Electric Thermal Energy Storage (ETES)

November 8th 2017

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Transition of energy supply

Increasing penetration of renewable energy in the energy grid to achieve emission reduction targets

- Outcome of COP21: reduction of carbon output to keep global warming to well below 2 °C
- EU emission reduction targets: 40% by 2030, 80% by 2050

Challenges for the energy sector

- **Batteries not economic to scale up** for large scale / long duration applications
- **Large scale storage** w/ unique USPs enhancing grid stability, replacing fossil reserve capacity and deferring T&D investments
- But currently, benefits of large scale storage not yet fully valued in today commercially positive business case
- **Curtailment of renewables** caused by surplus energy
  e.g. Germany: curtailment of 3.700 GWh in 2016,
  thereof 85% from wind - compensation cost: 370 Mio. Euro

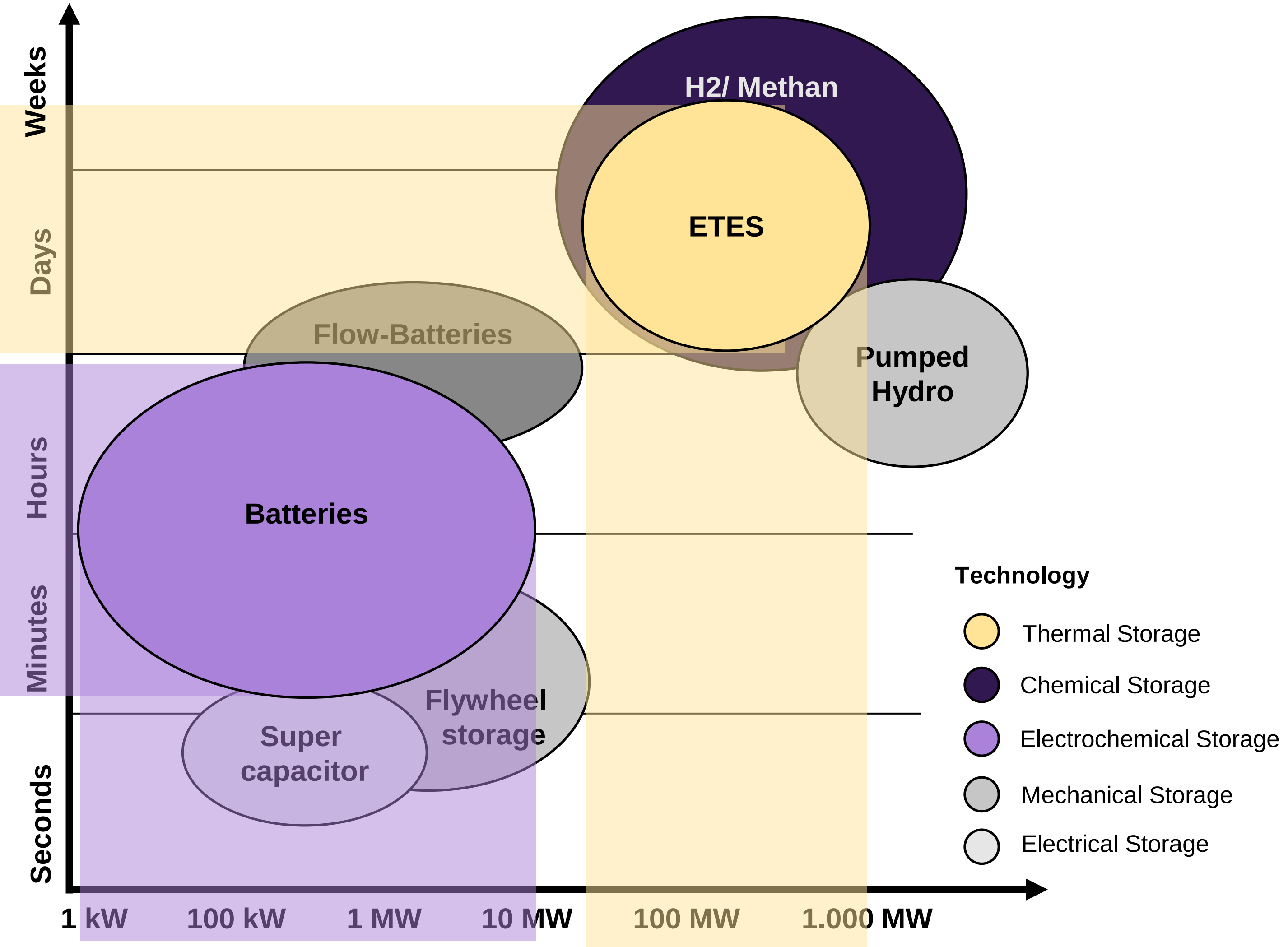
ETES as large scale and long-term storage

Complementary technology to batteries

- Different technologies with different use cases and economics are available

With close to **50% efficiency** possible, ETES is the **most efficient** low cost energy storage solution for **large amounts of energy**

- A combination of a wind turbine with ETES is the **ideal setup** for a renewable energy source with **base load capability**
- Since **heat** is the storage medium of choice, ETES fits perfectly into the energy mix
- Reuse of existing conventional power plants ("brownfield approach") can enable a **low cost renewable energy system** by reusing existing infrastructure

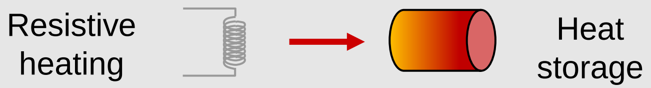


Storage principle: Power-to-Heat-to-Power

Working principle

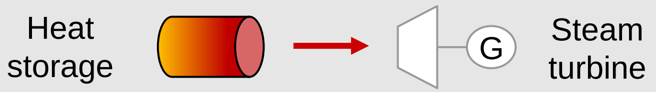
Technology approach driven by simplicity of the storage concept and the cost effectiveness of components

Charging cycle
(resistive heating)



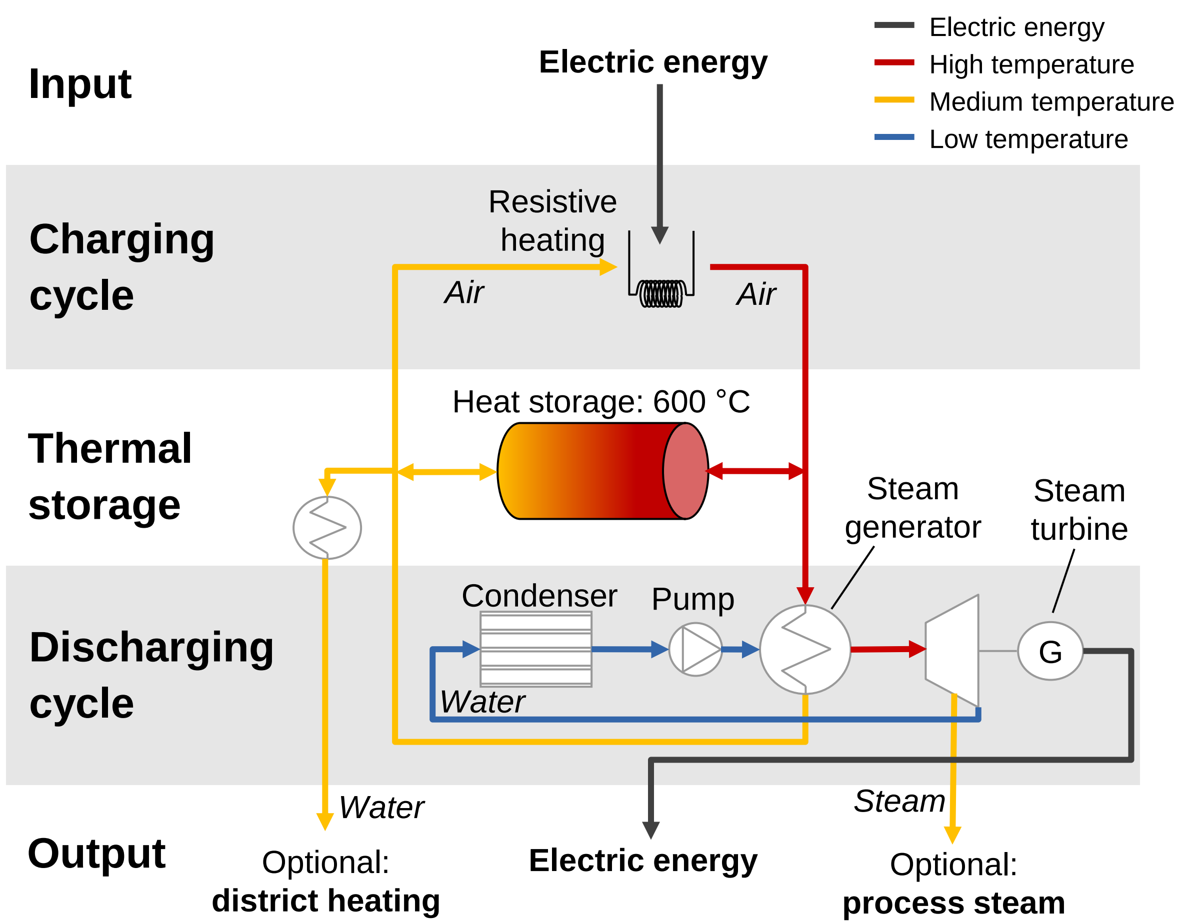
- Air is heated with a resistive heater and stored in a low cost heat storage
- Resistive heating allows for maximum flexibility and fast response

Discharging cycle
(steam power plant)



- Turning **heat into power using steam** is a well known procedure, that generates over 80% of the worlds electricity
- This allows for retrofit of existing conventional power plants

Process diagram



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Proof of concept for high temperature storage

Technical specifications

- 700 kW charging power
- 4-5 MWh charging capacity

Achievements so far

- **95% heat storage efficiency**
- **Control strategy optimization** with +10% storage improvement
- **Material choices identified** for demonstrator: storage, insulation
- IP: > 60 active patent families so far (e.g. for charging cycle, thermal energy storage, integration in power plant)

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Joint funded project with with local partners to give a proof-of-concept for the ETES technology

- Close collaboration with **local authorities** in Hamburg starting from beginning of activities
- Joint effort with Hamburg Energie and Technical University Hamburg-Harburg on proof-of-concept
- **Application for public funding in May 2015**

Demonstration project (proof-of-concept)

- Funded by the **6th Energy Research Program,** a funding scheme to support research for environmental, reliable, and affordable energy supply.
- Largest publicly funded project in the Siemens group
- **Total volume: 27‘ €, project running from 2016 to 2021**

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

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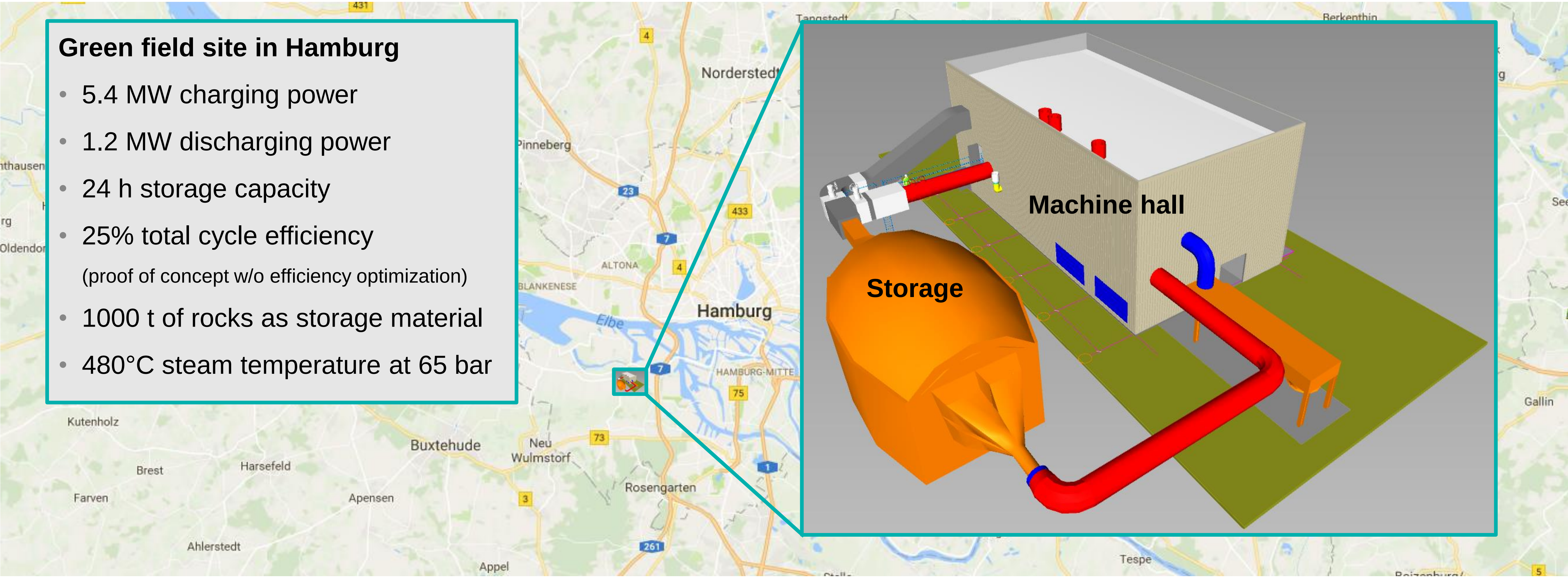
Facts and figures

Green field site in Hamburg

- 5.4 MW charging power
- 1.2 MW discharging power
- 24 h storage capacity
- 25% total cycle efficiency
  (proof of concept w/o efficiency optimization)
- 1000 t of rocks as storage material
- 480°C steam temperature at 65 bar



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Business principles

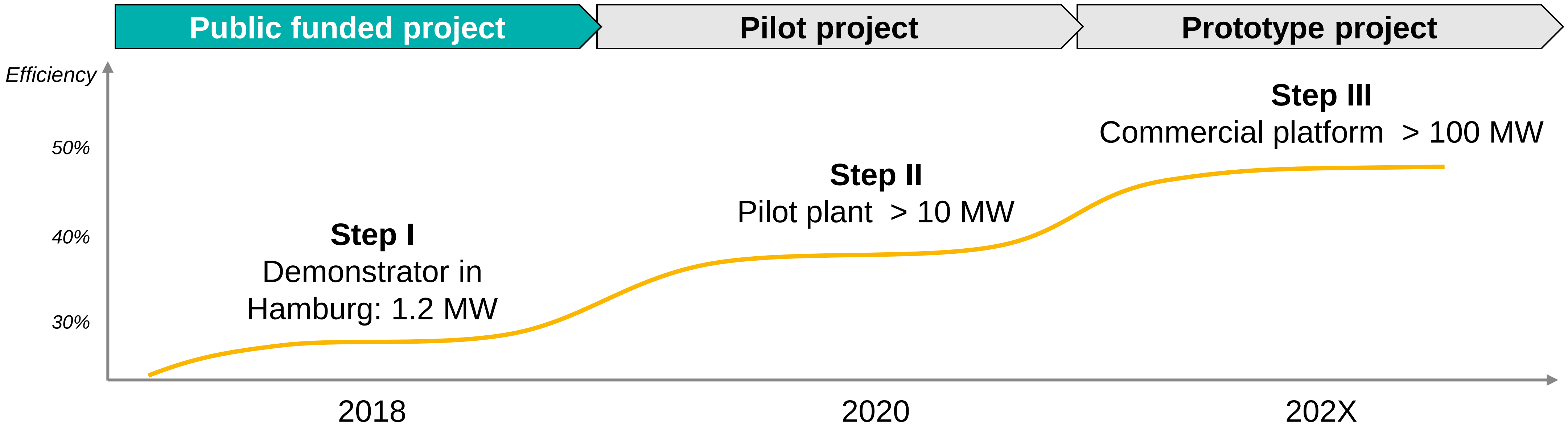
Comparison large scale and batteries

	Large scale	Li-Ion
Service life (years)	+	-
Scalability	+ +	-
Flexibility	-	+
Efficiency	o	+ +
Economies of scale	+ +	-

Market trend supports biz case in long term

Electricity arbitrage	Higher price spreads and improving forecasting abilities
Ancillary services	Growing demand due to higher volatile renewable energy penetration
Reserve capacity	Trend to use electricity from renewable generation as reserve power
Heat sales	Power-to-Heat applications and growing district heating markets

Three steps towards commercialization of the technology



- Proof of concept for thermal storage solution
- R&D on heat storage

- Enhancement of technical solution
- Possible size range: 10 MW - 50 MW

- Rollout of proven solution to customers globally

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Demonstrator ➔ Pilot Plant ➔ Large scale storage

Development steps

- High temperature storage: proof of concept ✓
- Demonstrator (2018): 1.2 MW / 1 d* / η ~ 25%
- Pilot plant (2020): ~30 MW / 1-3 d* / η ~ 35%
- Large scale storage (202X): 100 MW / 2-7 d* / η ~ 50%

*Continuous discharge time

Economics of scale

- Raising competitiveness with increase of power output
- 50% cost saving by retrofit possible

Next steps

- Construction and testing of demonstrator in Hamburg

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Thanks

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