Industrial waste heat recovery, technologies and examples
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ZAE Bayern – Applied Energy Research for the Energy Economy

From basic research to full-size demonstrators

ZAE fills the gap between basic research and commercialisation of new ideas
Ways of Waste Heat Utilization

Waste Heat

- Direct Use
  - Sensible
  - Latent
  - Chemical
- Storage
  - Chiller
  - Heat Pump
- Transformation
  - Thermal
  - Into Electricity
    - ORC (Thermo-Electric Effect)
    - Sterling-Engine
Thermal Driven Heat Pumps/Chillers

- **Source**
- **Chiller**
- **Heat Pump**
- **Sink**

**Waste Heat/ Auxiliary Power**

- **Temperature**
  - Ambient
  - Cooling Demand
  - 120°C
  - 90°C
  - 15°C
  - 6°C/<0°C
Thermal Energy Storage

Sensible
- Water storage
- Thermal oil/Solid materials/Salt hydrates
- Ruth storage
- Water pressurized

Latent
- Zeolite

Chemical
- Regenerators

State of the art
Demonstration
R&D
Determination of Waste Heat Utilization Potentials

1. Data acquisition
   - Mass flow
   - Temperature
   - Energy consumption data
   Reconditioning and storage of measurement data

2. Monitoring
   - Of the waste heat situation
   - And the heating / cooling demand

3. System-analysis
   - Determines waste heat recovery potentials

4. Strategy
   - Evaluation of the waste heat utilisation potentials and creation of an action plan
   - Especially for dynamic processes
   - Open technology system view
   - Designed for complex problems
   - Innovative system solutions
   - Fast implementation

Energy System
- Industrial waste heat
- Direct use
- Heat Storage
- Heat pump/Chiller
- External consumer heating/cooling
- Domestic heating and cooling
- Process heating and cooling
Mobile Thermal Energy Storage for Waste Incineration Plant

- shift in time and location possible -> additional customers
- flexible energy transport where pipelines are not cost effective
- high storage capacity and thermal power by sorption technology
Mobile Thermal Energy Storage for Waste Incineration Plant

- charging station

![Diagram of waste heat storage system with zeolite]

**AMB**

- waste heat (steam) 150 °C

- 30 °C

- Zeolite

- $T_{\text{out}} = 45 - 50 ^\circ \text{C}$

- rel. hum. = 85 - 95 %
Mobile Thermal Energy Storage for Waste Incineration Plant

- discharging station

Auxiliary heating

Feed

Dryer

Zeolite

\[ T_{\text{out}} = 185 ^\circ \text{C} \]

\[ \text{rel. hum.} < 3 \% \]

\[ T_{\text{in}} = 58 ^\circ \text{C} \]

\[ \text{rel. hum.} = 64 \% \]
High Temperature Storage in a Foundry

Waste heat recovery today

14h/day

- 0.7 MW Water-Cooling (90°C)
- 2.5 MW Heat Transfer Oil Cooling (230°C)

24h/day

- Furnace on
- Furnace off

1.6 MW

Waste Heat

Demand

- 0.6 MW Paint Dryer at 160°C (all season)
- 0.5 MW Heating/DHW + >0.5 MW District Heating (winter)
High Temperature Storage in a Foundry

Waste heat recovery **tomorrow**

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**Waste Heat**

- **14h/day**
  - 0.7 MW Water-Cooling (90°C)
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- **24h/day**
  - Furnace off

**Demand**

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**1.6 MW**

**1.15 MW**

**TES (up to 220°C)**

**1.6 MW**
High Temperature Storage in a Foundry
Sensible thermal energy storage up to 220°C

Dual-Media thermal storage

• Replacing oil by cheap solid material (e.g. rock) reduces costs

• Direct thermal contact between solid material and HTO enables good heat transfer

• Storage capacity can be increased by using suitable solid material
High Temperature Storage in a Foundry
Sensible thermal energy storage up to 220°C

- Increase in capacity 15%
- Decrease in costs 60%

$c_{p,HTO} = 1000 \text{J/kgK}$
$c_{p,HTO} = 2500 \text{J/kgK}$
$\rho_s = 2650 \text{kg/m}^3$
$\rho_v = 850 \text{kg/m}^3$
$\text{costs}_s = 100 \text{€/m}^3$
$\text{costs}_{HTO} = 1800 \text{€/m}^3$
High Temperature Storage in a Foundry
Sensible thermal energy storage up to 220°C

- R&D phase successfully completed
- Demonstration plant planned for 2019
CHP-Unit combined with an Absorption Chiller

Standard CHP-Unit in combination with a Single-Effect chiller

- state of the art
- decentral placement of CHP-Unit and chiller possible
- low efficiency and unflexible chiller process
CHP-Unit combined with an Absorption Chiller

Adapted CHP-Unit in combination with an Double/Single-Effect chiller

- direct use of flue gas by the double effect chiller and simultaneous use of hot water by the single stage increases the efficiency
- flexible supply with heating and cooling energy increases runtime of CHP-Unit
- CHP-Unit and chiller are more complex and no decentral placement possible
CHP-Unit combined with an Absorption Chiller Demonstration Plant – Key Figures

- industrial area with hot and chilled water network in southern Germany
- hot water demand: 7500 MWh annual / 3 MW peak
- chilled water demand: 4000 MWh annual / 1.5 MW peak
CHP-Unit combined with an Absorption Chiller Demonstration Plant – Results

- 3.7 MWh of cooling demand could be covered
- Double/Single effect concept can deliver **64% more** cooling energy
Obstacles and Challenges

• Knowledge about waste heat situation and potentials
• Knowledge about technologies (costumer, planner)
• To get knowledge is costly without direct cost advantage

• High investment costs for waste heat recovery systems
• Investment is economic but payback time expectations often not realistic
• Suitable financing models are rare

• Main goal is production not energy efficiency
Thank you for your attention!

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