WIEDERMANN

alexander.wiedermann@man-es.com

MAN Energy Sulutions SE, Germany

Consultant

- Leading Editor of White Paper
- ETIP SNET Co-Chair of WG3 Flexibility Generation

ETIP Smart Networks for Energy Transition (SNET)

The ETIP Smart Networks for Energy Transition (SNET) role is to **guide Research, Development & Innovation (RD&I) to support Europe's energy transition:**

Drafting Strategic R&I Roadmap and Implementation Plans, and key policy papers and recommendations to the EC

Address business and technology trends contributing to the overall energy system optimisation at affordable investment and operation costs

Investigate new transmission and distribution technologies, interfacing with storage, demand response, flexible generation and RES following the full digitalization

ETIP SNET Organisation

European Commission

Governing Board
Composed by European Associations in the following energy field sectors

Transmission System Operators (TSOs)	Distribution System Operators (DSOs)	National Representatives	Research & Academia
Storage (technology and services providers)	Consumers (aggregated and not aggregated)	Thermal Generation (flexible)	Renewable Energy Sources Generation
ICT, Network and Software providers	Equipment manufacturers and suppliers (non-ICT)	Interface to Other Energy Carriers (Heat, Transport, Gas, ...)	Regulators

Working Group 1
Reliable, economic and efficient energy system

Working Group 2
Storage technologies and system flexibilities

Working Group 3
Flexible generation

Working Group 4
Digitalisation of the electricity system and customer participation

Working Group 5
Innovation implementation in the business environment

NSCG
National Stakeholders Coordination Group

ETIP SNET Main achievements and publications

- **Vision 2050**
- **ETIP SNET R&I Implementation Plan 2022-2025**
- **ETIP SNET R&I Roadmap 2022 – 2031**

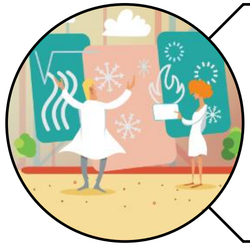
ETIP SNET Main achievements and publications

Retrievable from the ETIP SNET website

ETIP on Renewable Heating and Cooling (RHC) in a nutshell

- Founded in 2008, representing research and industry of heating & cooling technologies in Europe

Bring together stakeholders from the RHC sectors to **define a common strategy for increasing the use of renewable energy technologies for heating and cooling**



Support to the definition of a stable and favourable research policy framework for the development of renewable heating and cooling technologies at EU level

Increase **visibility and role** of RHC sectors

ETIP on Renewable Heating and Cooling (RHC) in a nutshell

- RHC-ETIP‘s work is structured according to Technology panels, with an emphasis on being solutions-oriented through the work of horizontal working groups:

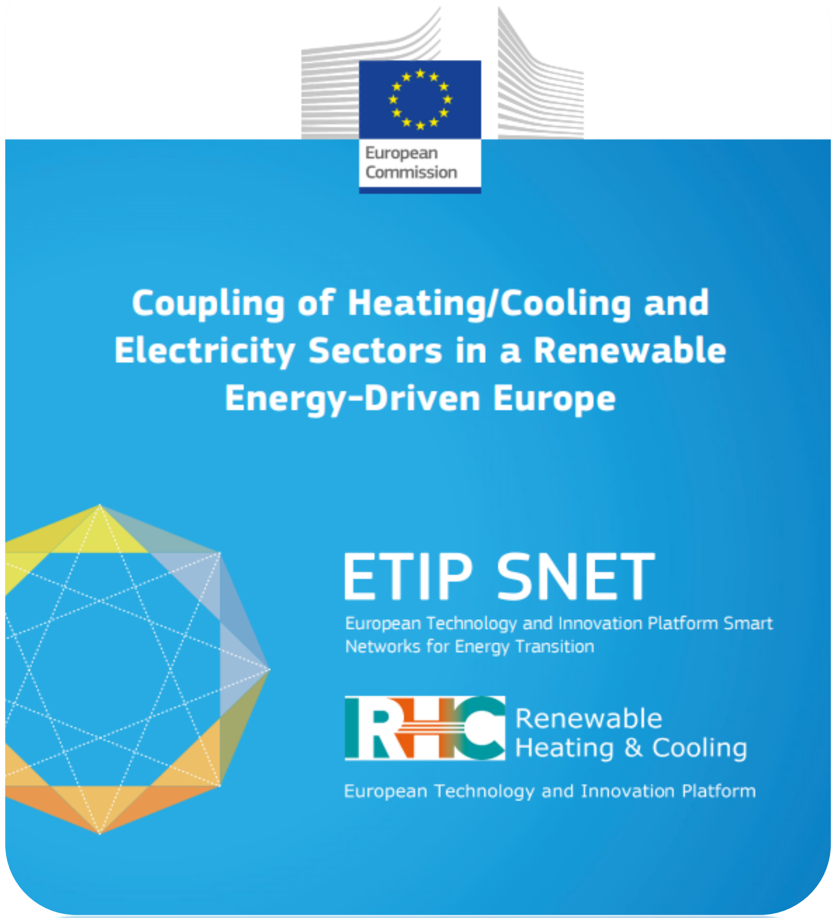
RHC-ETIP main achievements and publications

- 2050 Vision for 100% Renewable Heating and Cooling in Europe
- Strategic Research and Innovation Agenda for Climate-Neutral Heating and Cooling in Europe
- Strategic Report on Implementation of Research and Innovation Priorities and Deployment Trends of the Renewable Heating and Cooling Technologies

RHC-ETIP main achievements and publications

Available at the RHC-platform website

Coupling of heating/cooling and electricity sectors in a renewable energy-driven Europe



Link to the publication here

Corporate author(s):
Directorate-General for Energy (European Commission);
ETIP SNET;
RHC Renewable Heating & Cooling.

Personal author(s): Wiedermann Alexander; Calderoni Marco; Bernstrauch Olaf; Herce Carlos; Nowak Thomas; Jansohn Peter; Pastor Ricardo; Rutz Dominik; Iliceto Antonio; Ionel Ioana; Ilo Albana; Urchueguía Javier F.

Published: 2022

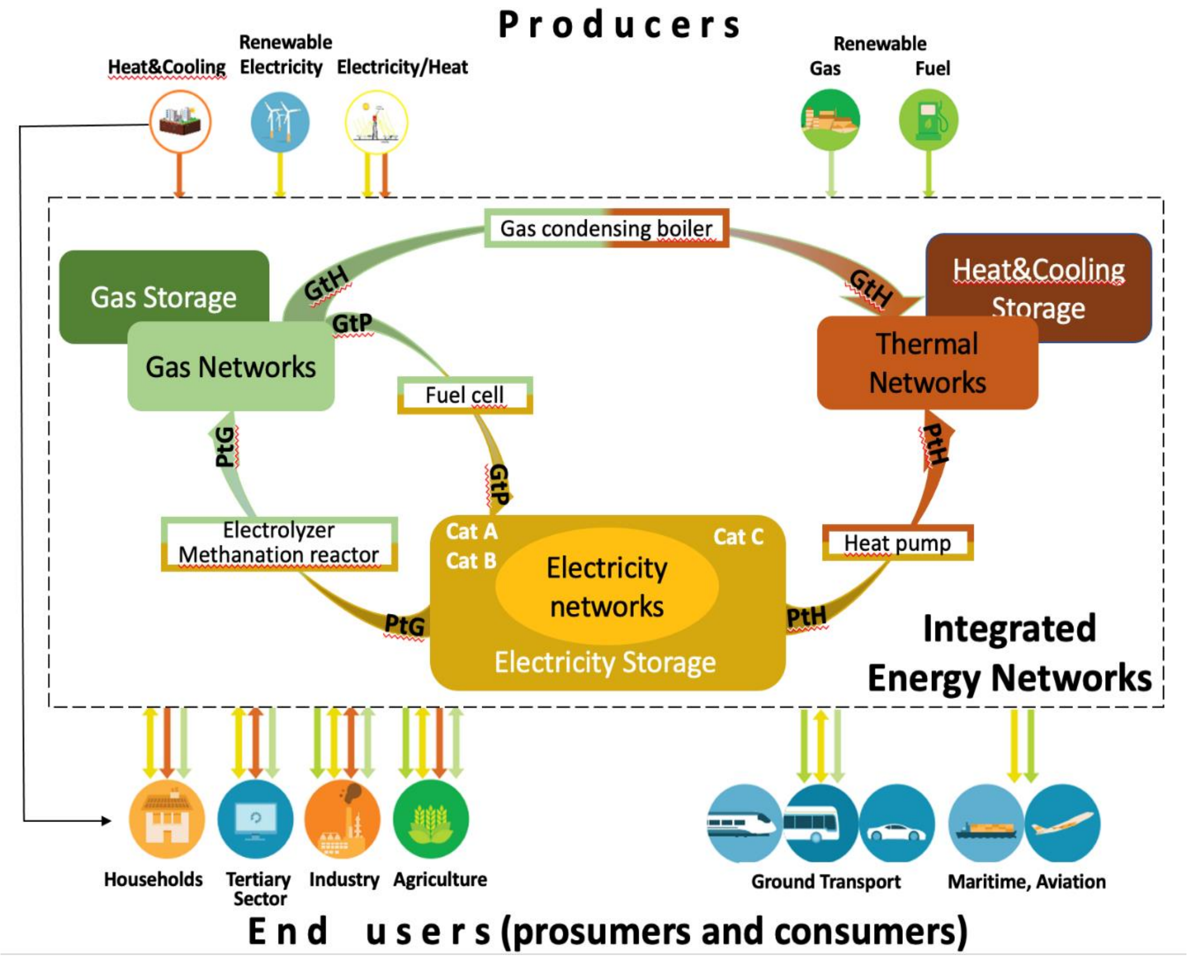
Coupling of heating/cooling and electricity sectors in a renewable energy-driven Europe

Scope of the paper in a nutshell:

- *Coupling of the existing electrification and heating/cooling technologies is key for a full decarbonisation of the energy system*
- *Work out the most promising energy sources and carriers*
- *Evaluate sector coupling components and technologies and their readiness to achieve decarbonisation within the timelines set by the EU in "Fit-for-55" and "REPowerEU" - packages*
- *Highlight the importance of thermal energy storage aligned with the extension of vRES*
- *Work out R&I requirements forming the basis of new business models*
- *Create public awareness for accepting cost intensive efforts and investments to achieve the goals*
- *Highlight the importance of education and new skills*

Coupling of heating/cooling and electricity sectors in a renewable energy-driven Europe

Holistic View on Systems level:



Conversion between electricity, gas and thermal networks:

*Role of **Power-to-Gas, Power-to-Thermal** and **Gas-to-Heat** processes to balance production and comsumers' demands*

Coupling of heating/cooling and electricity sectors in a renewable energy-driven Europe

- *Sector coupling components:*
  - *Heat pumps, both large scale (industrial plants- and DHC-connected) and aggregation of small devices (residential and tertiary devices)*
  - *Thermal storage, both large scale (industrial plants- and DHC-connected) and aggregation of small devices (through advanced controllers)*
- *Heat and power demand co-management: Power-to-X, X-to-Power*
- *Biomass utilisation*
- *Integration of industrial waste heat in overall heating and cooling networks*
- *Foster RHC in industries and buildings sectors*
- *"Smart Networks" and District Heating and Cooling*
- *Hydrogen as future energy carrier*

EU and national funding required to support set up of new business models

Coupling of heating/cooling and electricity sectors in a renewable energy-driven Europe

- *Need incentives to change market framework and political mind set*
- *Create public awareness*
- *Create skills and ensure education of trained designers, planners and installers*

Decarbonisation of European energy systems will require highest economic efforts and extended investment incentives at Pan-European level

Coupling of heating/cooling and electricity sectors in a renewable energy-driven Europe

Sessions		**Speakers**
9:50-10:05	Session I: **Technological potentials and barriers**	• Ralf-Roman Schmidt • Caroline Haglund Stignor • Olaf Bernstrauch

Session I: Technological potentials and barriers

Speaker:

RALF-ROMAN SCHMIDT
ralf-roman.schmidt@ait.ac.at

Senior Research Engineer
AIT Austrian Institute of Technology GmbH
(Austria)

- Chair of the ETIP-RHC
- Chair of the District Heating and Cooling and Thermal Energy Storage Technology Panel

Session I: Technological potentials and barriers

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Solar thermal, geothermal, bioenergy, district heating and cooling, and ambient and excess heat recovery - complemented with renewable electricity - are the **backbone of a radically new, user oriented, carbon-neutral, efficient, reliable, and flexible energy system**

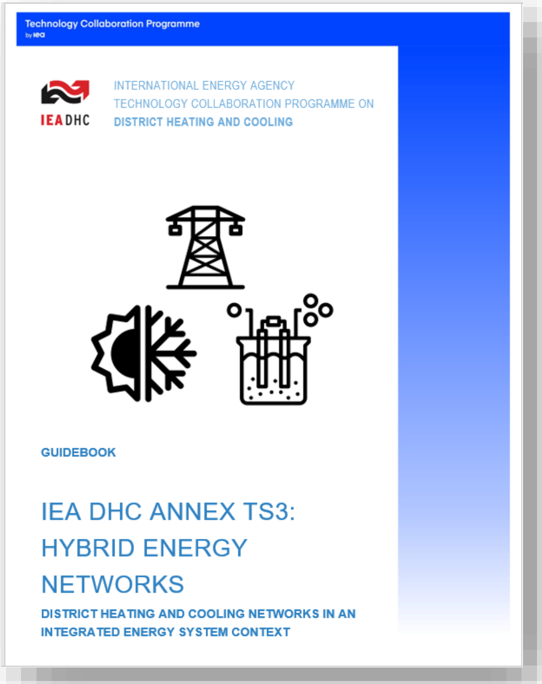
RHC technologies are mature, commercial, and market ready, today. They will be continuously developed for **increasing their performance and competitiveness**.

However, without **strong political support** to speed up the **market uptake** of these solutions, the 2050 vision will hardly become reality.

Session I: Technological potentials and barriers

The IEA DHC Annex TS3 Guidebook:
District Heating and Cooling in an Integrated Energy System Context

- Developed by an **international cooperation platform**, based on several workshops, webinars, and meetings; and involving the IEA International Smart Grid Action Network (ISGAN)



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Part A – Background
- Introduction
- Motivation

Part B - Concepts and technologies
- The Concept of Hybrid Energy Networks
- Large-Scale Heat Pumps in DHC
- The Double Loop Concept

Part C - System perspective
- The Point of View of the Transmission System Operators for Electricity and Gas
- The role of CHP plants and Heat Pumps from an European perspective
- National Scale Assessments for Austria and Denmark
- Hydrogen and District Heating

Part D - implementation
- Business models and boundary conditions
- Case Studies

Part E – Optimization and Evaluation
- Modeling, simulation, and optimization
- Resource exergy analysis
- Analysis of the Strengths, Weaknesses, Opportunities, and Threats

- **Appendix**
  - A Large Scale HPs
  - B Country Report Austria
  - C Country Report Denmark
  - D Country Report Germany
  - E Country Report Italy
  - F Country Report Sweden
  - G National Scale Assessments for Austria and Denmark
  - H Case Studies – Details
  - I Exergy analysis – Details
  - J SWOT Analysis - Detailed Results

Session I: Technological potentials and barriers

The IEA DHC Annex TS3 Guidebook:
District Heating and Cooling in an Integrated Energy System Context

- **Selected key results:**
  - **low temperature / cold networks** (4/5GDHC) offer the highest efficiency and flexibility
  - **Thermal storages** are important for seasonal energy shifting and ancillary services
  - (Tans-)national **energy systems models** should consider DH flexibility and efficiency
  - In DH, the optimal share of **CHP and HPs** will be 3-7%, and 40% - 75%
  - **Gas fired CHP** have the lowest system costs (depending on the price of renewable fuels)
  - Waste heat from **electrolysers** could cover up to 64% of the EU DH demand in 2040
  - **Integrated energy markets** are developing, including the idea of energy cooperations
  - **Digitalisation** can help manage the increasing complexity with integration
  - New approaches for **modelling, simulating and optimizing** are required
  - The **main threats** are a possible disruption of existing business and uncertainties (regarding regulatory framework, market design & evolution, availability of waste heat)

Session I: Technological potentials and barriers

Speaker:

CAROLINE HAGLUND STIGNOR
caroline.haglundstignor@ri.se

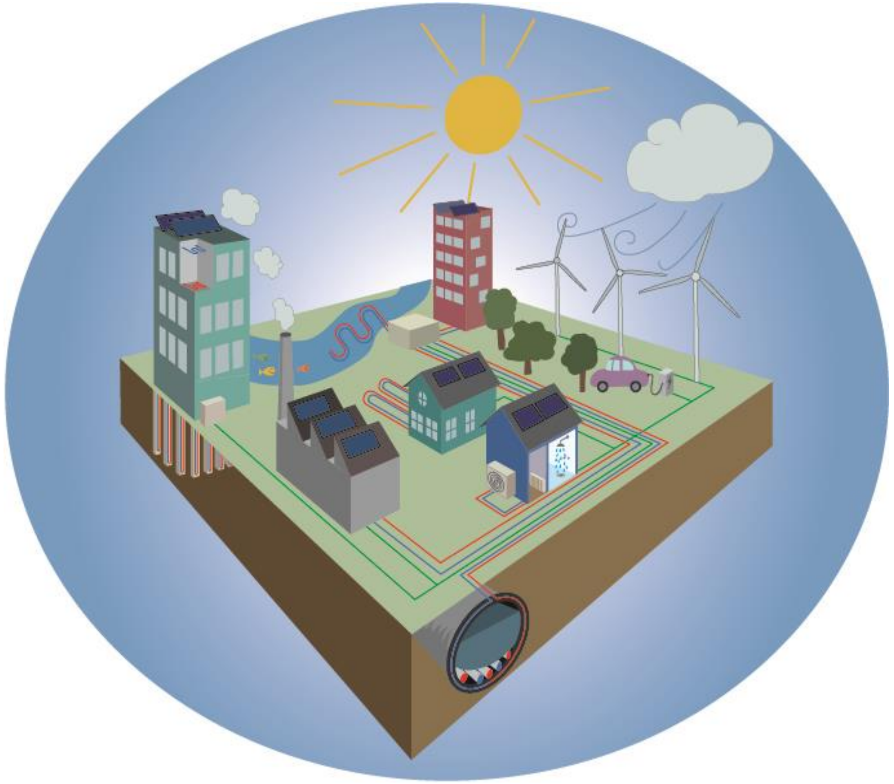
Focus Area Manager Energy Efficiency
RISE (Sweden)

- RHC-ETIP Chair of the Heat Pump Technology Panel

Heat Pumping Technology

… is a **proven efficient and clean technology available** on the market

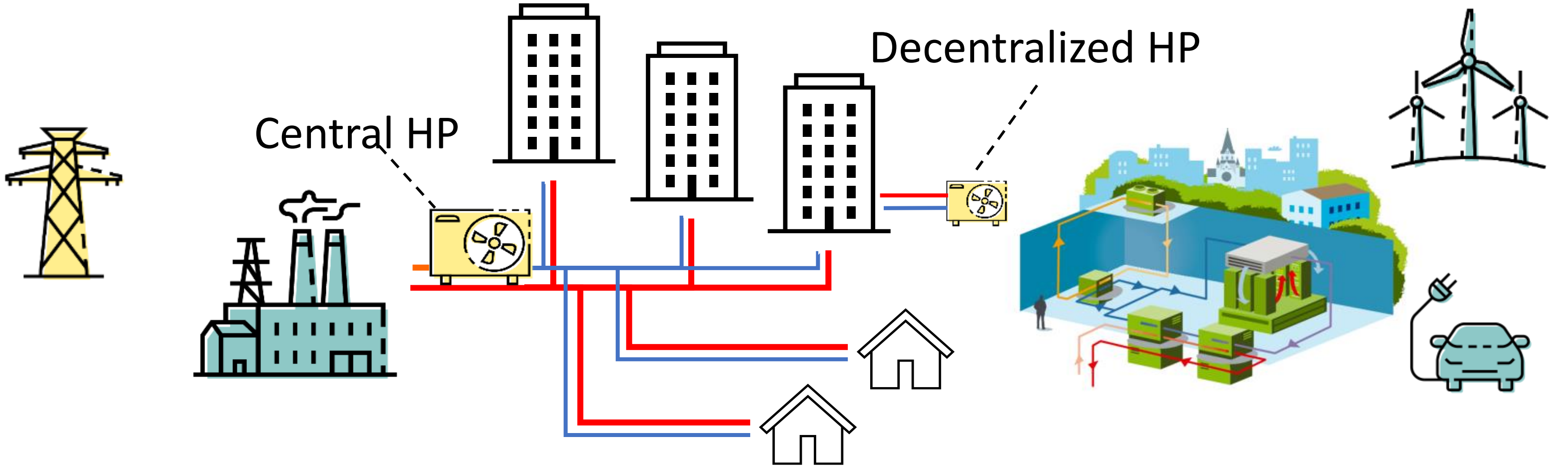
- upgrades renewable energy & reduces CO_2 emissions
- is an excellent flexibility provider to **balance the grid** to handle **intermittent production**
- contributes to improved **energy security and resilience**
- contributes to improved **energy efficiency**
- can deliver **heating AND cooling**



Session I: Technological potentials and barriers

Heat pumps' potentials to balance the electric grid

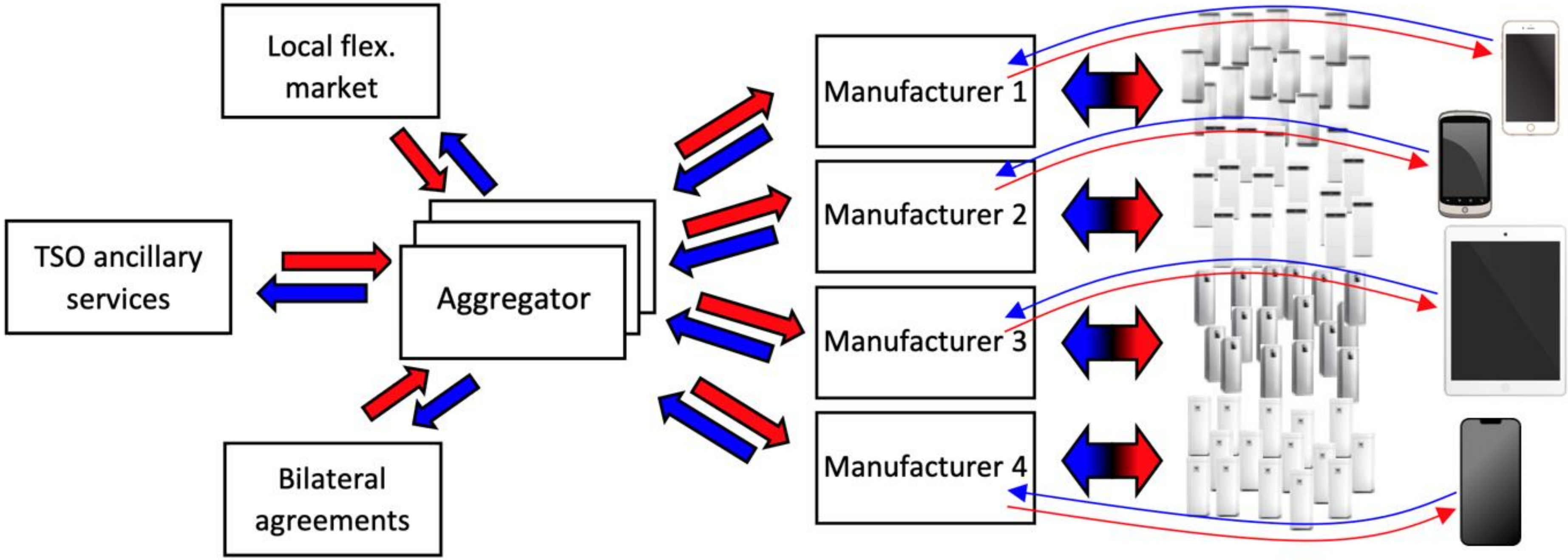
- By controlling the power consumption of the heat pump one can:
  - Help **balancing** the power systems **variations** in supply and demand
  - By using the **thermal inertia** in thermal grids, storages and buildings the heat pump can provide demand response
- The electric load from one single (small) HP gives low flexibility
- A **coalition** of heat pumps needs to be controlled together to support the power grid with a useful size flexibility
- An advantage of using a **combination** of heat pumping technology and thermal networks/grids is the **greater flexibility** in heat production and storage options



Source: Song et al., Flexibility potential of heat pump in Swedish thermal grids - For district heating companies and end users, 14th IEA Heat Pump Conference, Chicago, 2023

Session I: Technological potentials and barriers

Potential for cluster controlling of distributed heat pumps



TSO = Transmission System Operator, in US called RTO (Regional transmission organization)

Source: Walfridson et al., Large scale demand response of heat pumps to support the national power system, 14th IEA Heat Pump Conference, Chicago, 2023

Session I: Technological potentials and barriers

Speaker:

OLAF BERNSTRAUCH
olaf.bernstrauch@siemens-energy.com

Principal Key Expert Innovation Management
Siemens Energy Global GmbH & Co. KG

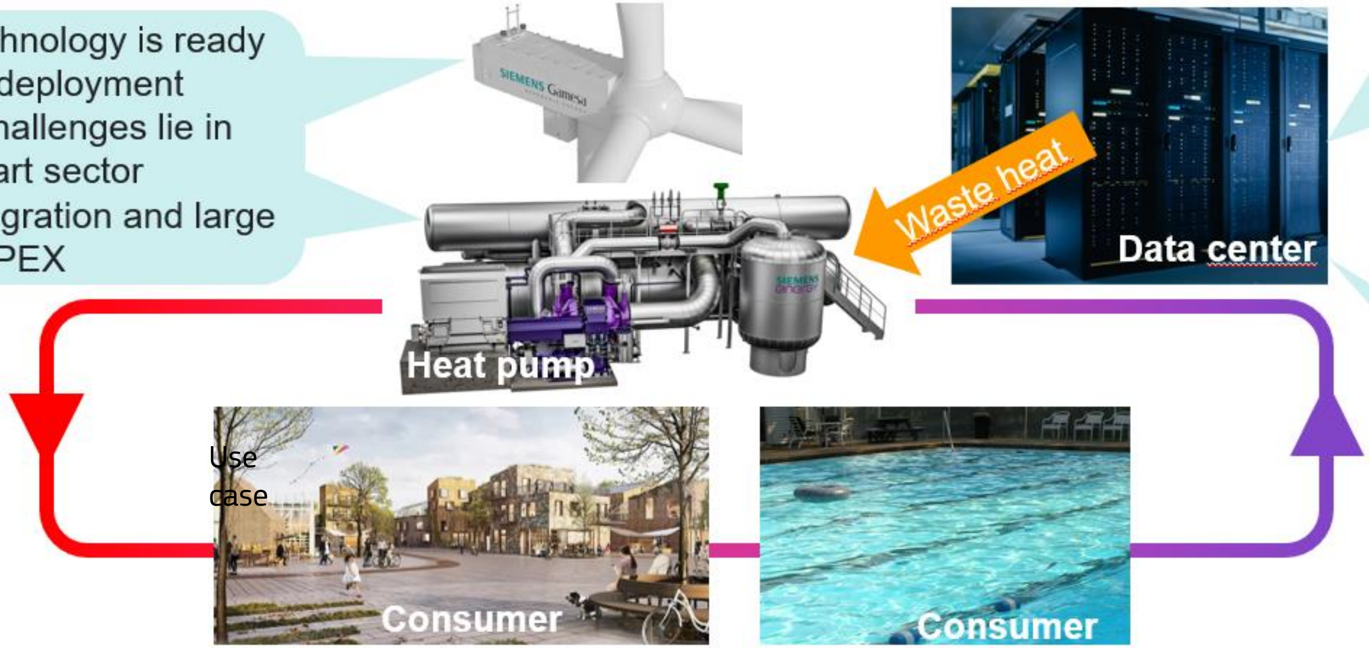
- Chair of ETIP SNET WG3 Flexible Generation
- Chair of EUTurbines WG Research
- ETN Project Board Member

Session I: Technological potentials and barriers

Example 1 for decarbonized heat: **Wind-to-heat in a renewable micro-grid environment**

Technology is ready for deployment – challenges lie in smart sector integration and large CAPEX

Data center covers part of heat demand – and thereby gets cooled reliably



Constant-temperature waste heat allows year-round efficient and reliable operation of heat pump

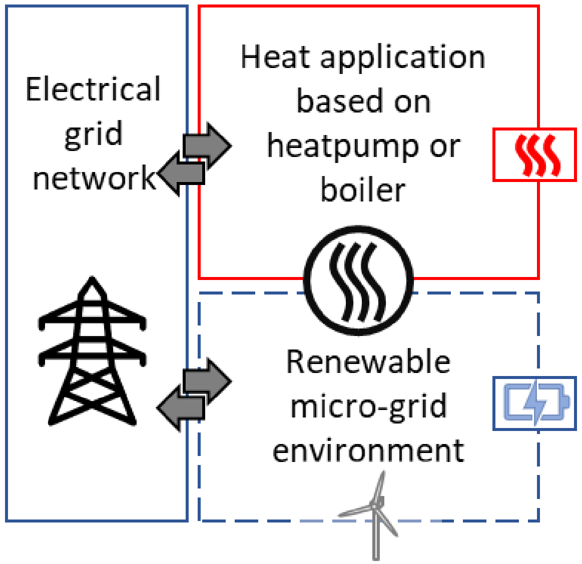
Heat pump	Waste heat	Wind
70MW$_{th}$ (all year)	14MW (all year)	**40MW (installed capacity)**
COP_{WP} =3.5		CF_{wind} =0.4

Source SGRE

Session I: Technological potentials and barriers

Example 1 for decarbonized heat: **Wind-to-heat in a renewable micro-grid environment**

Concept of HRM[1] for heat



Potential

- Renewable microgrid to directly supply heat via boiler or HP to heat application to reduce peak loads on grid and reduce supply costs
- In case of low heat loads or insufficient renewable energy supply the system can be balanced through grid embedment

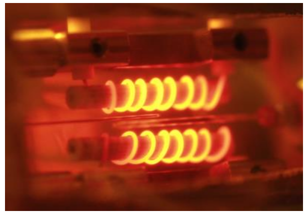
Note 1: HRM = Hybrid Renewable Microgrid

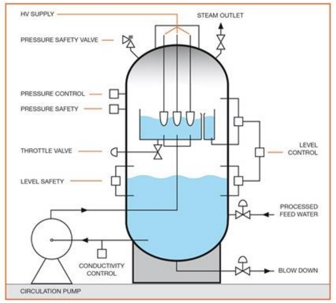
Electrica l storage | Thermal storage | Offgrid capable wind system

Session I: Technological potentials and barriers

Example 2 for decarbonized heat: **Emission-free Electric Heater for Fluids**

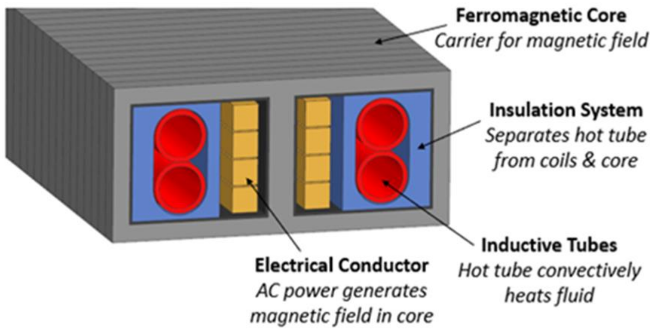
- **Conventional Approach** (3 most common technologies for heating)
  - Resistive
  - Radiative
  - Conductive (electric boilers)
- ***Could not overcome 2 key challenges***
  - Low voltage at high MW (1000V, 4400 V, 10-100 MW)
  - Critical electrical components exposed to high temperatures & corrosive process fluid





Parat Electric Boiler

- **Inductive Solution**
- ✓ Critical electrical components:
  - maintained below 150°C
  - Not exposed to fluid (non-contacting)
- ✓ Efficiency > 99%
- ✓ Process Fluid: single phase gas or liquids (incl. Molten Salt, Oil, Air, CO2)
- ✓ 200-1000°C, up to 27kV, up to 1000 MWth
- ✓ High power density, Lower cost for system
- ✓ Higher reliability, lower OPEX (reduced maintenance)
- ✓ Modular and scalable



Session I: Technological potentials and barriers

Session I: Questions & Answers?

Coupling of heating/cooling and electricity sectors in a renewable energy-driven Europe

Session		Speakes
10:15-10:35	Session II: **Thermal storage as an enabler of system integration and sector coupling**	• Antonio Iliceto • Albana Ilo • Olaf Bernstrauch • Javier Urchueguia

Session II: Thermal storage as an enabler of system integration and sector coupling

Speaker:

ANTONIO ILICETO
antonio.iliceto@terna.it

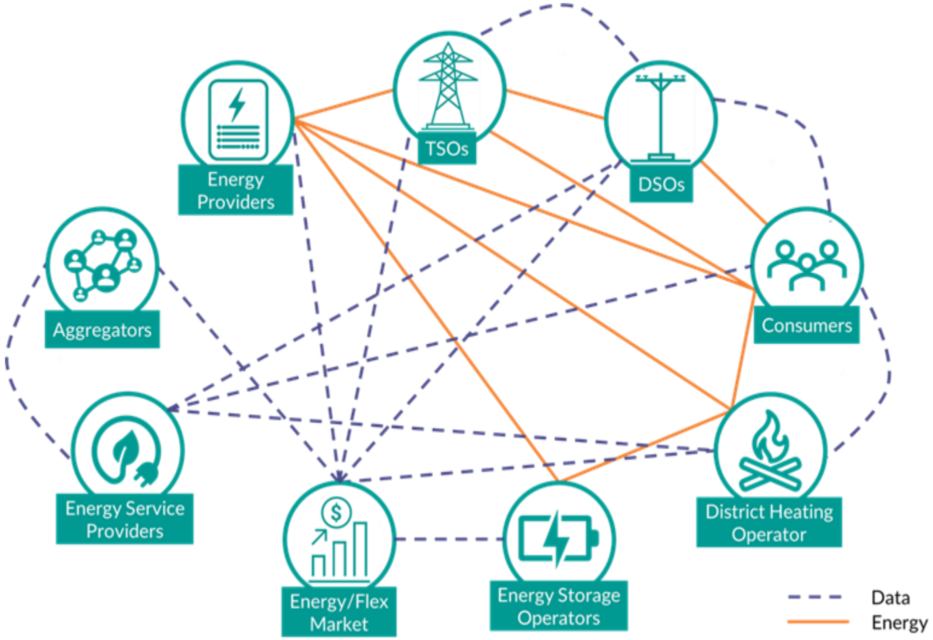
Strategies, Planning, and Dispatching Department TERNA (Italy)

- Governing Board member ETIP SNET for ENTSO-E (TSO association)
- Co-Chair of ETIP SNET WG1 Power Grids and Energy System View

Session II: Thermal storage as an enabler of system integration and sector coupling

- The H&C sector is quite fragmented, characterized by an ageing and inefficient buildings and appliances stock; it relies on CO2 emitting sources and has traditionally little connections with the electricity sector.

- Under the future perspective of an integrated energy system, the interactions among Power and Heat sector, where synergies are to be pursued, fall under 3 categories:



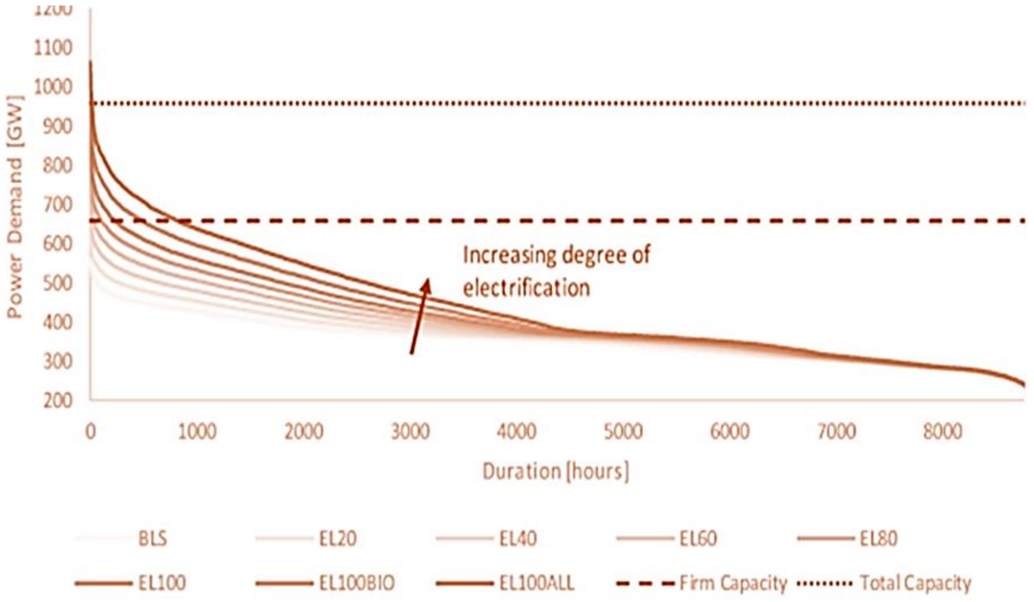
Electrification of heating systems, implying electric load increase and load profile modification, as well as flexibility provision from demand response and exploitation of **intrinsic thermal behaviour** of H&C systems

Thermal storage systems for medium/long term flexibility at energy system level; heat energy can be stored at a cost approximately 100 times lower than in an electrochemical battery (of course with very different performances, especially dynamic)

Co-optimisation of both sectors through **most efficient use of energy sources**, conversion devices and consumption patterns, including Combined Heat and Power (CHP), District Heating (DH) and Waste-to-Heat, also through d**igitalisation (already deply embedded in the electricity sector,** but lagging behind in H&C)

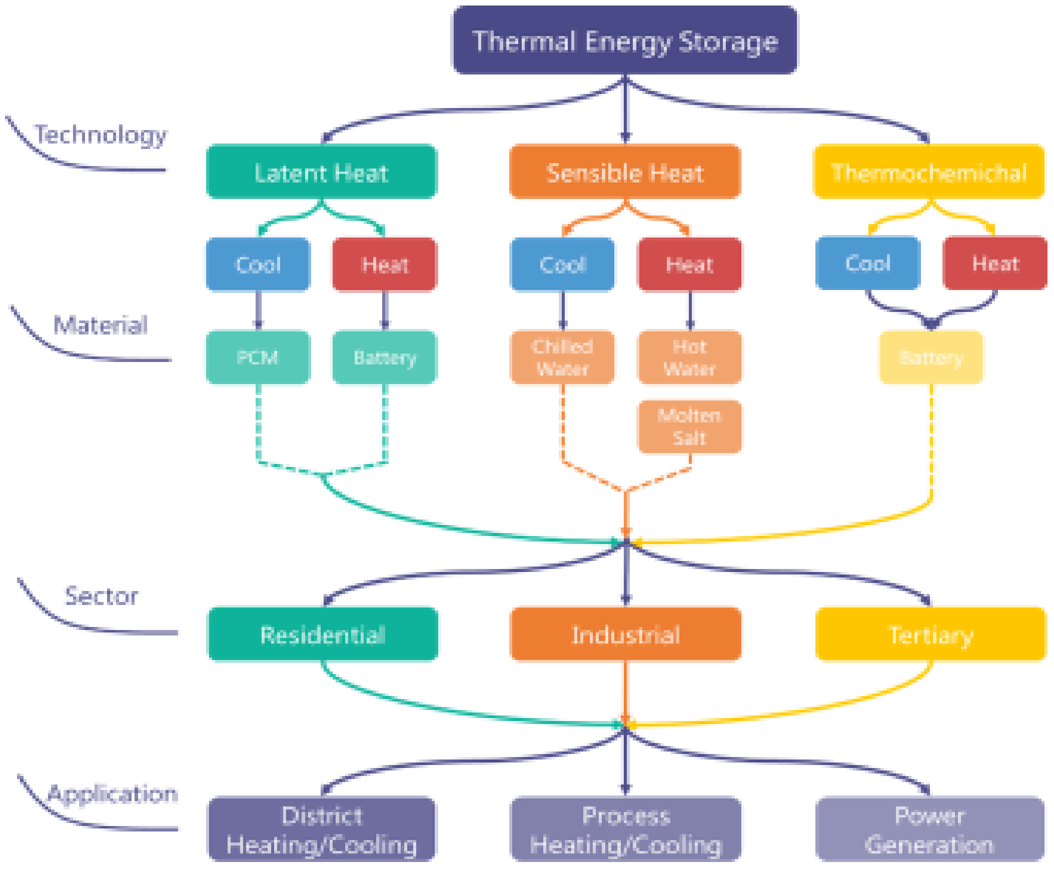
Session II: Thermal storage as an enabler of system integration and sector coupling

- The fundamental principle of thermal storage is to utilize the **thermal capacity** of an object (piece of material, device, or closed space), which characterizes the amount and speed of energy exchanges with the surrounding environment, depending on their temperature difference
- If the aim of the heating/cooling process is to **control the object's temperature**, its thermal inertia (intrinsic time-lapse in response of temperature vs heat exchange) can be exploited to modulate the load profile of the energy exchanged for heating/cooling; typical example are residential and service buildings. Such modulation is a flexibility option for the supplying system, usually requiring no or little additional investments.
- If instead t**he object is built on purpose to store thermal energy,** it represents a pure thermal storage device, to be operated according to energy system needs, decoupling load profiles of electric and thermal sectors; and to be assessed through a cost-benefit analysis of its investment + operating costs vs the benefits it brings to the system (typically, the different time-value of the energy input and output).



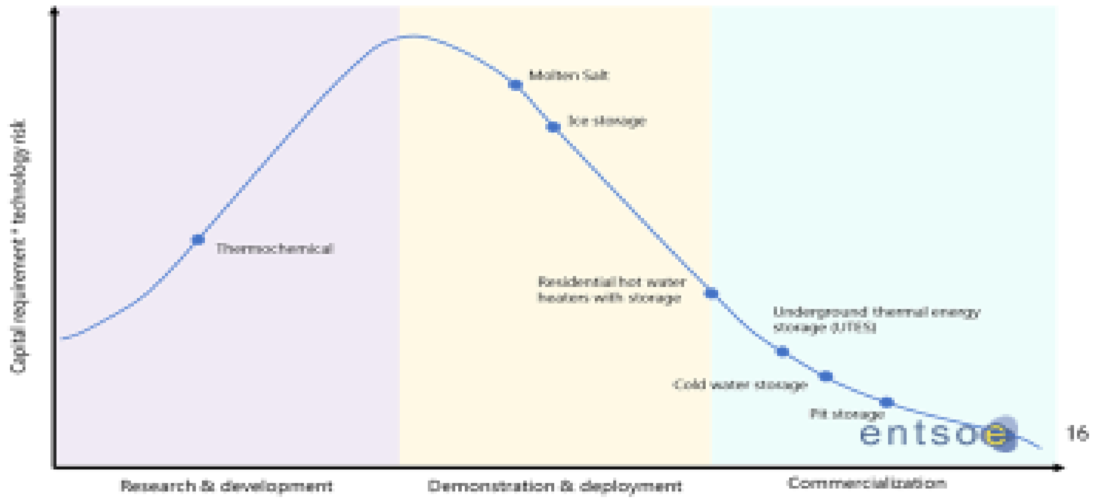
Small number of hours with high demand (steeper profile) → demand-side flexibility could reduce this number of hours and spread out the peak demand more evenly.

Thermal Energy Storage



- ✓ Thermal storage can be evaluated as an attractive **alternative to direct electrification** of H&C, managing the excessive clean energy in a flexible and efficient way.
- ✓ Thermochemical storage is able to achieve energy storage densities of 5–20 times greater than sensible storage.
- ✓ Pure TES (not thermal inertia of buildings) is being developed with good expectations on cost and performances

- ✓ Technical restrictions (e.g. thermal losses).
- ✓ High investment costs & diversity of the market.
- ✓ The TES potential associated with the building stock is easier during construction, the penetration could be limited in countries with low rates of new buildings construction.



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Session II: Thermal storage as an enabler of system integration and sector coupling

Speaker:

Prof. ALBANA ILO
albana.ilo@tuwien.ac.at

Holistic developments of Smart Grids (TU Wien, Austria)

- Member of ETIP SNET WG1 Power Grids and Energy System View

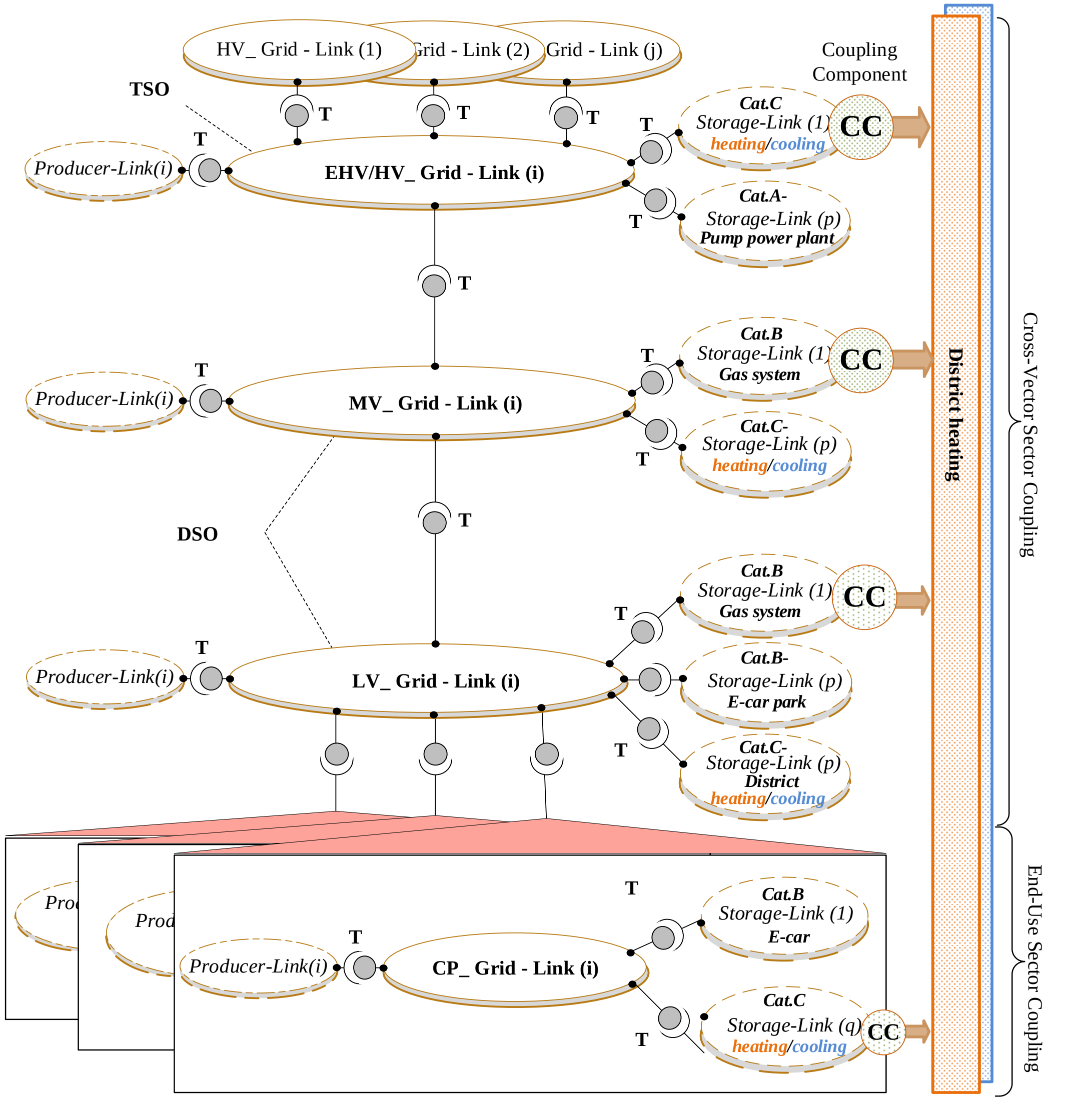
Session II: Thermal storage as an enabler of system integration and sector coupling

Storage categorization in the holistic LINK-Solution

Storage-Link category	Description
Cat. A	The stored energy is injected at the charging point of the grid.
Cat. B	The stored energy is not injected back into the charging point on the grid.
Cat. C	The stored energy reduces the electricity consumption at the charging point in the near future

In the “Cat. C” the electricity consumption can shift from peak to off-peak hours and can make buildings smart grid-ready by regulating equipment to respond to the peak electricity alerts on the power grid.

Session II: Thermal storage as an enabler of system integration and sector coupling



The holistic LINK architecture structures cross-vector sector coupling in all voltage levels of power grids and the end-user sector coupling, opening the perspective of jointly investigating power and heat/cooling grids.

Changing district heating systems from single source boilers with controllable fuels to multi-renewable supply systems.

Session II: Thermal storage as an enabler of system integration and sector coupling

Speaker:

OLAF BERNSTRAUCH
olaf.bernstrauch@siemens-energy.com

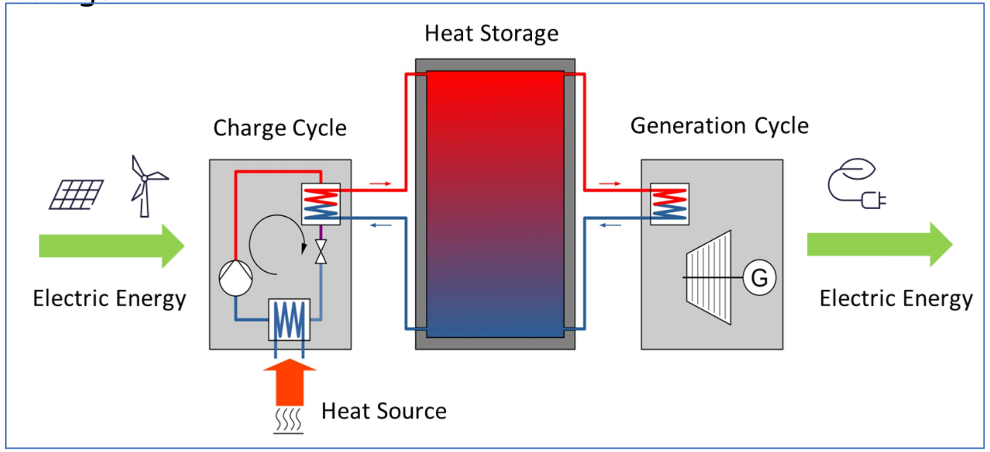
Principal Key Expert Innovation Management
Siemens Energy Global GmbH & Co. KG

- ETIP SNET Chair of WG3 Flexible Generation
- Chair of EUTurbines WG Research
- ETN Project Board Member

Session II: Thermal storage as an enabler of system integration and sector coupling

Example 1 for heat storage: **Carnot battery**

A Carnot battery is a type of long duration energy storage system that converts electricity to heat for thermal energy storage.



General Data (SE Carnot Battery, exemplary use case):
Max. storage temperature: **545 °C**
Generation time: **10 h**
Max. electric output: **100 MW→ 1000 MWh** capacity

Large variety of technical solutions feasible:

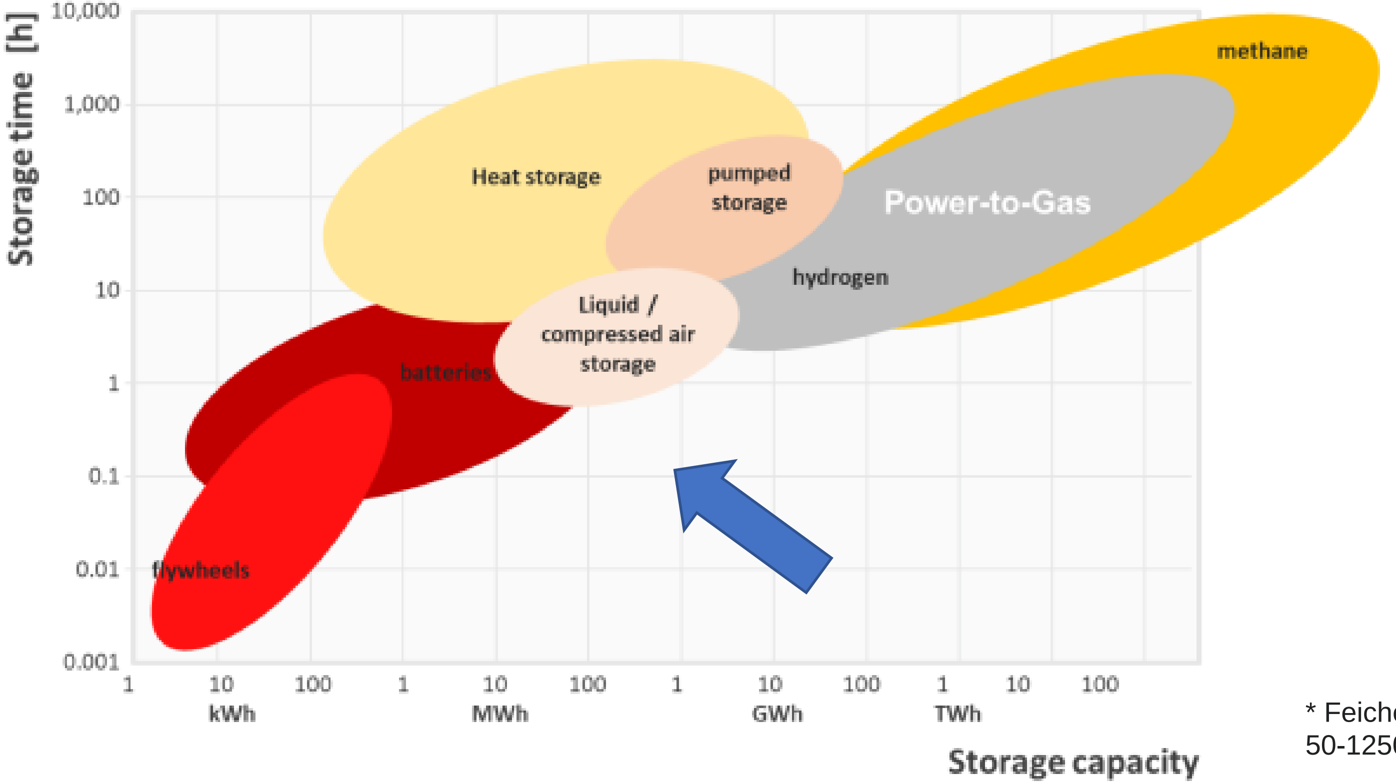
MALTA.INC:
- Process medium: Air
- Turbo compressor and turbine train for each cycle
- Thermal storage with molten salt and methanol

Siemens Energy:
- Process medium: Water / steam
- Turbo compressor for charge cycle, steam turbine for generation cycle
- Thermal storage with molten salt and water

Advantages:
large scale storage, long lifetime, process heat extraction from storage or steam extraction from turbines possible (different temp. levels, CHP application), opportunities for co-creation with end-users

Session II: Thermal storage as an enabler of system integration and sector coupling

Option 2 for storage: Compressed Air Energy Storage **CAES: Storage capacity up to 10 GWh***

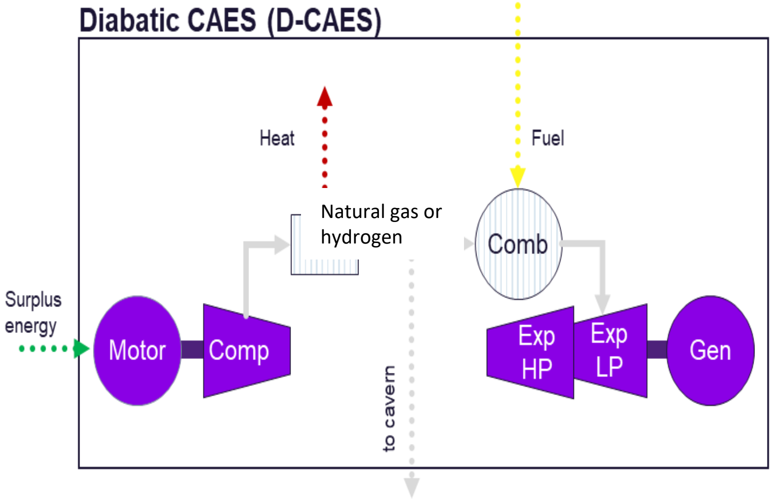


* Feicheng, Shandong, China: 7500 MWh, 50-1250 MW (abiab)

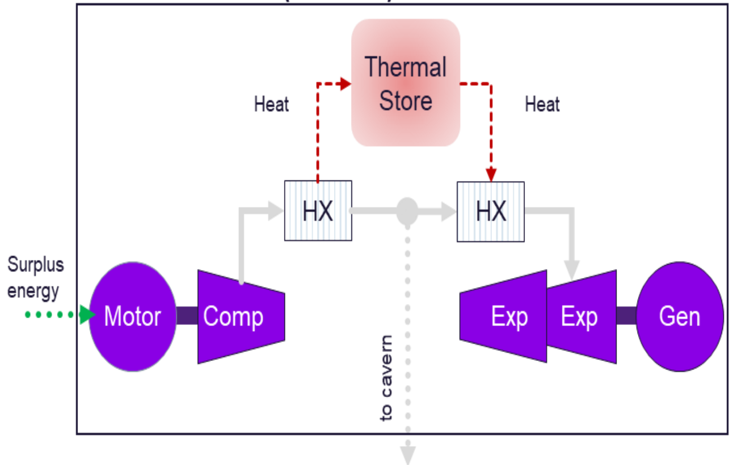
Session II: Thermal storage as an enabler of system integration and sector coupling

Option 2 for storage: Compressed Air Energy Storage **CAES:** Both CAES-variants (diabatic vs. adiabatic) have its justification

Diabatic CAES (D-CAES)



Adiabatic CAES (A-CAES)



Target Applications	More than 24 hours discharge time possible	Ideally less than 16 hours discharge time
	RTE up to 60%, Low CO_2, NOx emissions (H_2 Ready – No CO_2)	RTE up to 70%, Zero emissions
	Fast startup capability (<10 min) with high number of starts (20.000)	
G-t-M	Customer who require >24 hrs discharge-time and parallel compression / expansion & with fuel-access and acceptance for low emissions	Customers who require <16 hrs discharge-time & looking for Zero CO_2 and NO_X emissions. Large flexibility for cavern-pressure and power

RTE: Roundtrip efficiency

Session II: Thermal storage as an enabler of system integration and sector coupling

Speaker:

JAVIER URCHUEGUIA
jfurchueguia@fis.upv.es

Full Professor, Department of Applied Physics
Universitat Politècnica de València (UPV), Spain

- RHC-ETIP Chair of the Geothermal Technology Panel

Session II: Thermal storage as an enabler of system integration and sector coupling

Session II: Questions & Answers?

Coupling of heating/cooling and electricity sectors in a renewable energy-driven Europe

Session		Speakes
10:45-11:00	**Session III:** **<u>Skills needed for sector coupling</u>**	• Christian Holter • Albana Ilo

Session III: Skills needed for sector coupling

Speaker:

CHRISTIAN HOLTER
c.holter@solid.at

Founder of SOLID – Solar energy systems
SOLID SOLAR ENERGY SYSTEMS GMBH (Austria)

- RHC-ETIP Member of Solar Thermal Technology Panel

Session III: Skills needed for sector coupling

Masterplan

System based holistic approach considering demands and ressources replacing single technology promoting thinking

- *What is the final demand on energy?*
- *What is the best use of certain energies?*
- *How do regional factors lead in different solutions?*
- *How do we get energy to the place of use at the right time?*
- *What is the best balance between cheaper central production with extended transmission versus smaller more expensive production?*
- *How can best we match available ressources and demand?*
- *How can we direct investments towards system optimisation?*

Session III: Skills needed for sector coupling

Get it moving

Many technologies are ready to go!

- *Roll out of existing knowledge-*
  - *we need more people well educated in engineering, construction and operation*
- *Implementation with new entities and business models*
  - *We need people that make new Business Models and project financing happen for complex systems*
- *Thinking ahead long term*
  - *Decision makers need to consider building a new infrastructure on generations*
- *Improvement and more innovation for more efficiency*
  - *We need bright people for ongoing Research& innovation*

Session III: Skills needed for sector coupling

Speaker:

Prof. ALBANA ILO
albana.ilo@tuwien.ac.at

Holistic developments of Smart Grids
(TU Wien, Austria)

• ETIP SNET Member of WG1 Power Grids and Energy System View

Session III: Skills needed for sector coupling

< 6 years

6-14 years

*Educate people to **save energy by raising awareness of the importance of energy,** and not only by price mechanisms.*

Energy must be saved, even if it is cheap!

14 -18 years

> 18 years

***Fighting the silo mentality** that characterizes today's technical, professional, and research-oriented education toward a **holistic grasp with at least two energy vectors of focus**.*

*E.g. **introduction of cross-faculty master's programs** such as:*

"Electrical and thermal-fluids engineering"

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11:00-11:05	**Closing remarks**	• **Alexander Wiedermann**

Thanks for your participation!

ETIP SNET & RHC-ETIP webinar:

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29 June 09:30 - 11:05 CEST

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