

Decarbonization Utilizing Thermal Energy Storage Systems

EMSP Symposium

Arnold Haite

October^{21st}, 2021

Rely on good experience with

steinmüller engineering

The Engineers Company

IHI Corporation



IHI Global Headquarters Tokyo, Japan

Founded : 1853

Employees: 29,700

Net Sales: JPY 1,486 billion
(Consolidated) USD 13.5 billion

Global Network:

- Global headquarters: Tokyo
- Regional HQ: New York, Singapore, Shanghai
- Overseas offices: 15
- Subsidiaries: 231 (incl. 158 overseas companies)

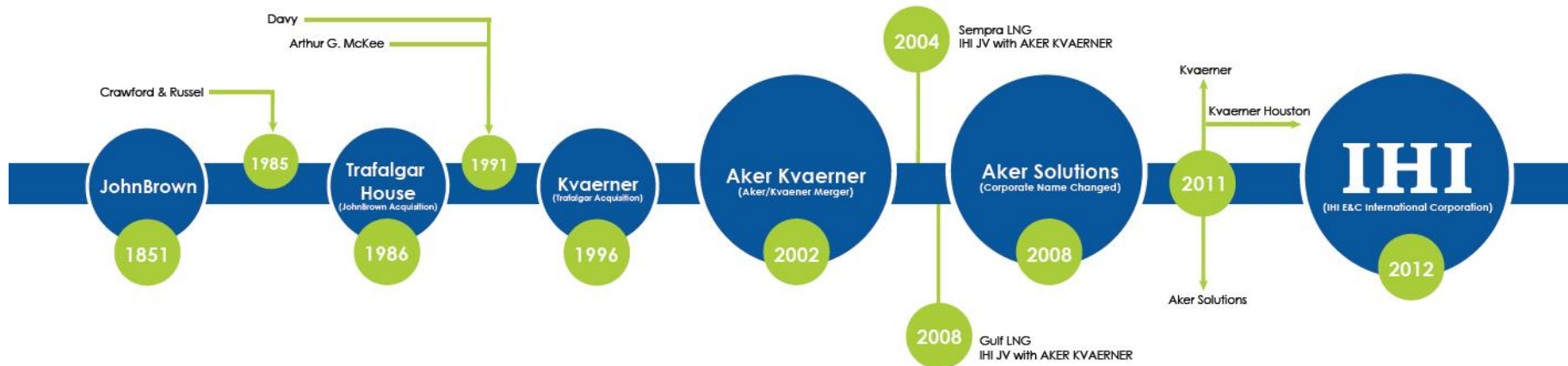
Further info.

<https://www.ihico.jp/en/>

IHI E&C International Corporation



- Part of IHI Group since 2012
- Offices in Houston, TX
- Full-Service Organization
 - Conceptual Studies/Tech. Evaluation
 - Pre-FEED and FEED
 - Engineering and Procurement
 - Construction Management
 - Operability, Commissioning & Startup
- Business area: *Hydrogen Generation (gray + green)*



Steinmüller Engineering GmbH

Part of IHI Group since 2014

Headquarter in Gummersbach, Germany

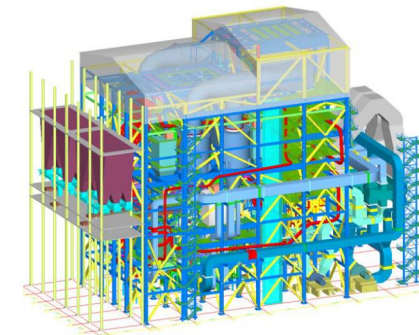
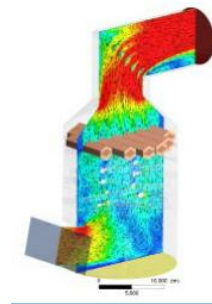
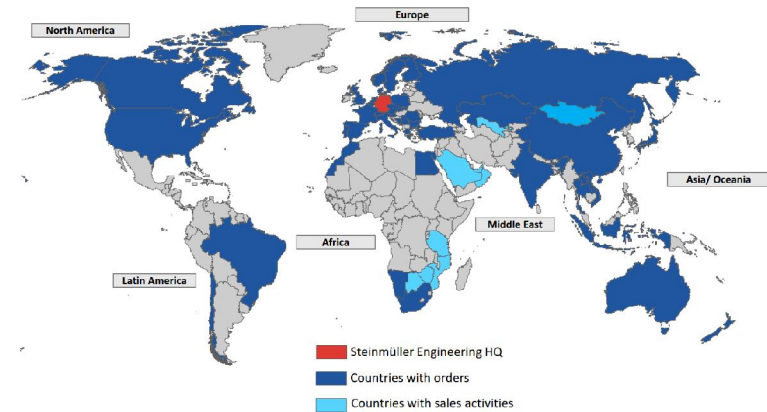
Services

- Feasibility studies
- Engineering
- Supply
- Erection
- Commissioning
- After sales

Main business areas

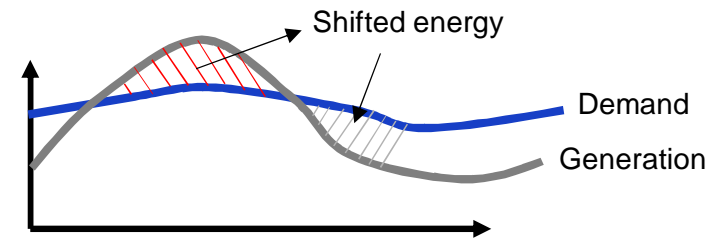
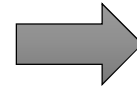
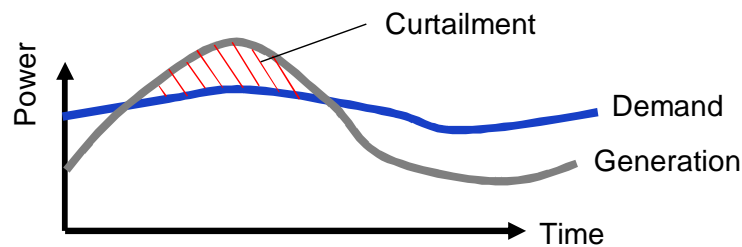
- Thermal energy storage
- Boilers & reactors
- Combustion & incineration
- Air pollution control

Worldwide service

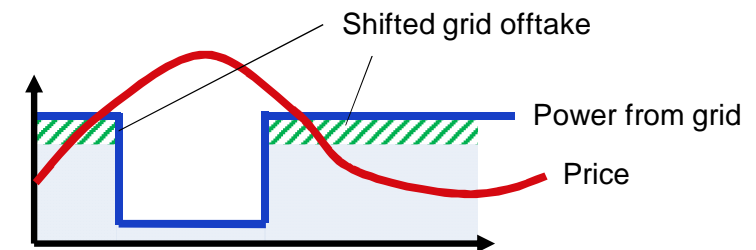
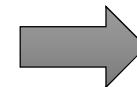
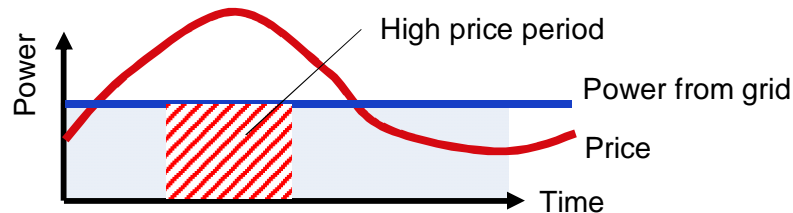


Power to Heat + Thermal Energy Storage (TES)

- Reduction of Green house gas (GHG) emissions leads to ban of fossil resources
- Electricity from renewable sources will become primary source of energy
- For covering heat demand, Power-to-Heat (PtH) is most efficient
- PtH in combination with a thermal energy storage (TES) allows:
 - to reduce curtailment / use installed renewables more effectively



- consumers to buy electricity when cheap



Proven high temperature TES technologies: Molten salt & Fixed bed

R&D Steinmüller Engineering



- Évora Molten Salt Platform, Portugal
- 1,6 MW_{th} steam generation
- 92 t of molten salt
- T_{max} approx. 560 ° C

- Comprises Solar collector, TES system, Steam generation system
- Testing of new salt mixture with lower melting temperature under real conditions
- Steam generation from molten salt in Once-Through boiler. Design allows high thermal gradients for intermittent operation and fast start-ups.

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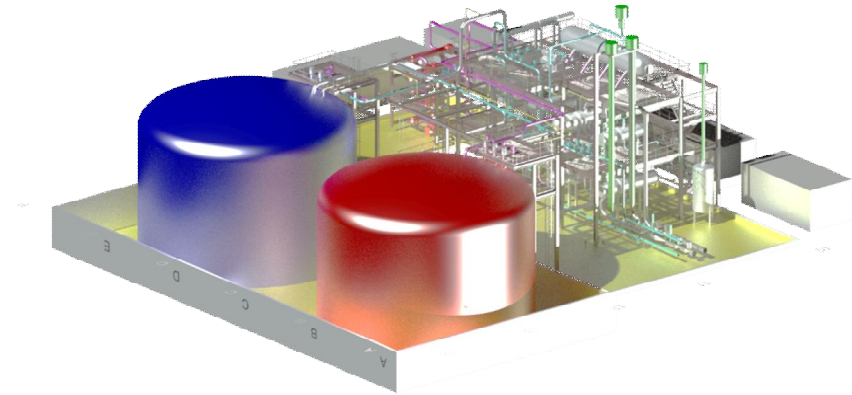


Extract of involved partners

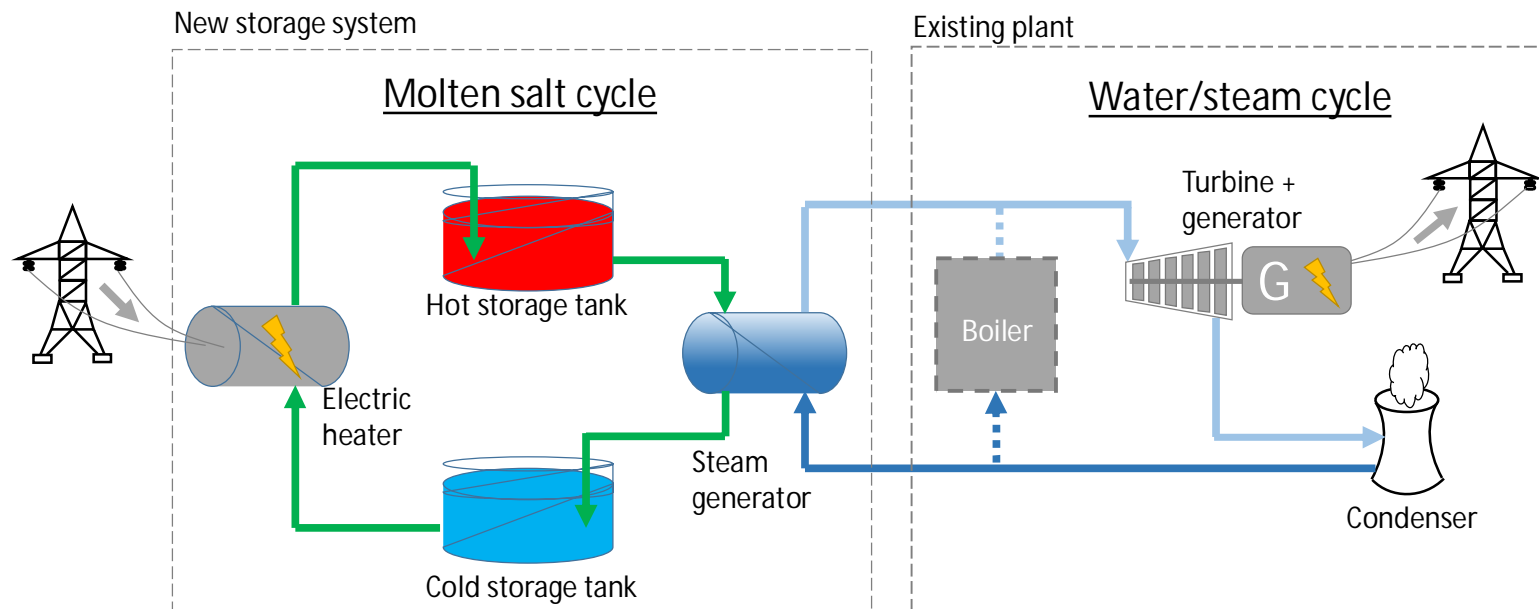
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Molten Salt TES Development

- High System efficiency
- Low foot print
- Limited to approx. 550 C steam (currently)



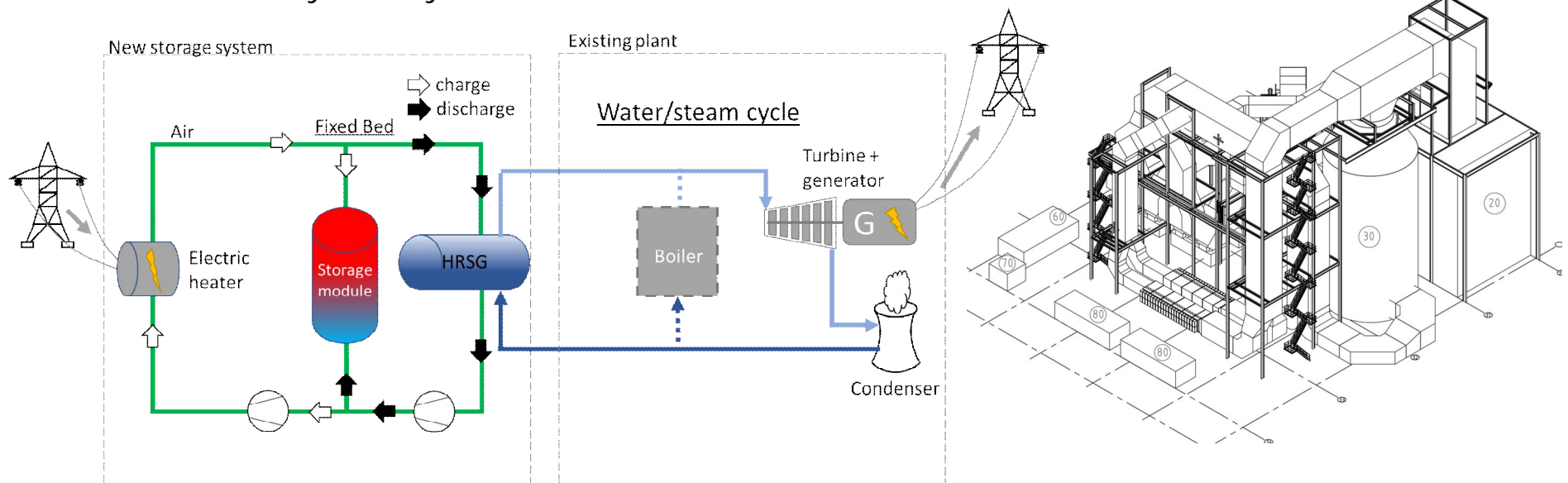
Carnot Battery



Solid Fixed Bed TES Plant Study

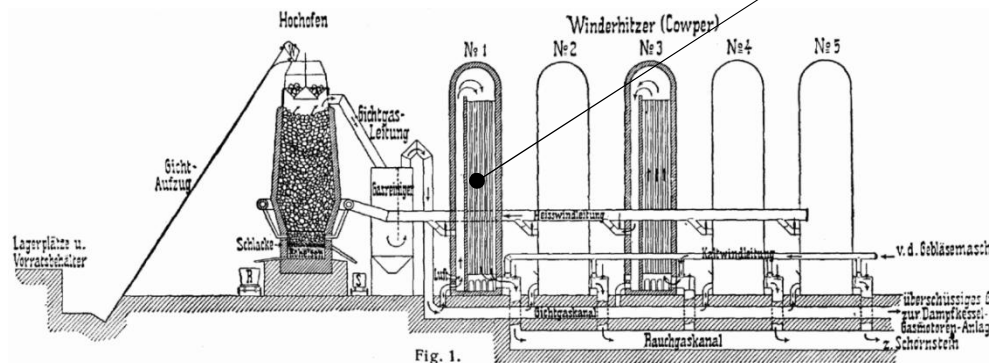
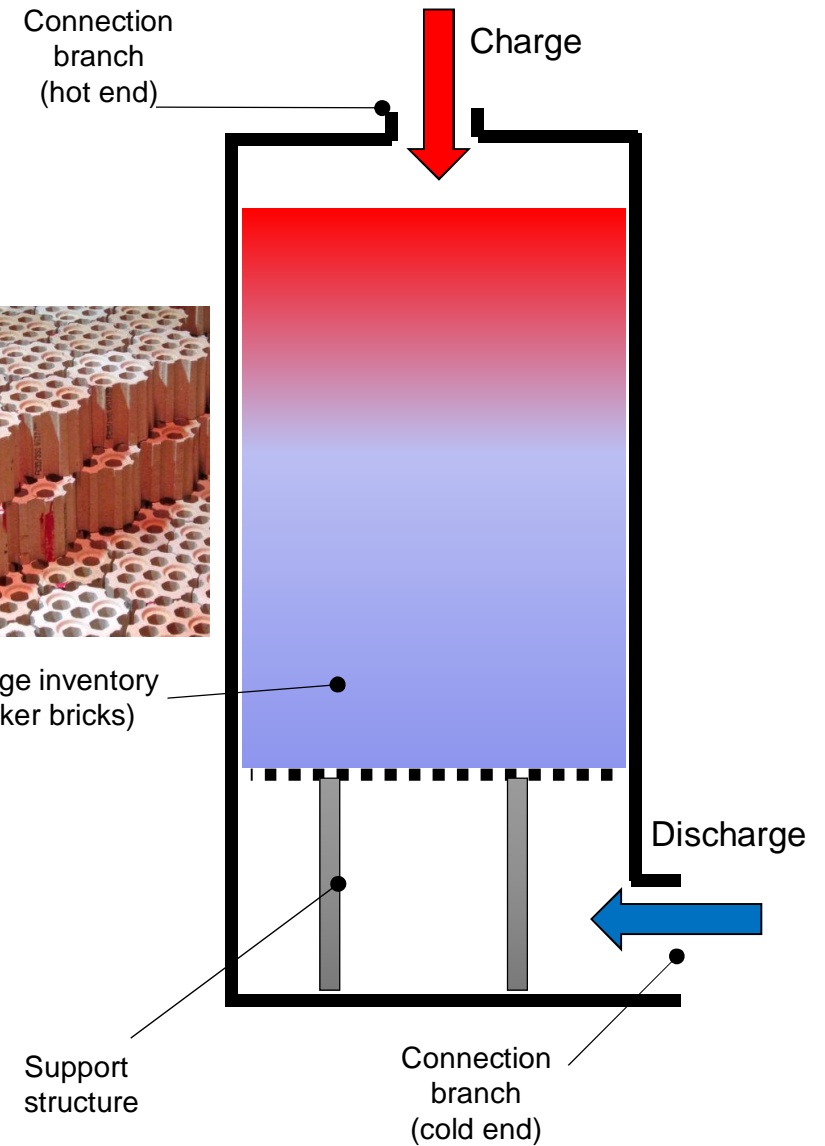
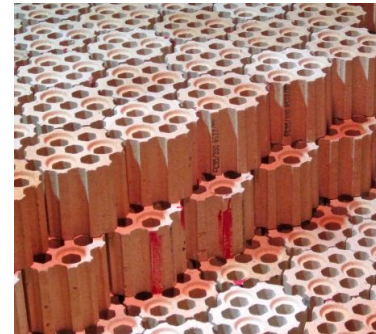
- Steam temperature of 610 °C and more possible
- Practically no maintenance on storage module
- Simple integration of back-up firing

Carnot Battery – Study for RWE Power



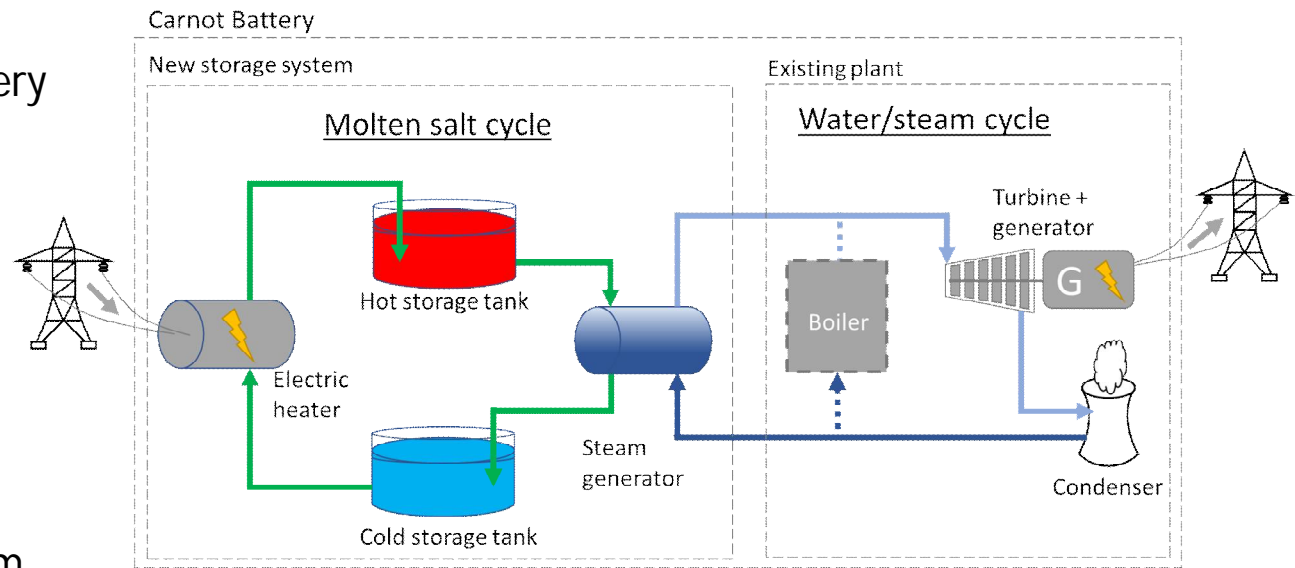
Solid Fixed Bed Energy Storage

- Proven in iron industry (hot blast stoves)
 - up to $> 1000^{\circ}\text{C}$
 - pressurized
 - flue gases
 - high cycle quantity
- practically maintenance free
- free thermal expansion of storage material
- low footprint compared with horizontal flow design

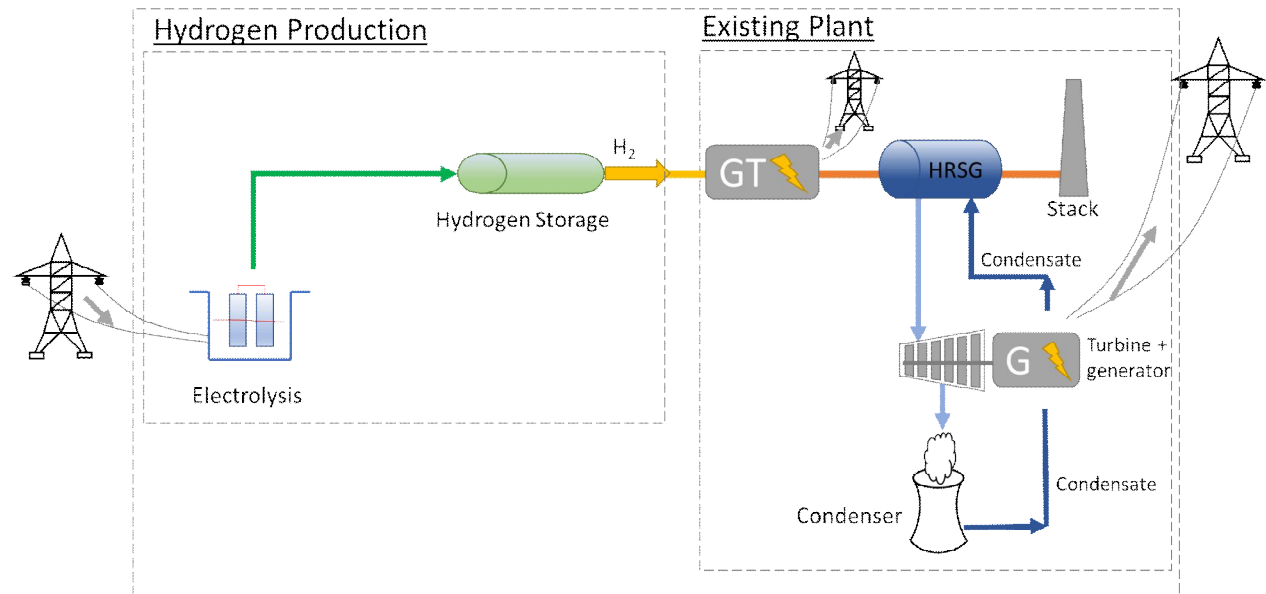


Comparison Case

Molten Salt Carnot Battery with Rankine Cycle



Hydrogen Storage System With Combined Cycle

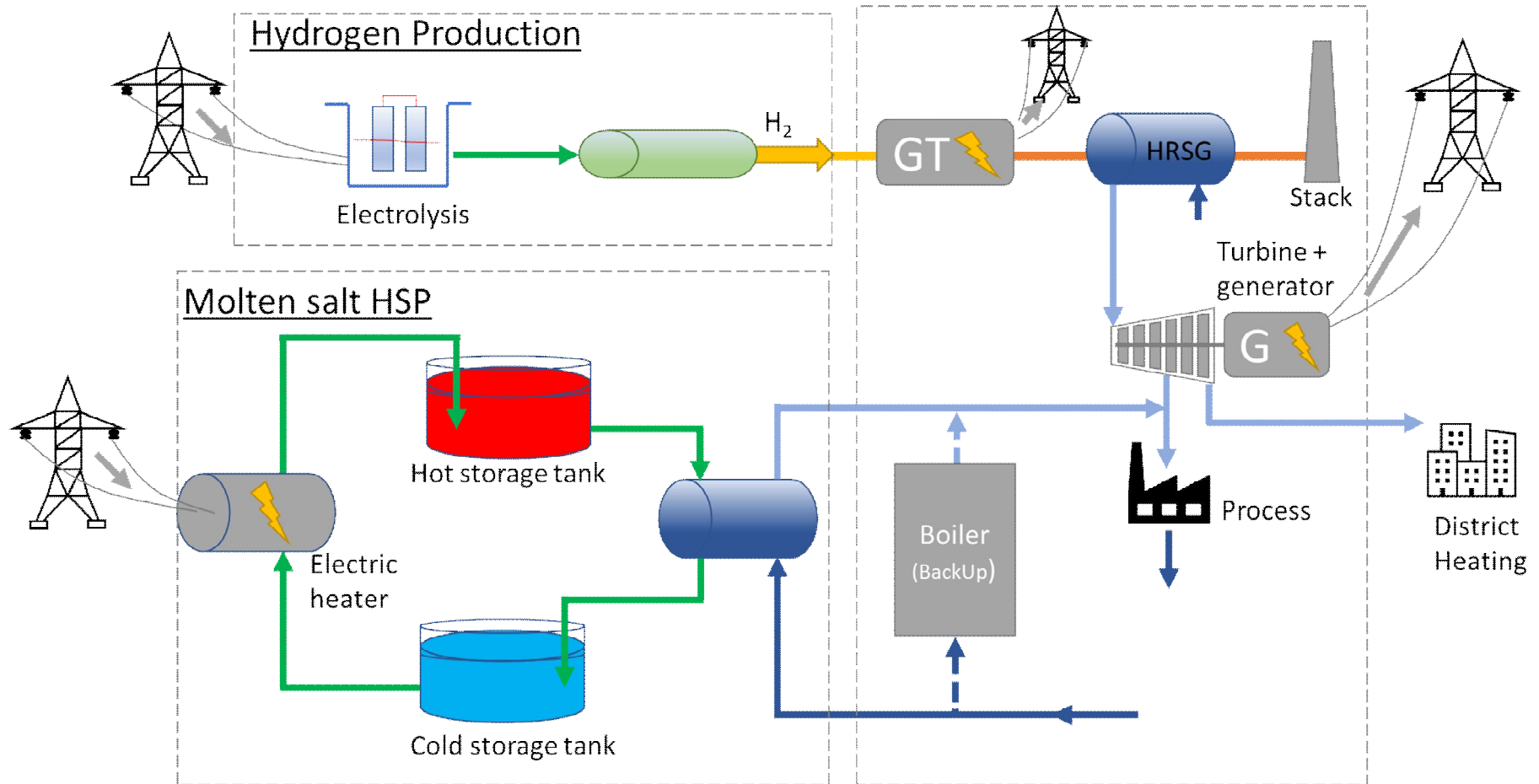


Comparison Results for 800MWh Energy Storage

	Molten Salt Carnot Battery	Hydrogen System
CAPEX	100 %	160 %
Major Consumables	Power	Power Demin Water Cooling Requirements
Power-To-Heat/H₂ Efficiency	85 – 90 %	60-65%
Power-To-Power Efficiency	40%	40%
Pre-requisites	Existing/new power plant nearby	Water supply accessible
Energy Losses	1% per day	None
Seasonal Storage	Not useful	Possible
Lifetime	> 20 yrs	> 20 yrs
Footprint	120 m x 120 m	300 m x 250 m

- Alkaline electrolyzer system
- 4 hours charging / hydrogen production- 6 hours discharge
- Excluding cost of power generation unit, i.e. existing power plant available
- Approximate figures

Exemplary Applications for Hydrogen-TES Hybrid



Summary

- Thermal Energy Storage (TES) represent another option to even out Renewable Energy Intermittency.
 - Well proven for decades
 - Major Cost – Salts + Electrical heaters
- TES vs. Hydrogen Storage option requires careful considerations
 - Location / Utilities Available
 - Capacity
 - Usage
- Synergy between the systems can yield additional advantages
- Enormous potential for innovation, economy of mass and scale
- Different storage solutions will be required for different project specific conditions

Thank you for your attention !