BIOWKK Workshop Dortmund 2012

Open adsorption systems for thermal energy storage applications

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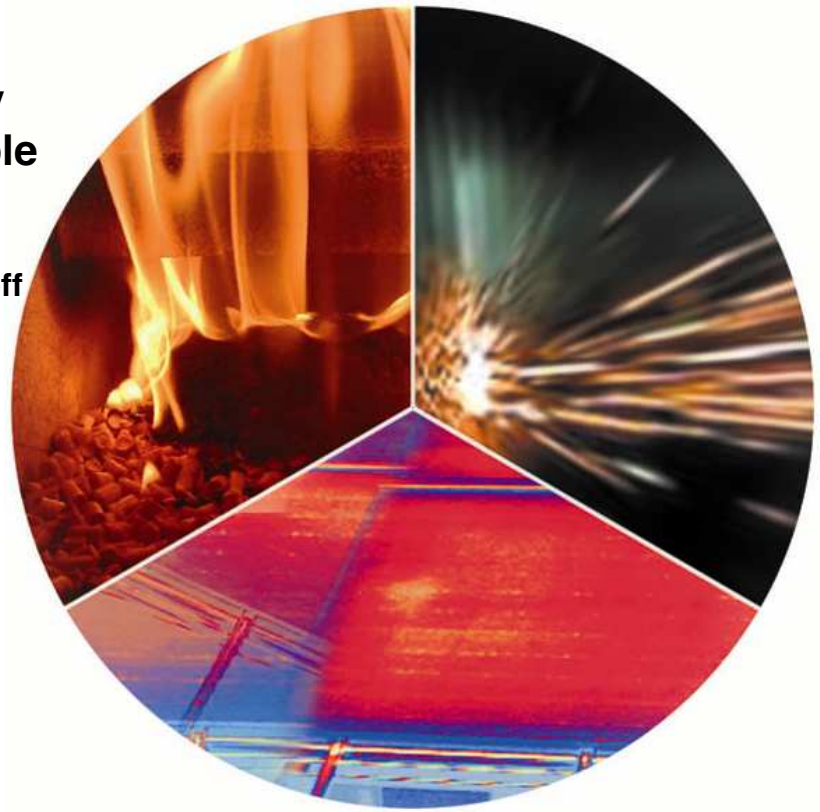

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Outline

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1. Introduction
2. Development
3. Examples
4. Summary

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1.Introduction
1.1 Thermal Energy Storage Technologies

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Sensible	Latent	Thermochemical
		
The energy storage density is defined by physics		
Specific heat capacity Temperature difference	Enthalpy of melting / Enthalpy of evaporating	Enthalpy of reaction
~ 40 – 80 kWh/m³	~ 50 – 140 kWh/m³	~ 80 – 300 kWh/m³

1. Introduction
1.2 Classification of Sorption Heat Storage

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Thermochemical Heat Storage		
Reversible Chemical Reactions	Sorption	
	Absorption	Adsorption
Chemical Bindings (e.g. Covalence)	Solubility, Mixing without reaction	Interaction of molecules (e.g. van der Waals)
$Mg(OH)_2$ $MgO+H_2O$	LiBr / Water	Zeolite / Water

Characteristics of sorption heat storage:

- Temperatures are not fixed
- Linked to the ambient

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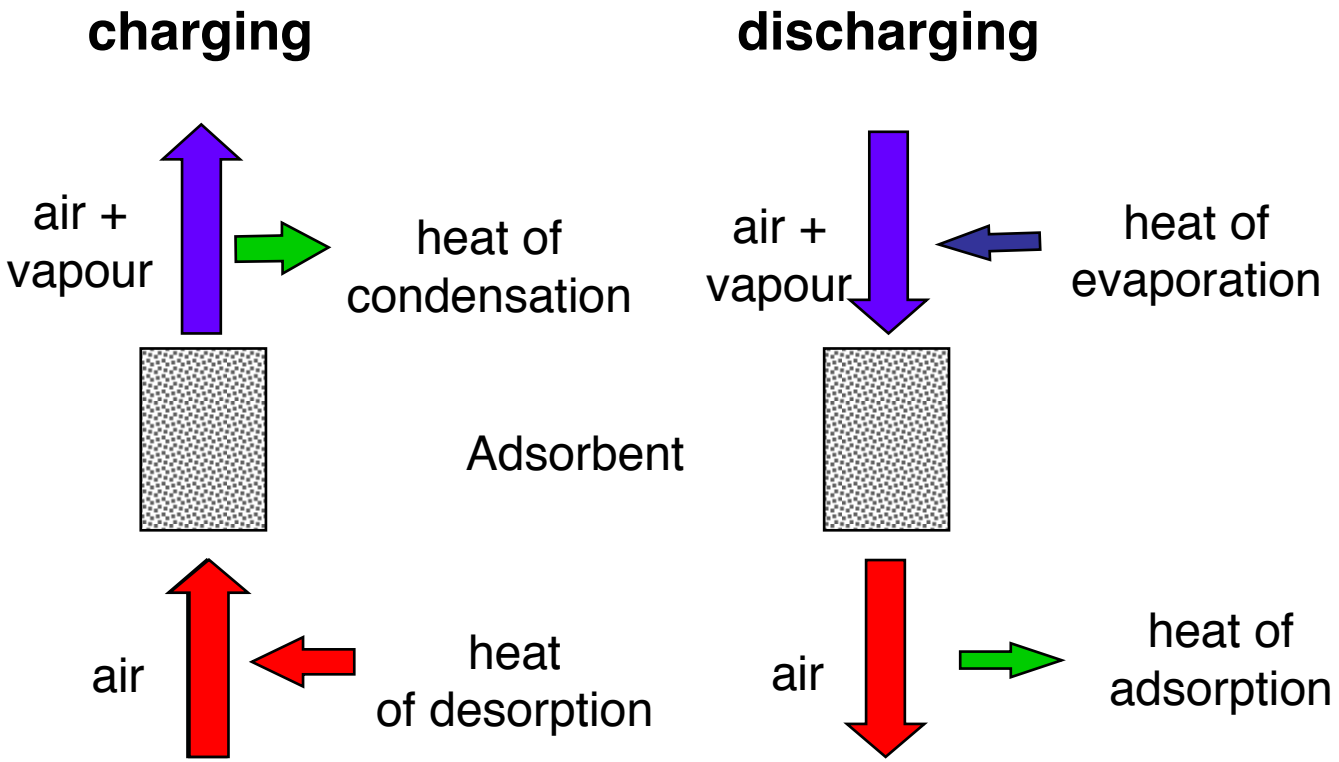

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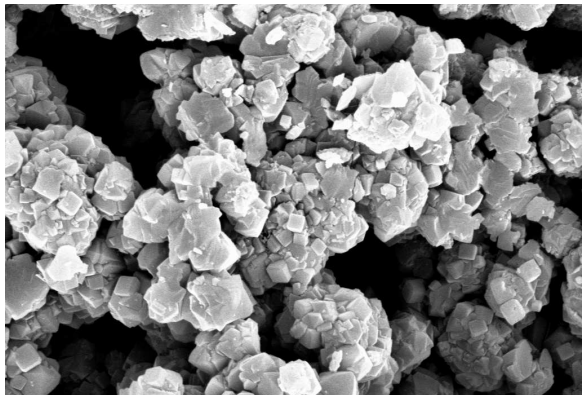

2. Development
2.1 Selection Criteria for Adsorbent Materials

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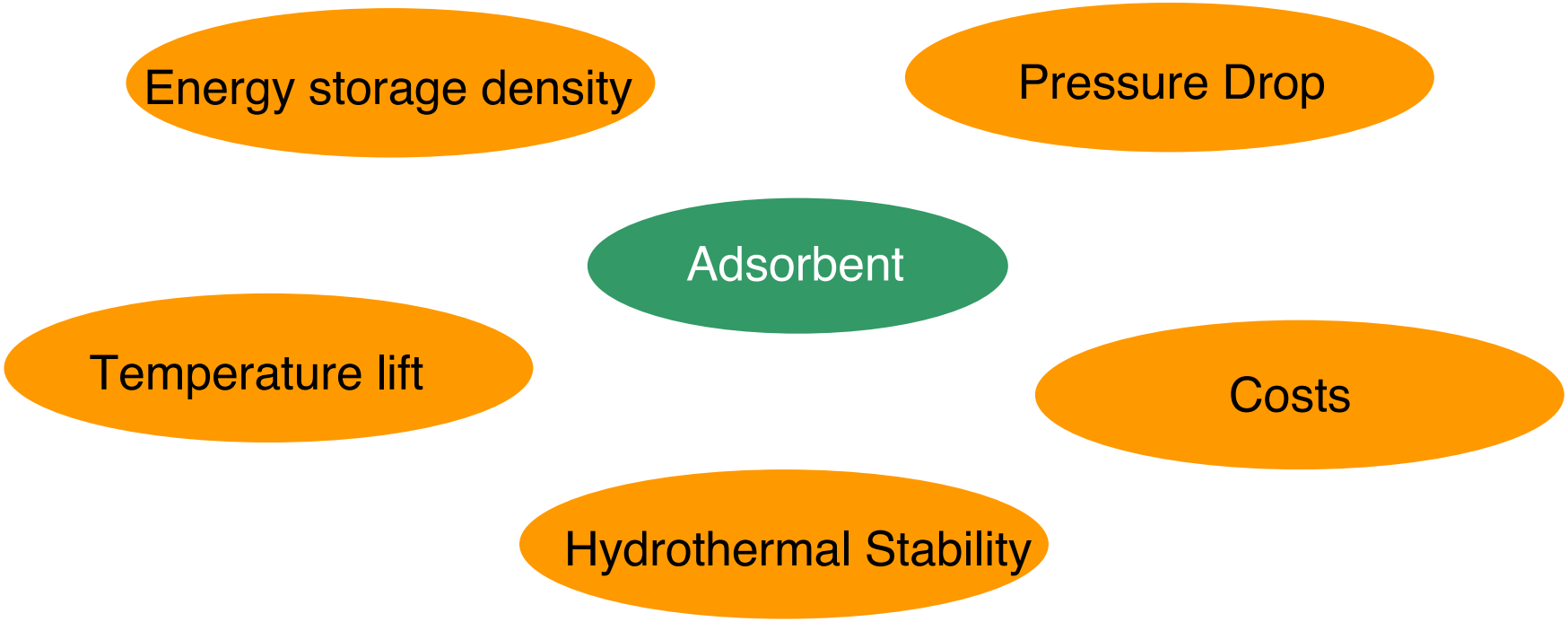

2. Development
2.2 Characterization of Adsorbent Materials

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Equilibrium

Possible Energy Storage Capacity

Stability

Durability of the material

Transient

Performance

2. Development
2.3 Suitable Adsorbent Materials

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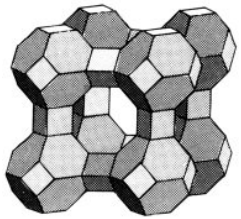
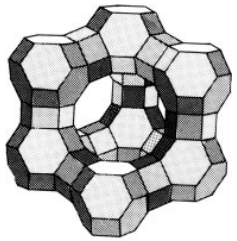
Adsorbent	Water uptake / %	Temperatur lift	Stability	Costs / kg
Silicagel	35 - 50	☹	😐	☺ 0.5 - 2 €
Zeolite	20 - 35	☺	😐	😐 2 - 10 €
ALPO / SAPO	35 - 50	?	?	☹
MOF	35 - 50	?	?	☹



Zeolite A: 2,000,000 t/a



Zeolite X / Y: 100,000 t/a

2. Development
2.4 Boundary Conditions

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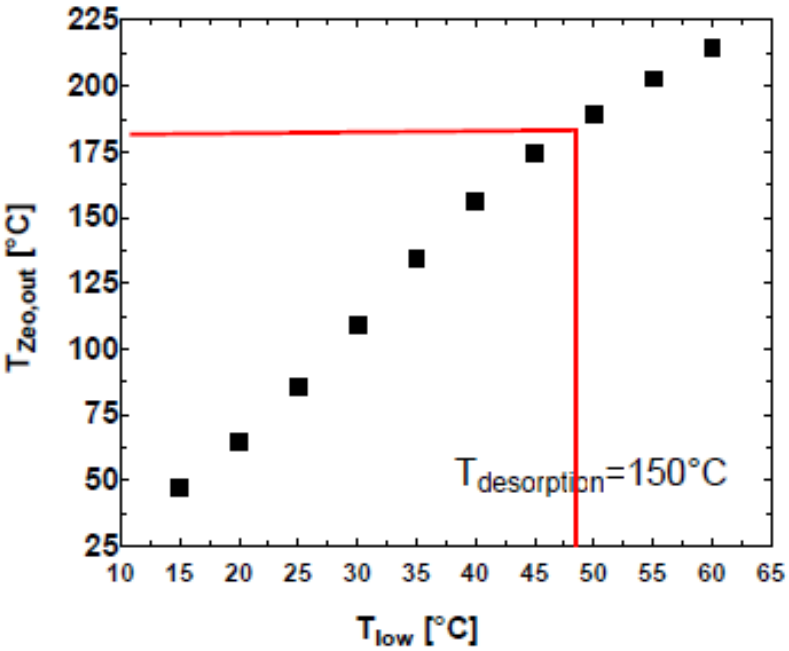

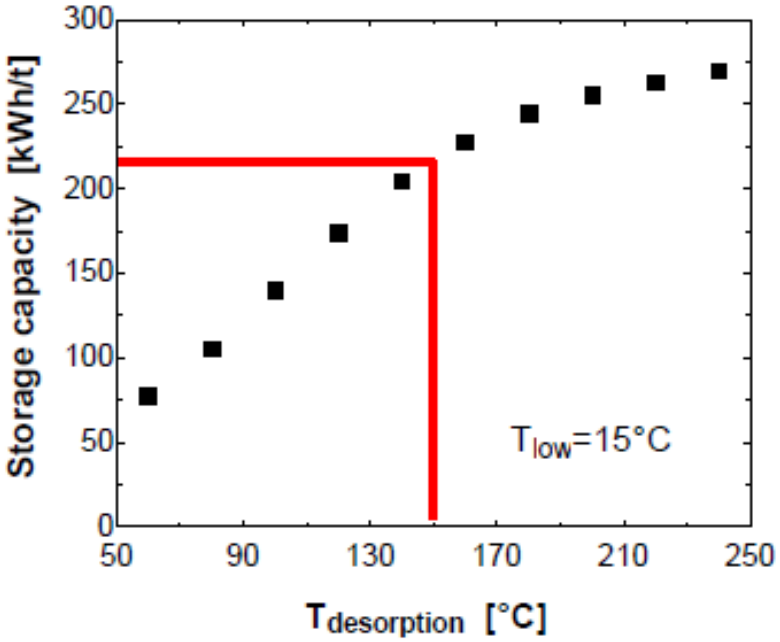

- Temperature lift depends on temperature of the inlet
- Storage capacity increases with higher temperatures of desorption

2. Development
2.5 Designing the Storage System

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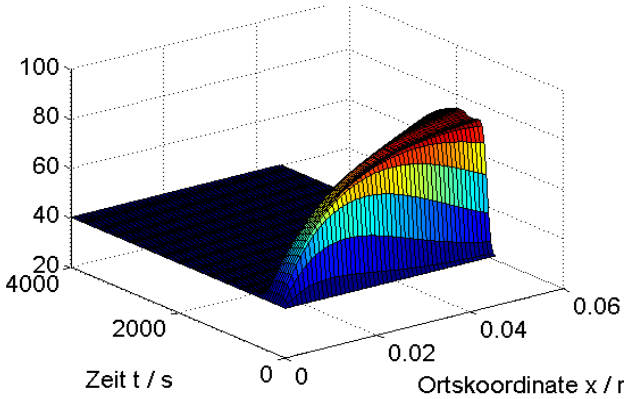
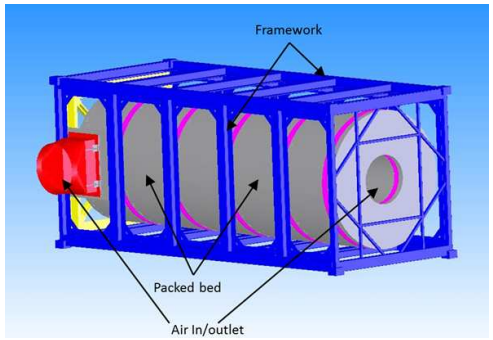
Simulation



Computer Aided Design



Construction

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3. Example
3.1 Mobile Sorption Heat Storage - Principle

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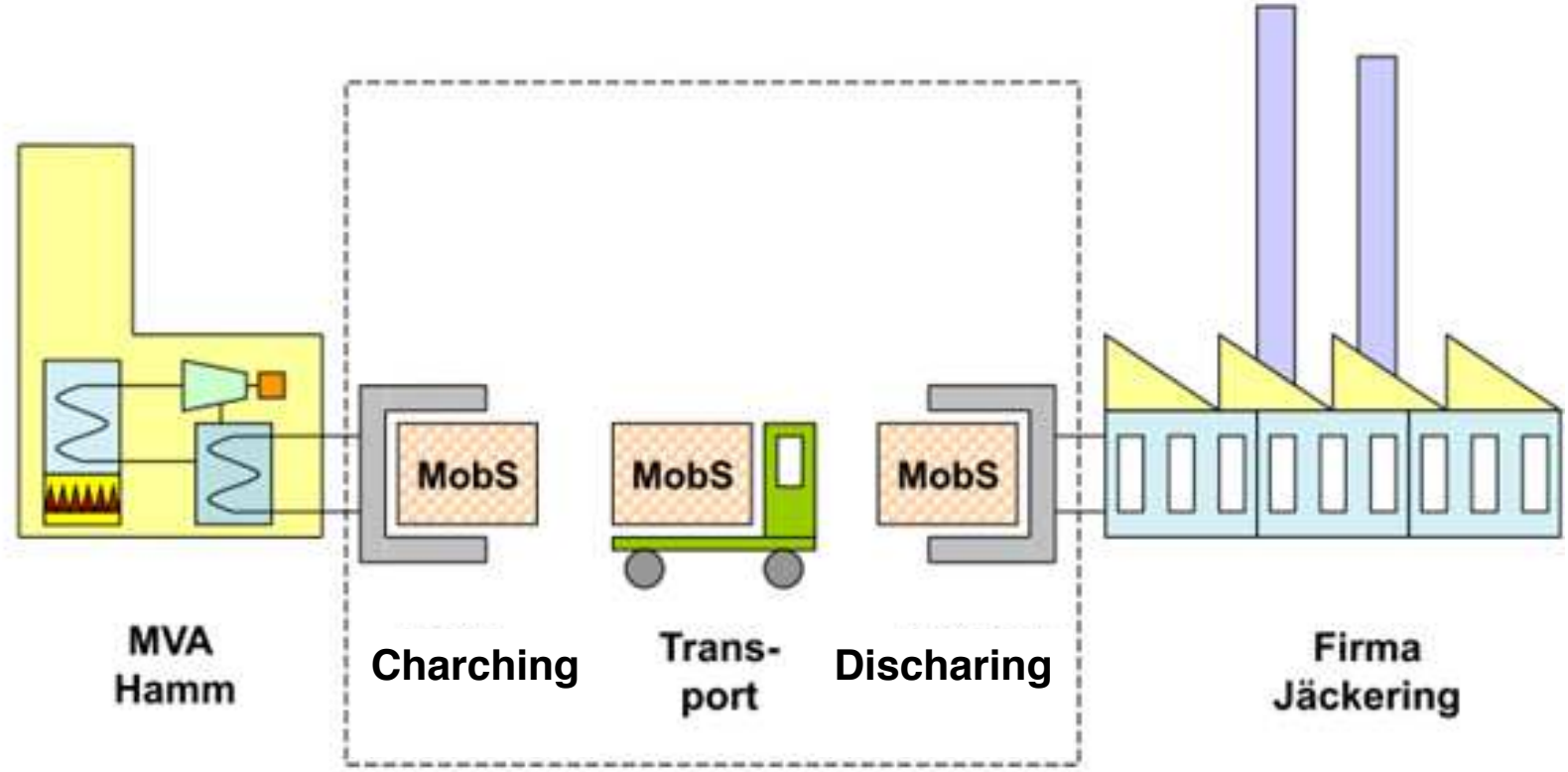
Waste Incinerator

Drying Process



3. Example
3.2 Mobile Sorption Heat Storage - Conditions

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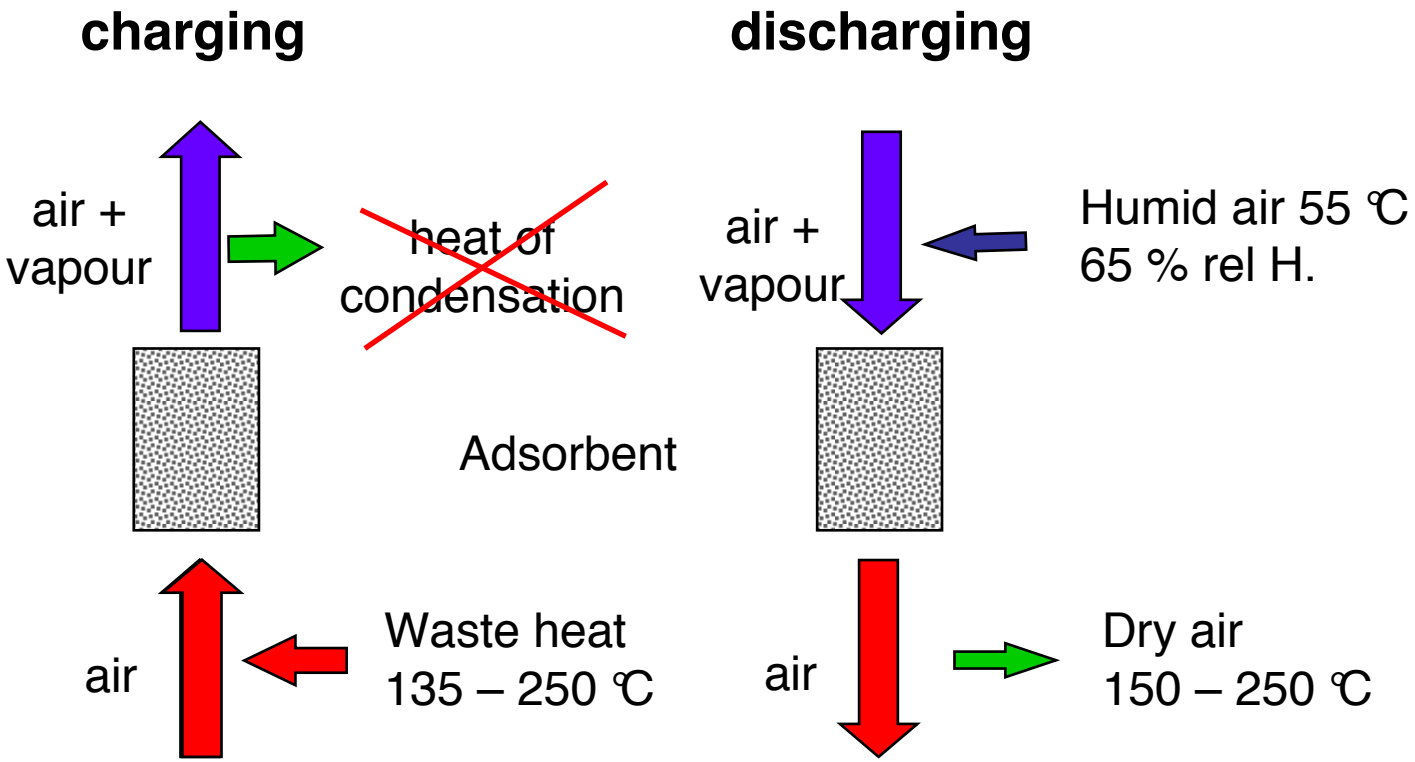

3. Example
3.3 Mobile Sorption Heat Storage - Realization

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- Length: 8.3 m
- Height: 2.9 m
- Zeolite: 14 t
- Energy “on the wheel”: up to 4 MWh

Charging

3. Example
3.4 Mobile Sorption Heat Storage - Simulation

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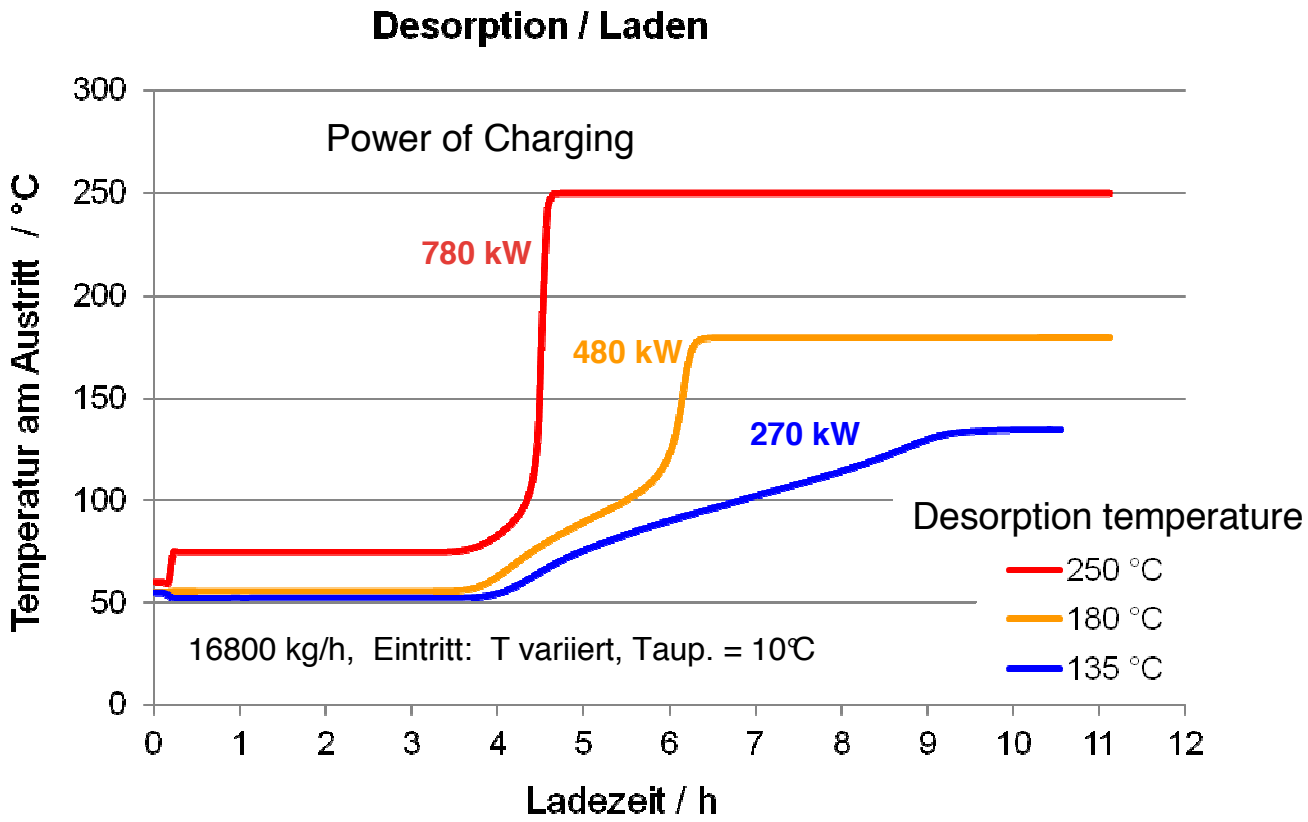

Simulated Data for ideal fixed bed

High desorption temperature:

- Short time for charging
- High power of charging

Low desorption temperature:

- Long time for charging
- Low power of charging

3. Example
3.4 Mobile Sorption Heat Storage - Simulation

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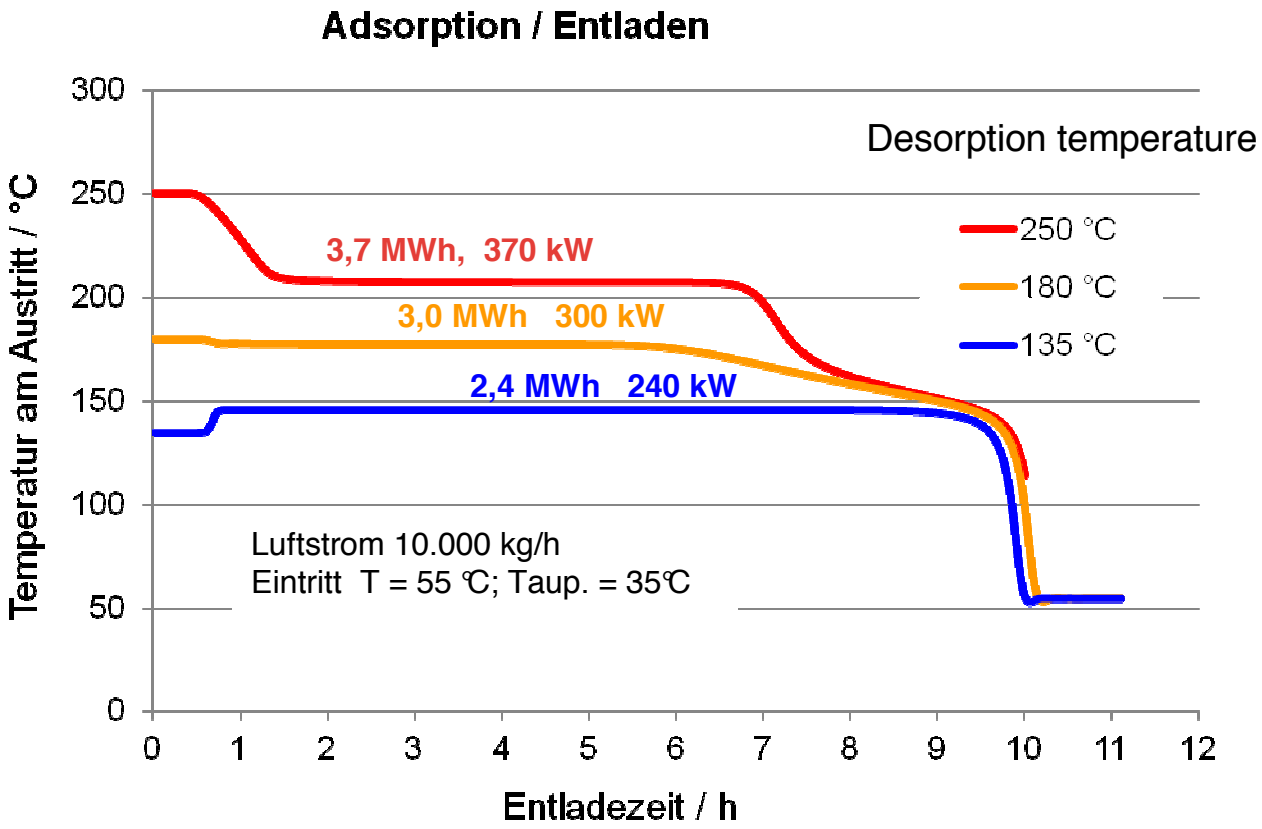

Simulated Data for ideal fixed bed

High desorption temperature:

- High storage density
- High power of discharging

Low desorption temperature:

- Lower storage density
- Lower power of discharging

3. Example
3.5 Mobile Sorption Heat Storage – Study

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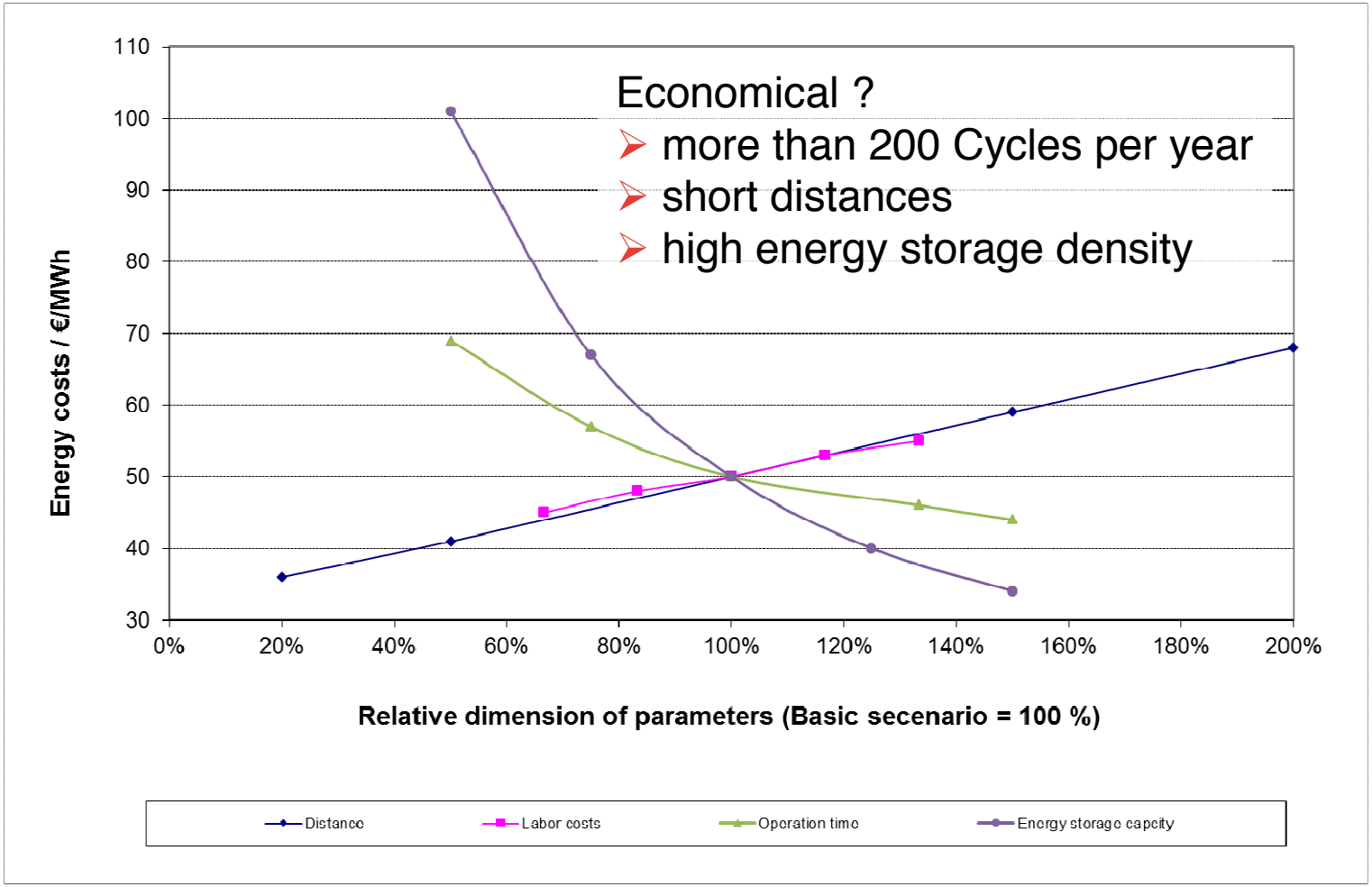

3. Example
3.6 Mobile Sorption Heat Storage - Overview

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Parameter	Unit	Results
Storage Capacity	kWh/m³	170 - 250 kWh/t 2,4 – 3,5 MWh
Charging Power Discharging Power	kW	250 – 800 kW 250 – 400 kW
Efficiency due to thermal losses	Energy charged / Energy discharged	0,9
Cycle time	h	Storage time: 1 h Cycle duration: 10 - 14 h
Economy	Heat generation costs	50 - 80 €/MWh

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- Open adsorption storages can improve the energy efficiency
- Improvement of efficiency depends on the boundary conditions
- Drying processes in combination with waste heat processes are promising for sorption heat storages

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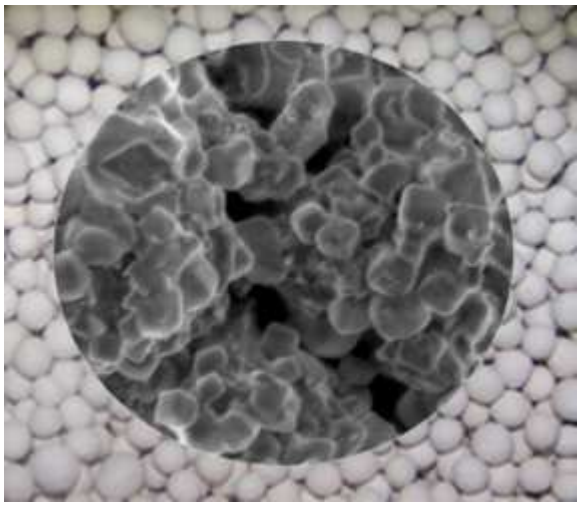
Thank you very much for your attention!



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