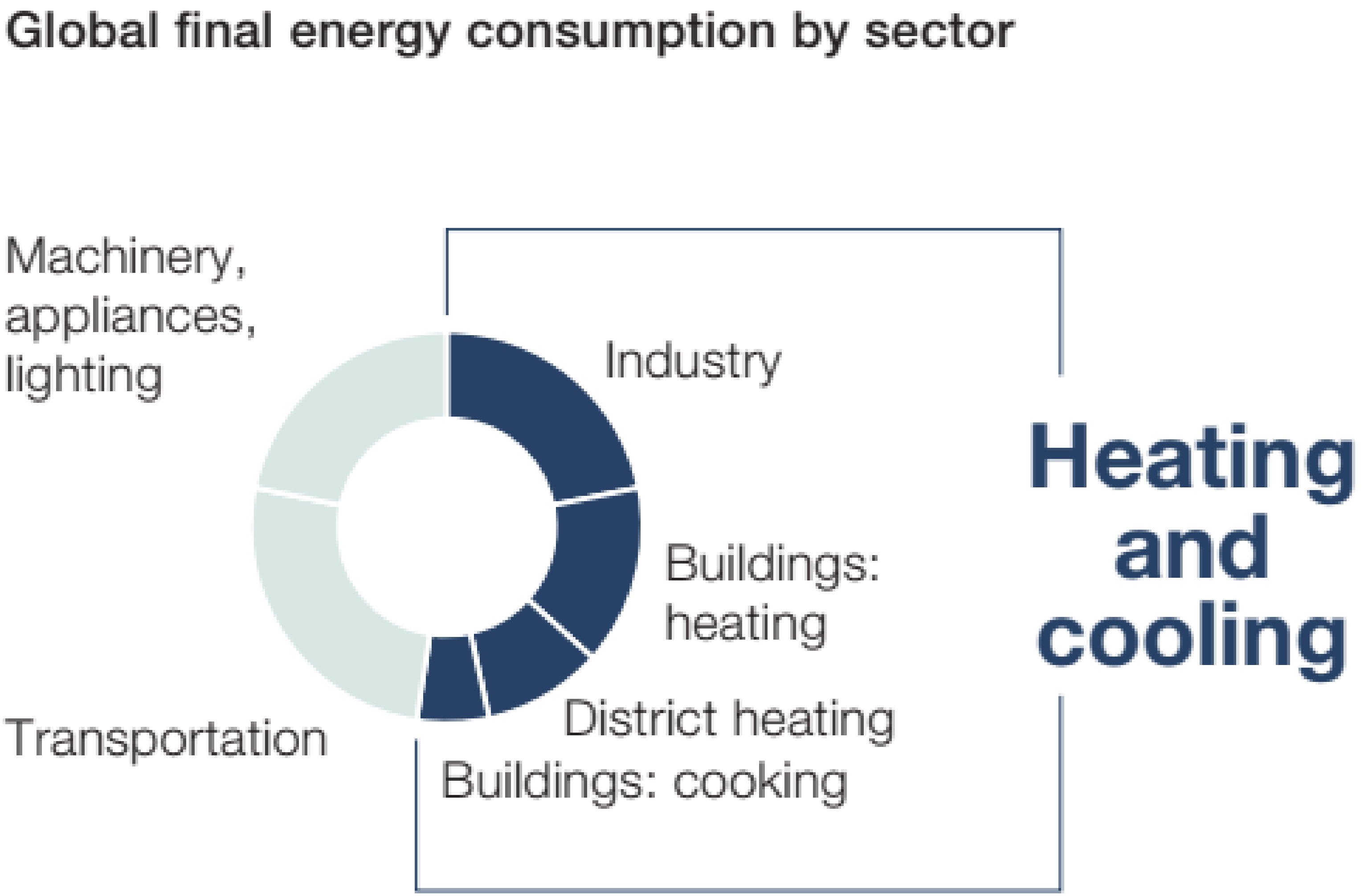
THERMAL STORAGE
- NEW DIRECTIONS

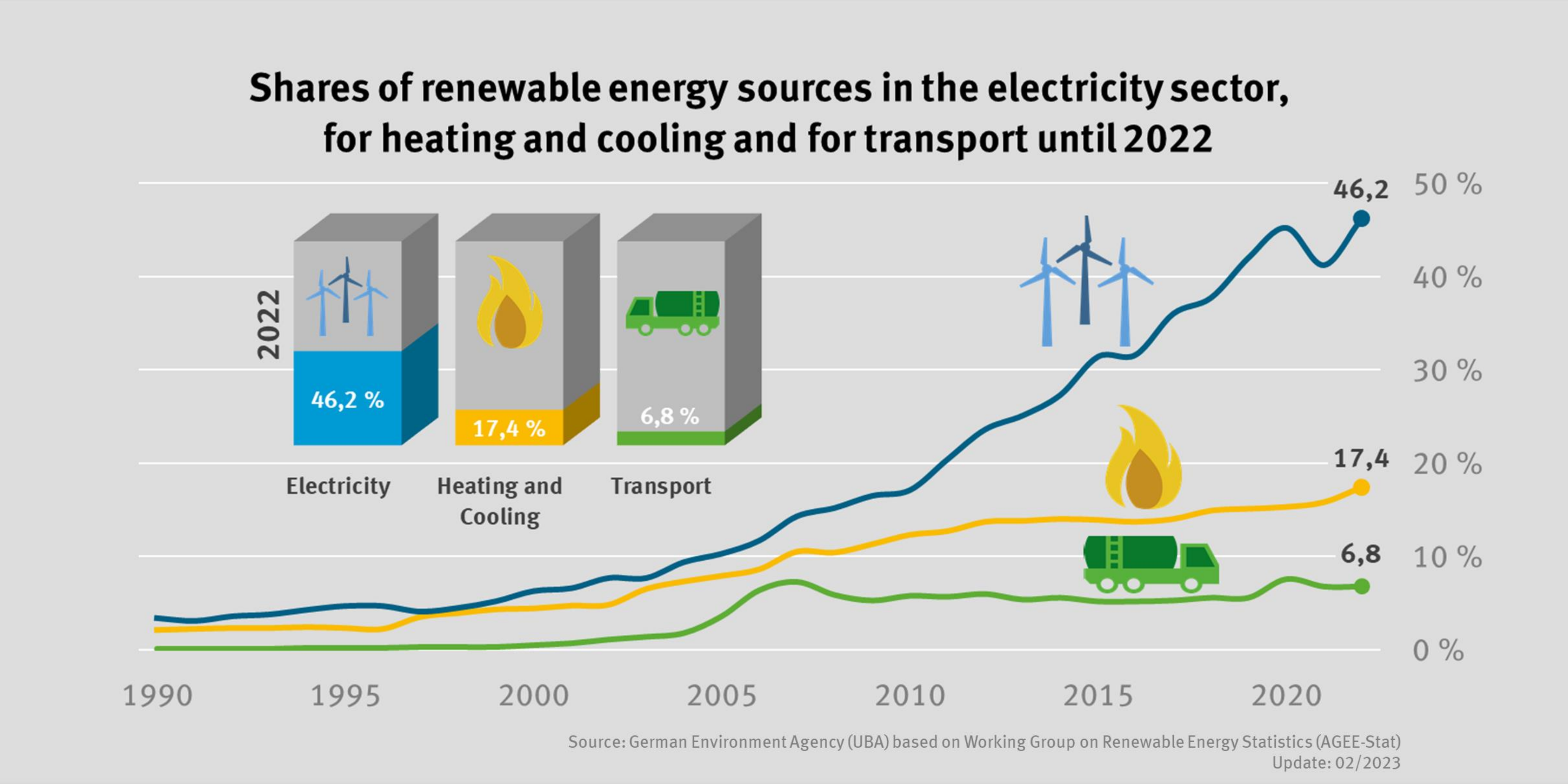
Prof. Dr. A. Vandersickel

The future energy system is not power only



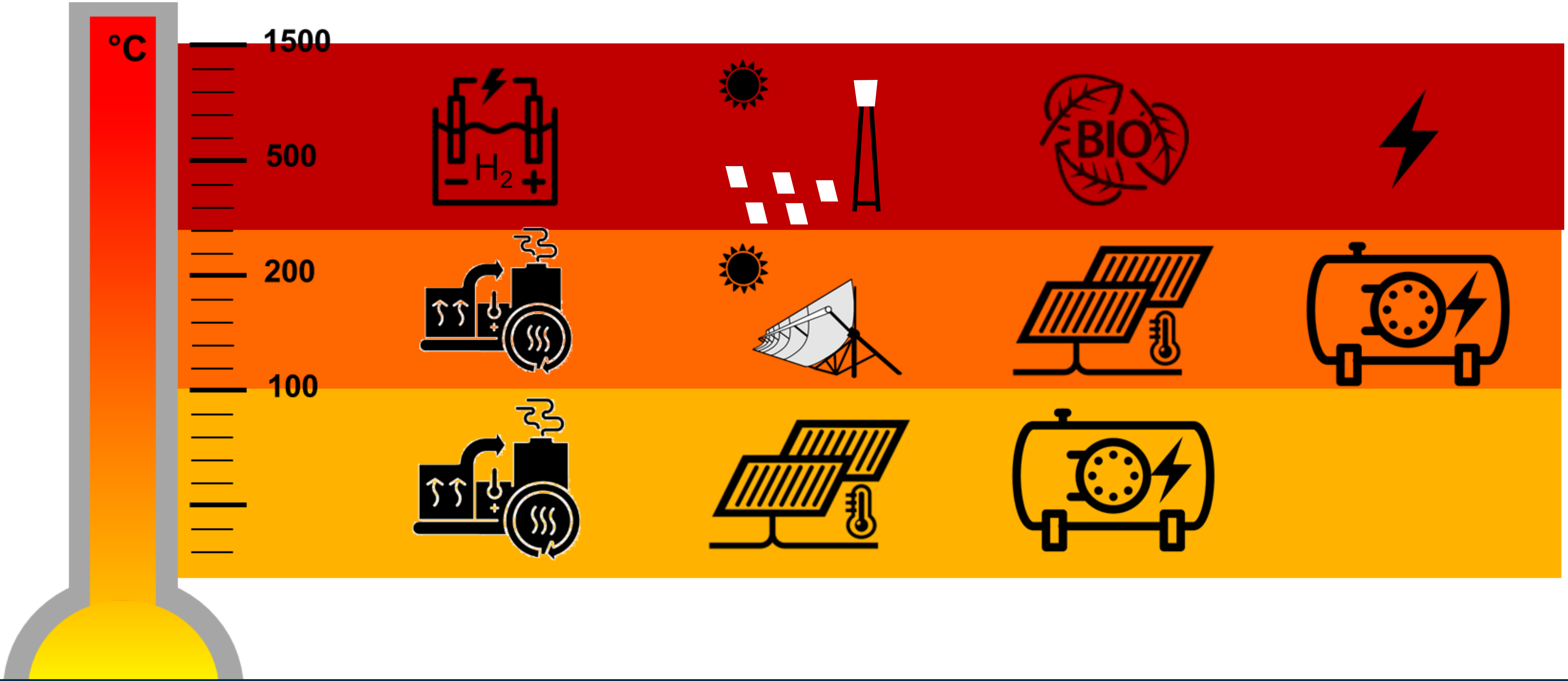
Net-zero heat Long Duration Energy Storage to accelerate energy system decarbonization, LDES 2022

The ‚Heat‘ transition has only started



What technogy options do we have?

Electrification as Key Enabler



By 2050 > 60 % electrification both in Buildings & Industry ~ IEA Net Zero by 2050

Efficient Waste Heat Recuperation

Objective

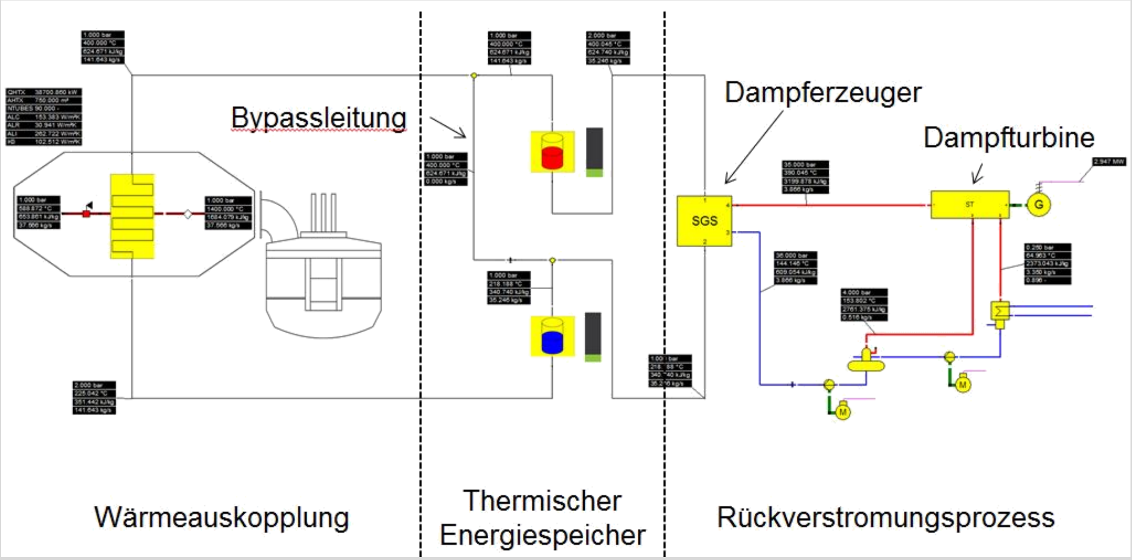
- Reduction of Heat Demand through heat reintegration, e.g. for Batch Processes
- Cost Optimised power generation

Possible Applications

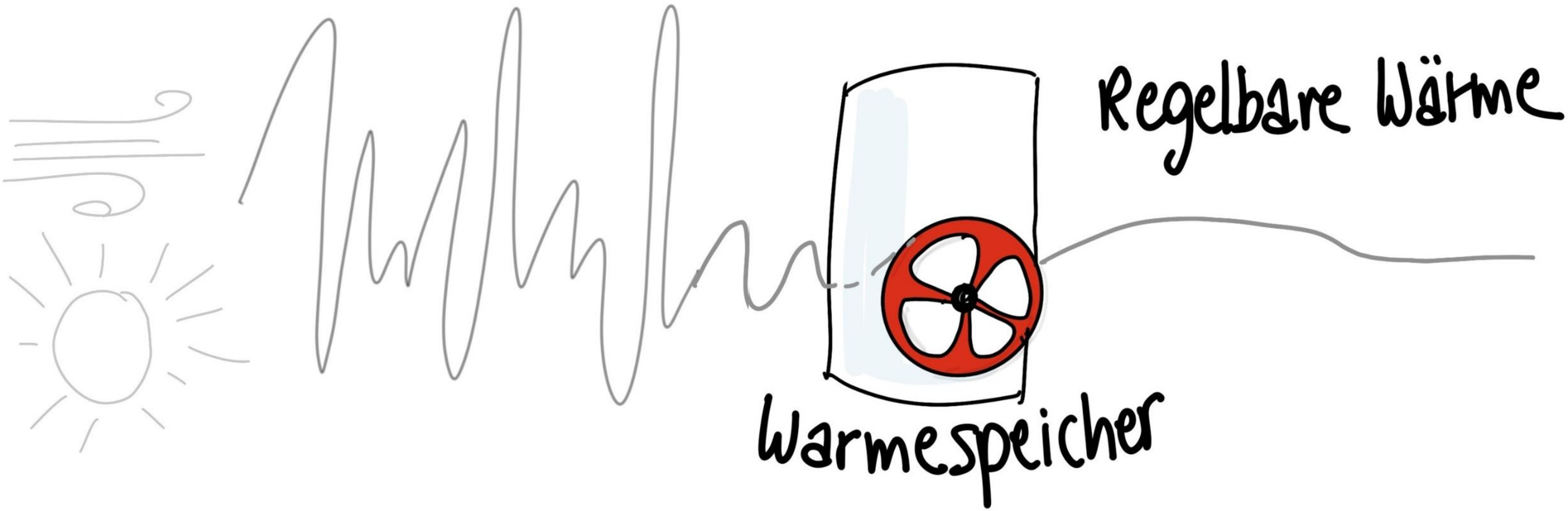
- Steel Industrie
- Foundary
- Tire Producer

Electric Arc Waste Heat Recuperation Projekt TESIN

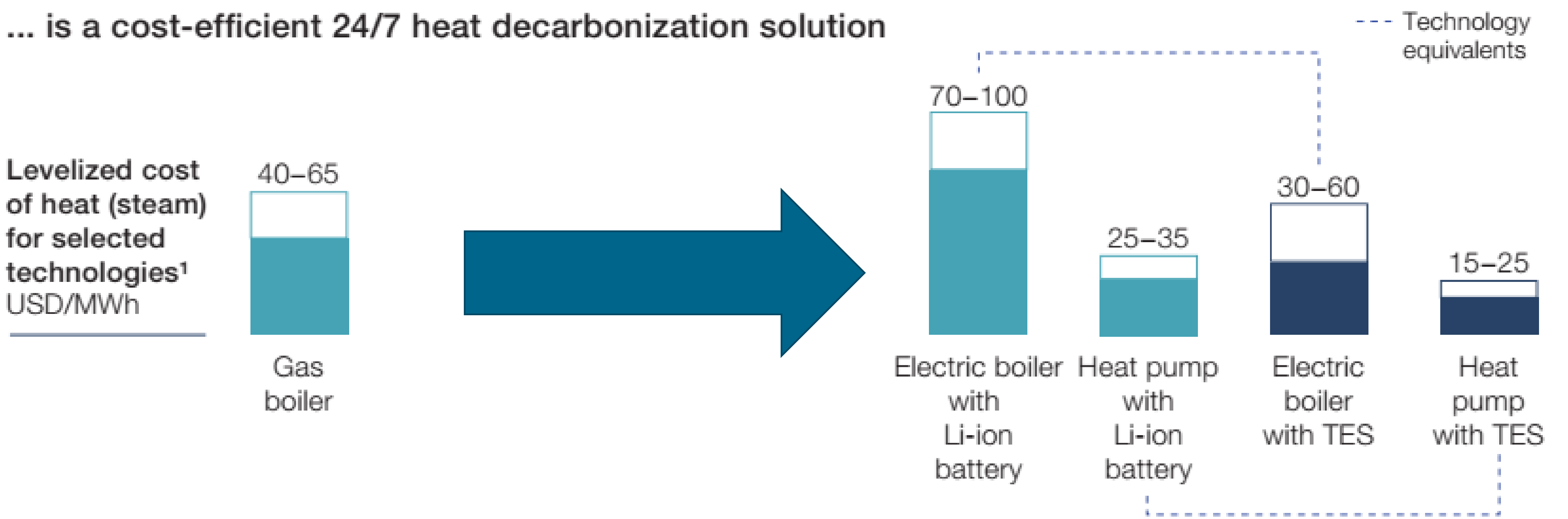
Molten Salt (5 MWh, 70 Tonne) with Steamturbine:
- Reliable and cost-effective heat generation
- CAPEX reduction (ORC vs. steam turbine)
- High efficiencies due to higher temperature



Thermal Storage – the Key to renewable Heat-on-Demand



Thermal Storage with Power-to-Heat



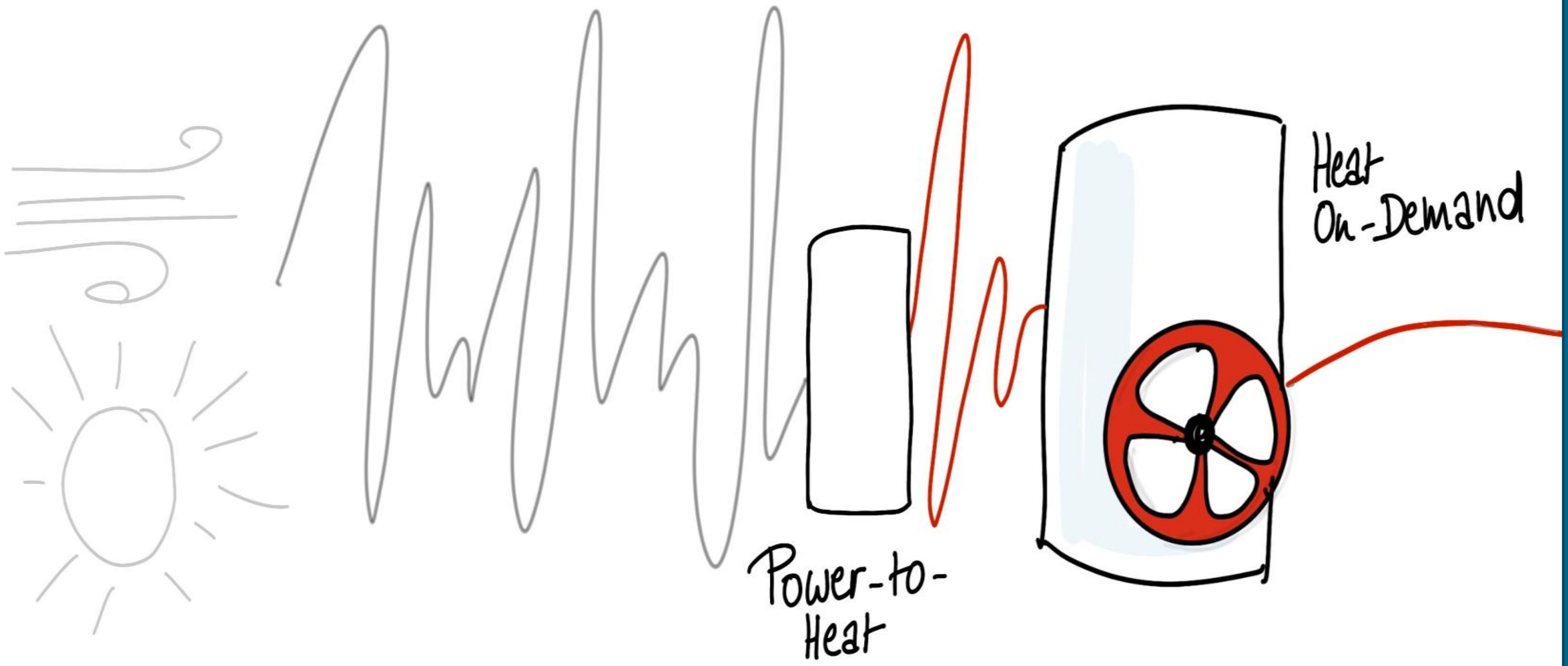
TES makes storing heat more cost-efficient than storing power for heat applications

TES requires less (no) critical materials than storing power

Adapted from Net-zero heat Long Duration Energy Storage to accelerate energy system decarbonization, LDES 2022

Flexible Sector Coupling with Power-to-Heat

High flexibility through a thermal storage



Storage supported PtH:

- Supports grid stability & enables integration of large shares of RE

Flexible Sector Coupling with Power-to-Heat

High flexibility through a thermal storage

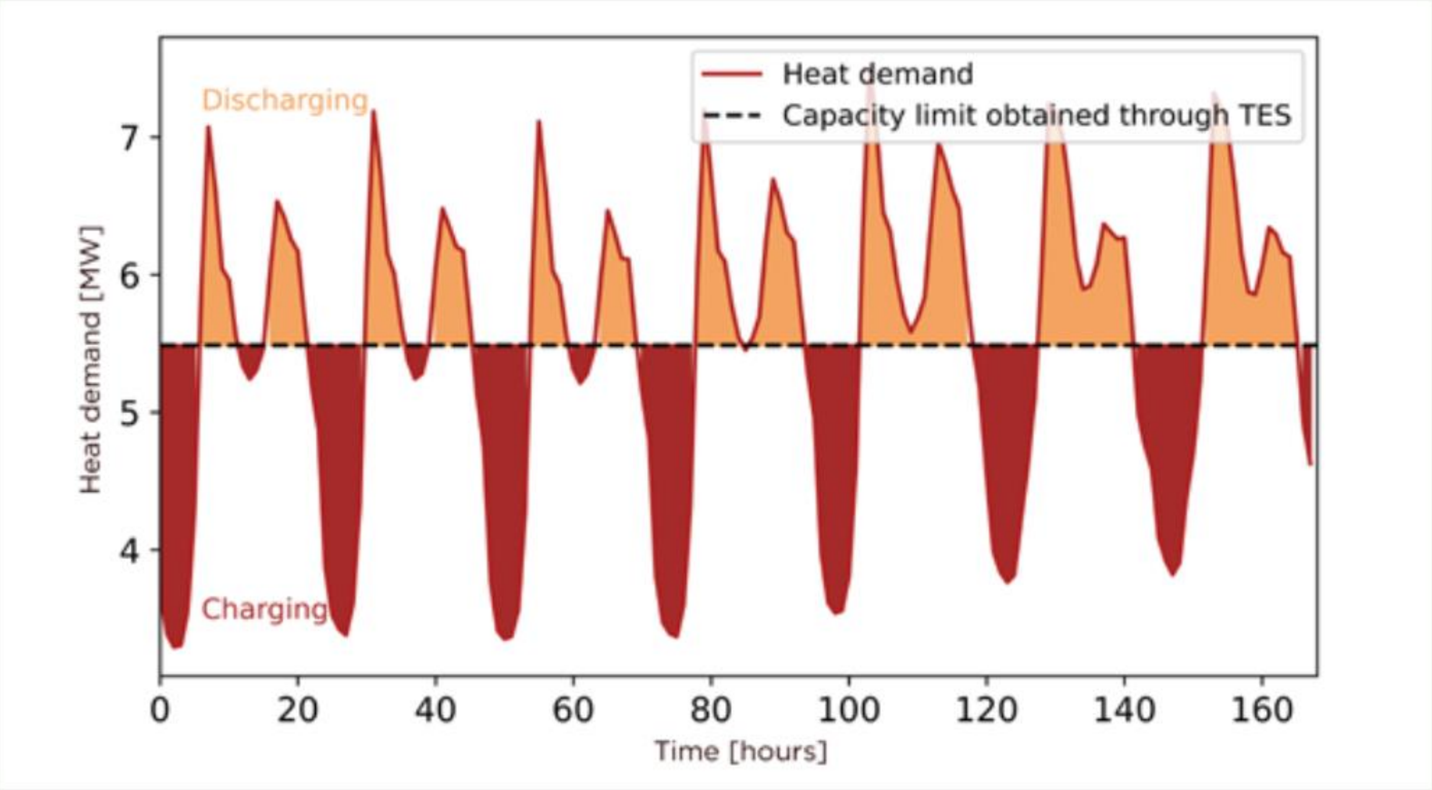


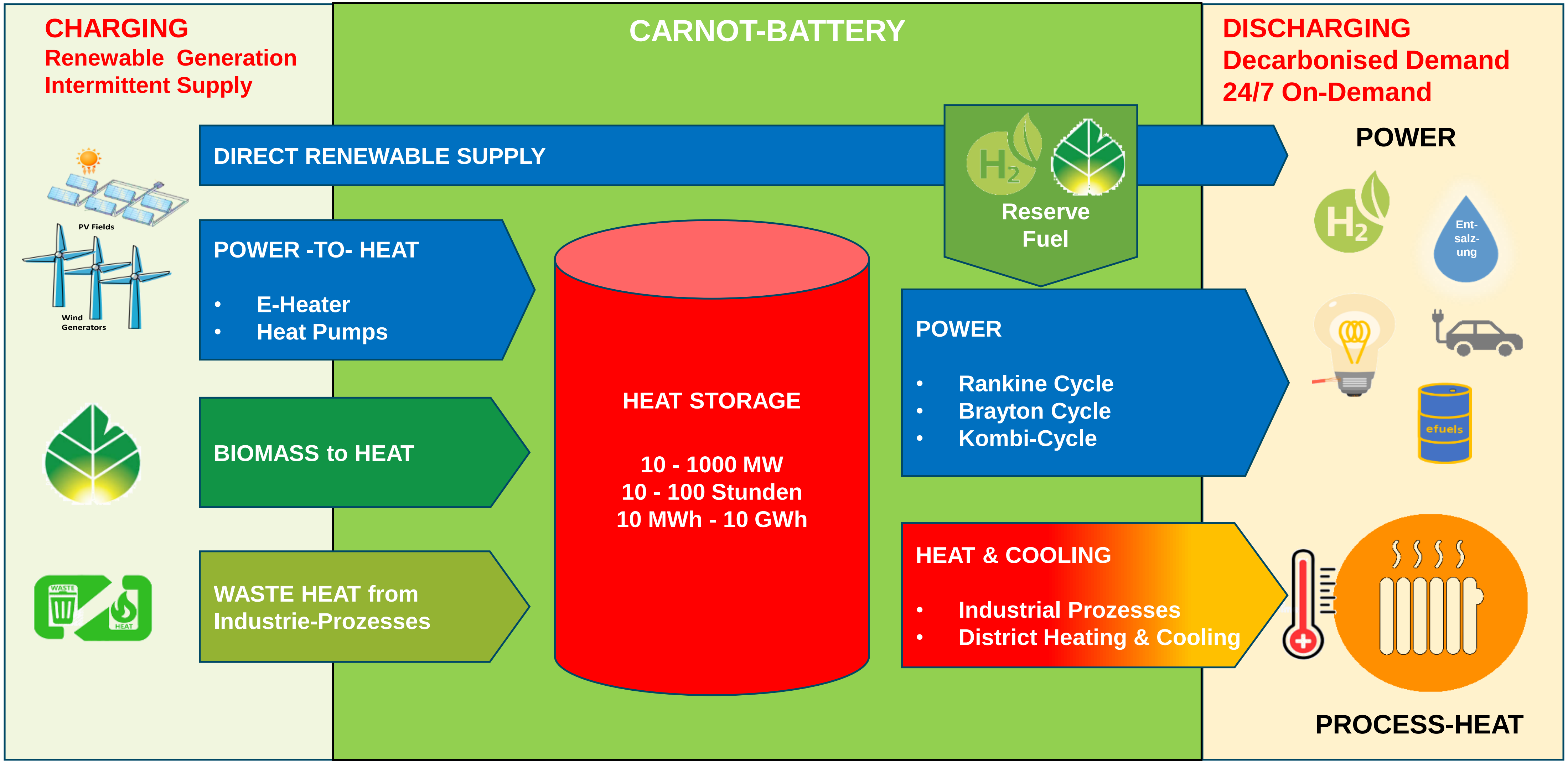
Figure 2 Peak shaving with TES: charging during low-demand periods and discharging during high-demand periods (©SINTEF).

Industrial Thermal Energy Storage Supporting the transition to decarbonise industry, EERA, Kauko et al.

Storage supported PtH:

- Supports grid stability & enables integration of large shares of RE
- Reduced required transmission capacity & provides grid relief
- Allows for electricity price optimisation

Heat Storage & Carnot Batteries for Decarbonisation - a Multitude of Opportunities



2023, TT-WSK. Gerrit Koll

Heat Storage in the high temperature range
No „One-fits-it-all“ Solution

	Regenerator	Regenerator	Molten Salt	Ruths	Phase Change Material	Liquid Metal	Hot Water
Storage Material	Ceramics	Natural Rock	Nitrate Salt (molten)	Pressurized Water	Nitrate Salts, Aluminium	$ZrSiO_4$	Water
Energy density *in kWh/m³*	75 - 200	75 - 200	75 - 200	bis 100	50 - 200	75 - 200	60-80
Max. Capacity	1000 MWh	23 MWh	4500 MWh	30 MWh	500 MWh	100 kWh	scalable
Typ. Temperatures	400-1600 °C	200-800 °C	170-560 °C	150-230 °C	130-330 °C	100-700 °C	< 100°C
Typ. Heat Transfer Fluids	Gases	Gases	Salt	Water/Steam	Steam	Lead/Bismuth	Water
Investment cost TES *in €/kWh*	15 – 40	-	15 – 70	70 – 300	40 – 80	Not known	25-30
Maturity (TRL)	6 – 9	4 – 5	4 – 9	8 – 9	4 – 5	3 – 4	9

Thermal Storage Developments – Examples from DLR

Institute of Engineering Thermodynamics

Thermal Process Technology

Prof. Annelies Vandersickel

Thermal Power Plant Components	Thermal Systems for Fluids	Thermal Systems with Phase Change	Thermo-chemical Systems
Dr. Stefan Zunft	*Dr. Thomas Bauer*	*Dr. Andrea Gutierrez*	*Dr. Marc Linder*
			
Regenerator and solid state storage **High temperature heat exchangers**	**Molten salt storage**	**Latent heat storage** **PXP storage**	**Thermochemical Storage** **Chemical Heat Pumps**

About 60 people located in Stuttgart & Cologne

Power-to-Heat & storage for air/gases up to 1200°C

What can R&D deliver?

Solid media PtH & storage

- Cost reduction through large scale design, also for pressurised systems

Objective:

- Storage costs 15 €/kWh

Test bed HOTREG Specifications
- Inventory mass: 3-5 tons
- Mass flow rates: 220 – 800 kg/h
- Max. heat rate: 180 kW
- Inlet temperatures
    - Charging: 600 – 830 °C
    - Discharging: 100 – 400 °C
- Max. pressure: 11 bar
- Optionally: Humid air operation

Power-to-Heat & storage for air/gases up to 1200°C

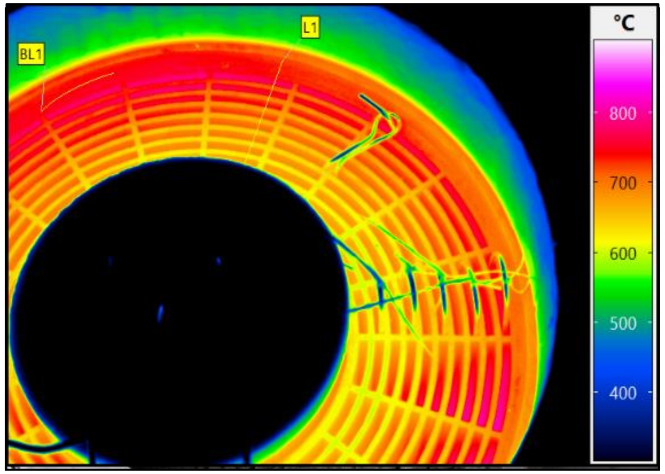
What can R&D deliver?

Solid media PtH & storage

- Cost reduction through large scale design, also for pressurised systems
- SiC-based electro-heaters

Objective:

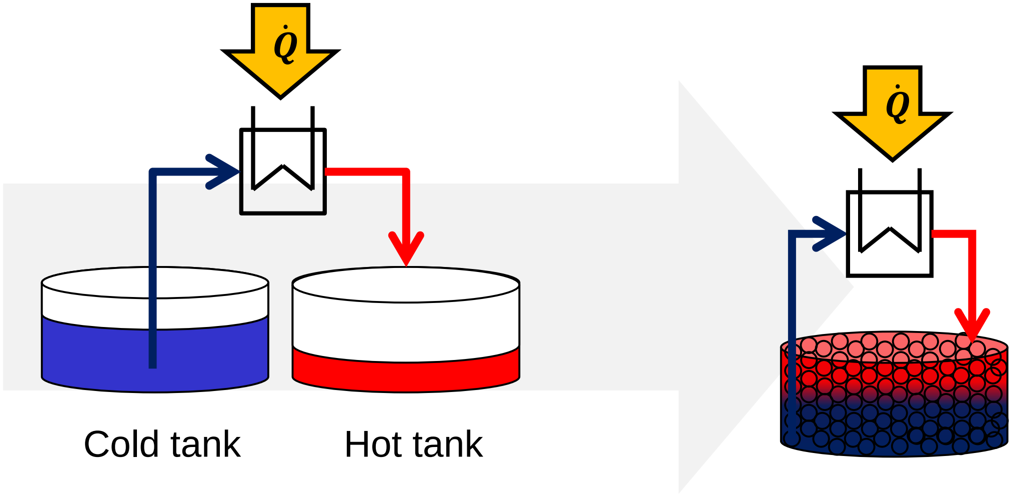
- Storage costs 15 €/kWh
- Unlock PtH for Temp. > 800°C

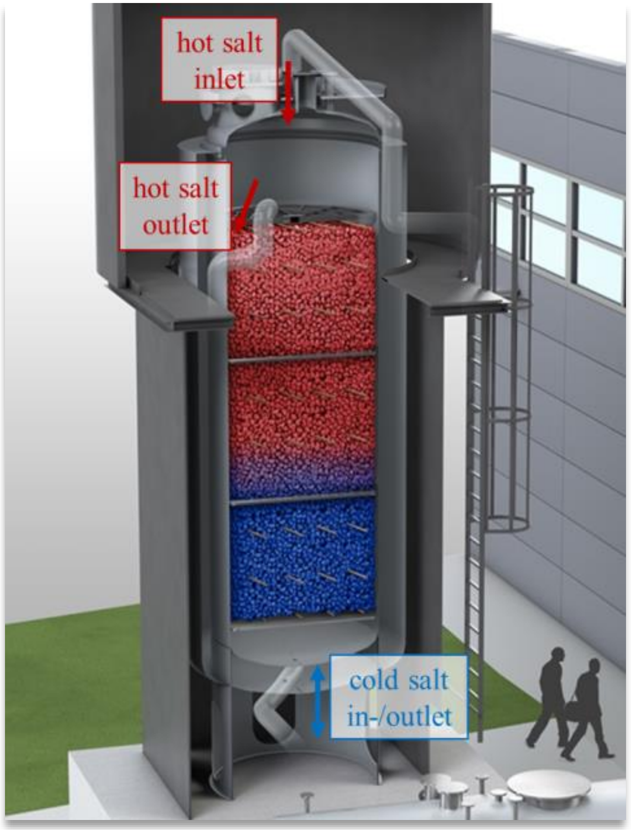


Molten Salts for 170°C – 600°C

What can R&D deliver?

- 20-40% cost reduction
- Design for longevity, even with thermocline induced stresses
- Electrical heater development



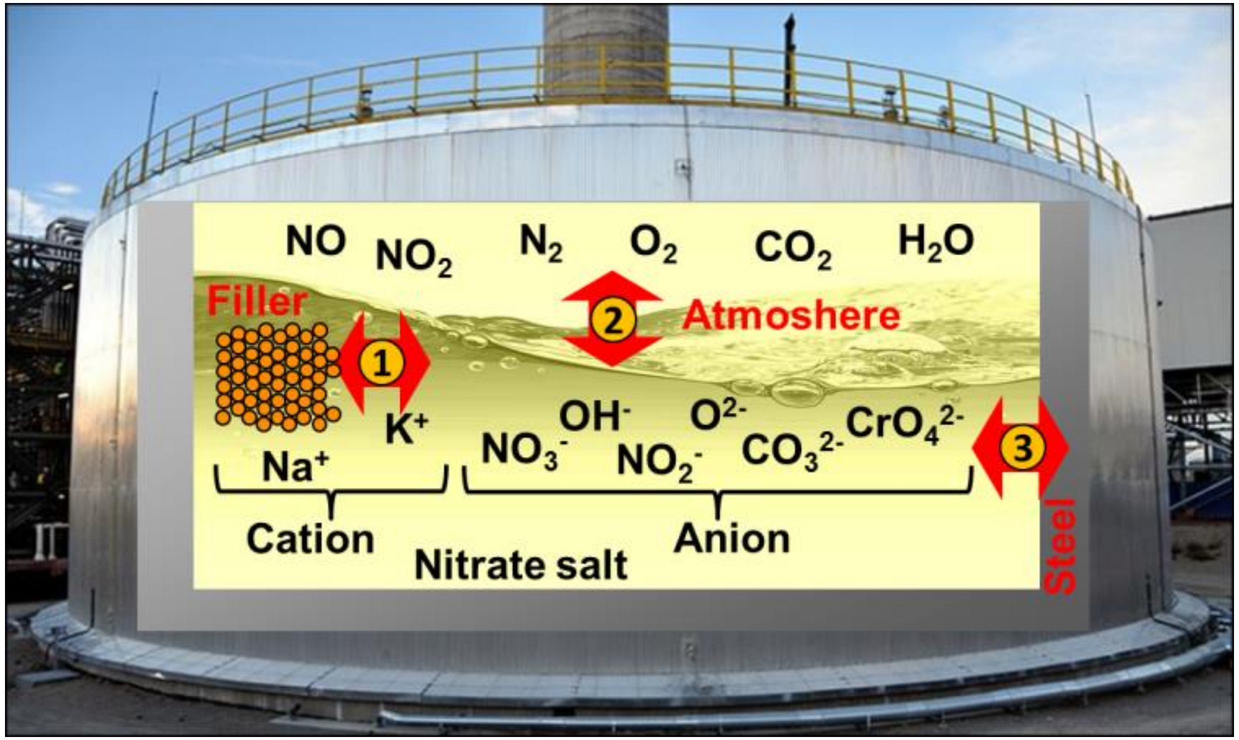


Continuous operation of the DLR *Test facility for thermal energy storage in molten salts* (TESIS) with approx. 100 tones of nitrate salt since Jan. 2019

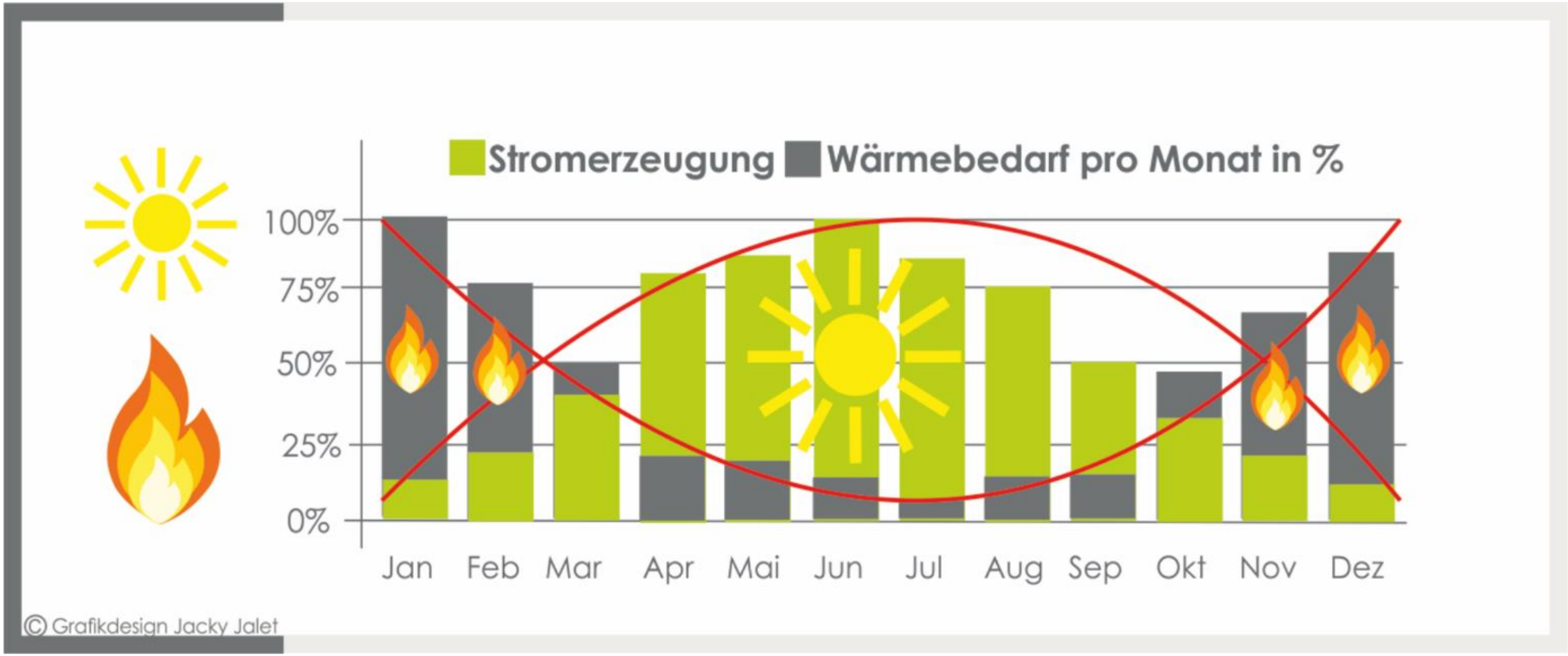
Pushing temperature through increased understanding
Molten Salt Material Research

Objectives:

- Increase max. Operating temperature from 565°C to 620°C
- Supress corrosion to allow use of standard steels
- Design components (tanks, E-Heater, HXGer) minimizing local decomposition

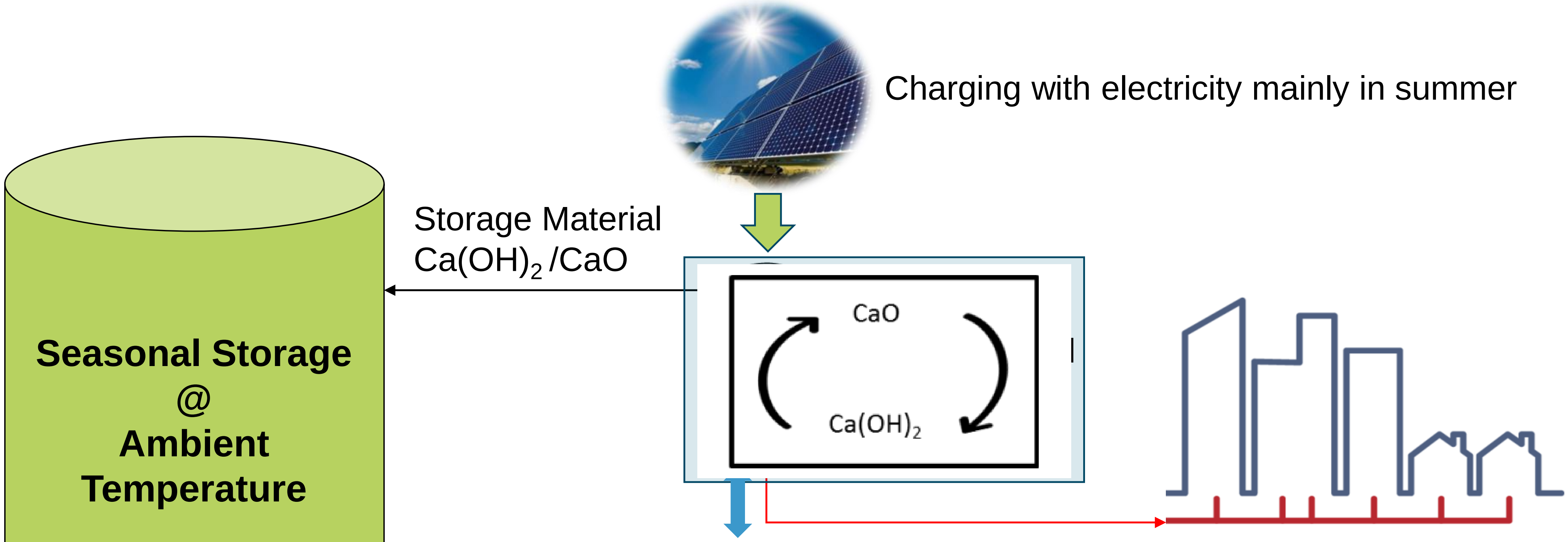


Seasonal storage – the holy grale of R&D?



Seasonal storage – the holy grale of R&D?

Power-to-Heat with thermochemical energy storage



Scalable Reactor demonstrated for 5-10 cycles providing renewable heating & seasonal balancing in the electricity grid

Thermal storage

- Is technically available in a wide T-range & entering the market
- has large cost reduction potential with upscaling
- in many cases more cost effective AND environmentally friendly as eg. batteries

Challenge – mitigate the lack of visibility and awareness in politics, at end users & consultants/energy planers

THANK YOU !