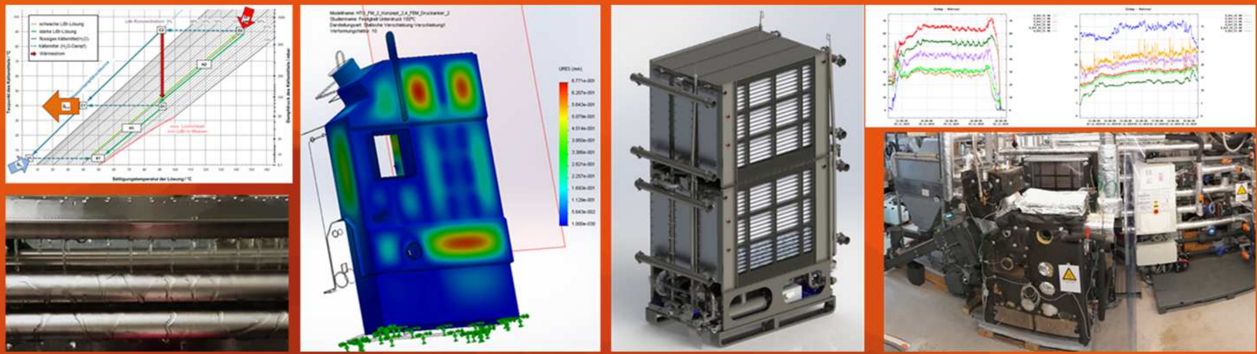


ZAE BAYERN

HDG Komfortabel heizen. Mit Holz!

Gefördert durch:

Bundesministerium für Wirtschaft und Klimaschutz

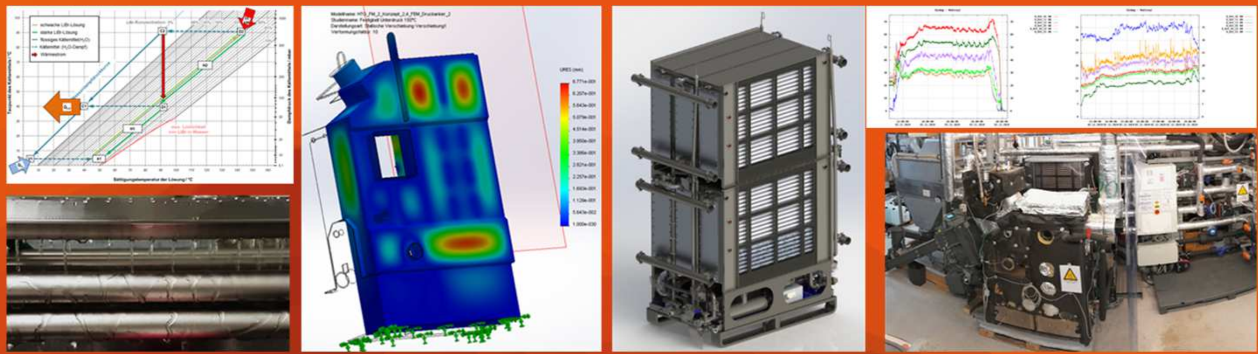
aufgrund eines Beschlusses des Deutschen Bundestages

ENERGY.
FUTURE.
ZAE.

Two-stage biomass-fired absorption heating and cooling system

Manuel KAUSCHE,
Martin Helm, Manuel Riepl, Wolfgang Aich

ZAE BAYERN



Two-stage biomass-fired absorption heating and cooling system

Gefördert durch:
Bundesministerium für Wirtschaft und Klimaschutz
aufgrund eines Beschlusses des Deutschen Bundestages

AGENDA:

- Advantages of biomass directly fired AHP's
- System concept and test-rig setup
- Test results for highly efficient double effect mode
- Outlook

Manuel KAUSCHE,
Martin Helm, Manuel Riepl, Wolfgang Aich

ZAE BAYERN

Advantages of a two-stage heating and cooling system with directly fired biomass-combustion

ZAE BAYERN

- Potential of (ligneous) biomass is big, but limited, *utilisation of wood: **"Building Construction FIRST!"***
- Heat from **biomass reliefs el. grids** and enables usage of wastewood
- Standardised, ***storable*** fuel and technically mature combustion: **wood chips or pellets**
- **Multistage = Flexibility** → in operation modes → temperatures → applications!

higher efficiency = less global warming! *(and: consider refrigerants…)*

working pair: lithiumbromide and water

	biomass boiler	biomass boiler & single effect (SE)	biomass directly fired double effect (DE)
BUE_h	0,9	1,5	2,0

"DE, 1 MW? Buy it!"

"DE, 100 kW??! To be developed…"

$$BUE_h = \text{BiomassUtilizationEfficiency}_{\text{"heat"}} = \frac{\text{heat}}{\text{fuel energy}}$$

Modelling of the heating and cooling system

ZAE BAYERN

engineering guideline

- economic and reliable, capacity-class: 100 kW
- producable with common fabrication methods of boiler manufacturers
- cubic “europalett“-design of main components

guiding design temperatures

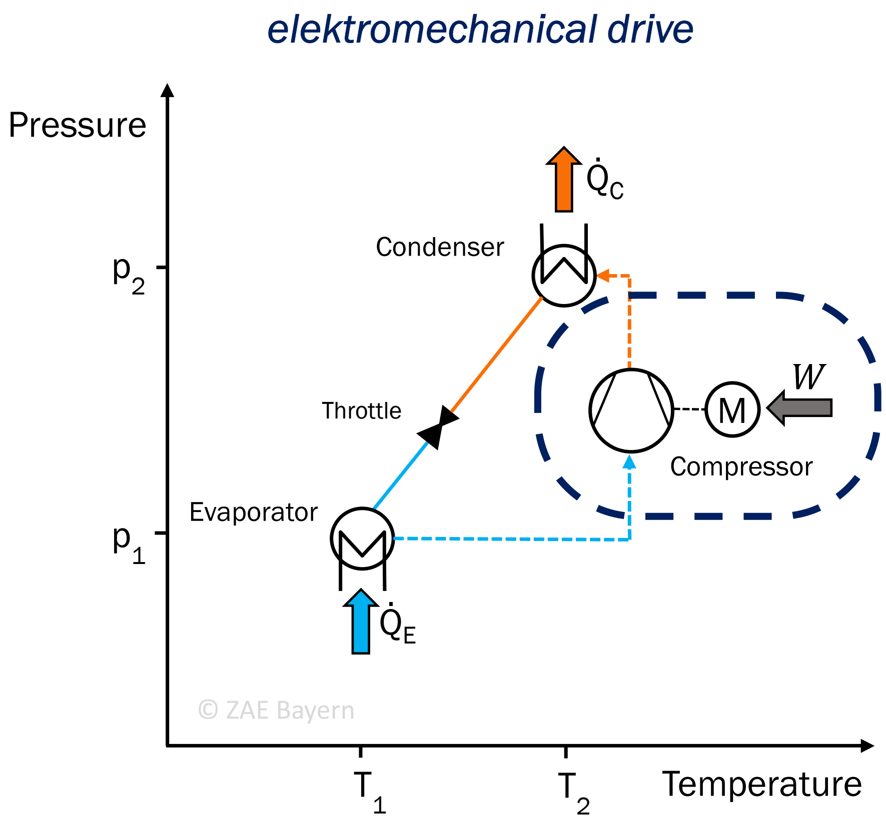
- choosen for application as a **double effect heat pump**
  - ✓ ambient heat source **4|8 °C** (groundwater, wastewater, geoth.probes, ...)
  - ✓ heat for new-building standards **41|31 °C** (e.g. floor heating)

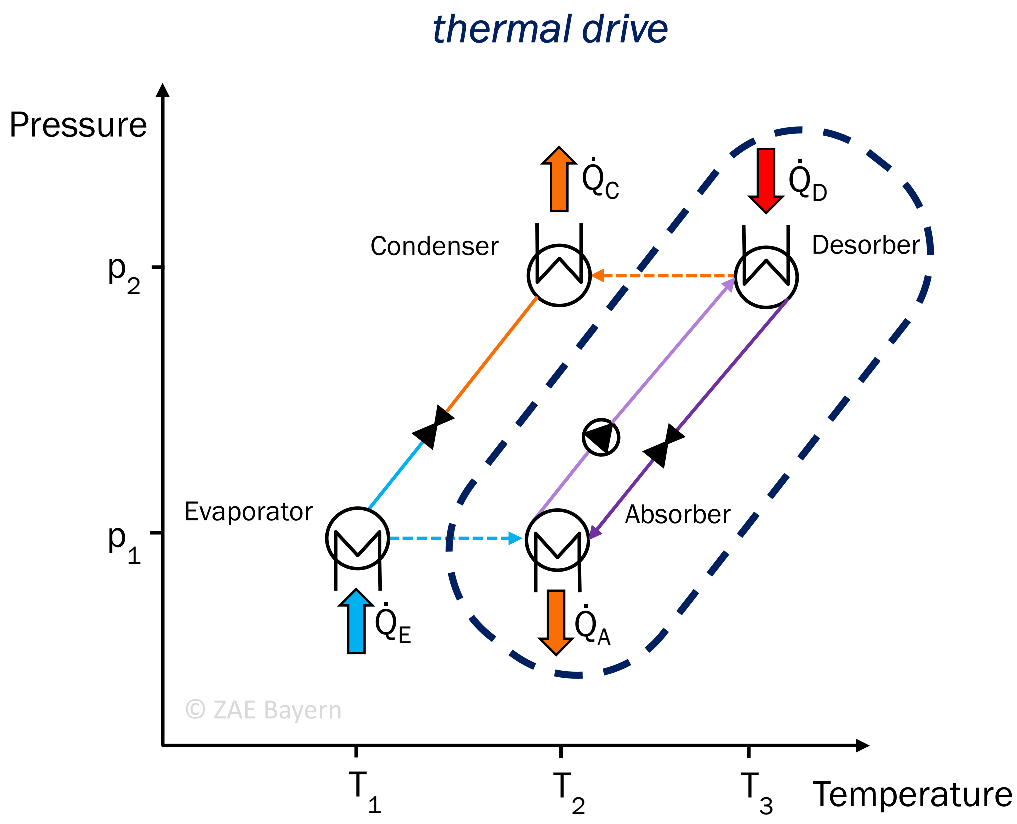
Modular system setup

- The choosen design and plug&play hydraulic system enables
  - ✓ ***Easy insertion*** *as well as* ***error-free installation*** *and integration into buildings or quarters.*
  - ✓ ***Coupling*** *of e.g.* ***solar thermal*** *or other* ***waste heat*** *for cooling (summer!), but also heat pump drive (winter!)*
  - ✓ ***Wells or geoth. probes*** *as well as geothermal energy (as ambient heat source) enable additional,* ***fuel-free cooling***

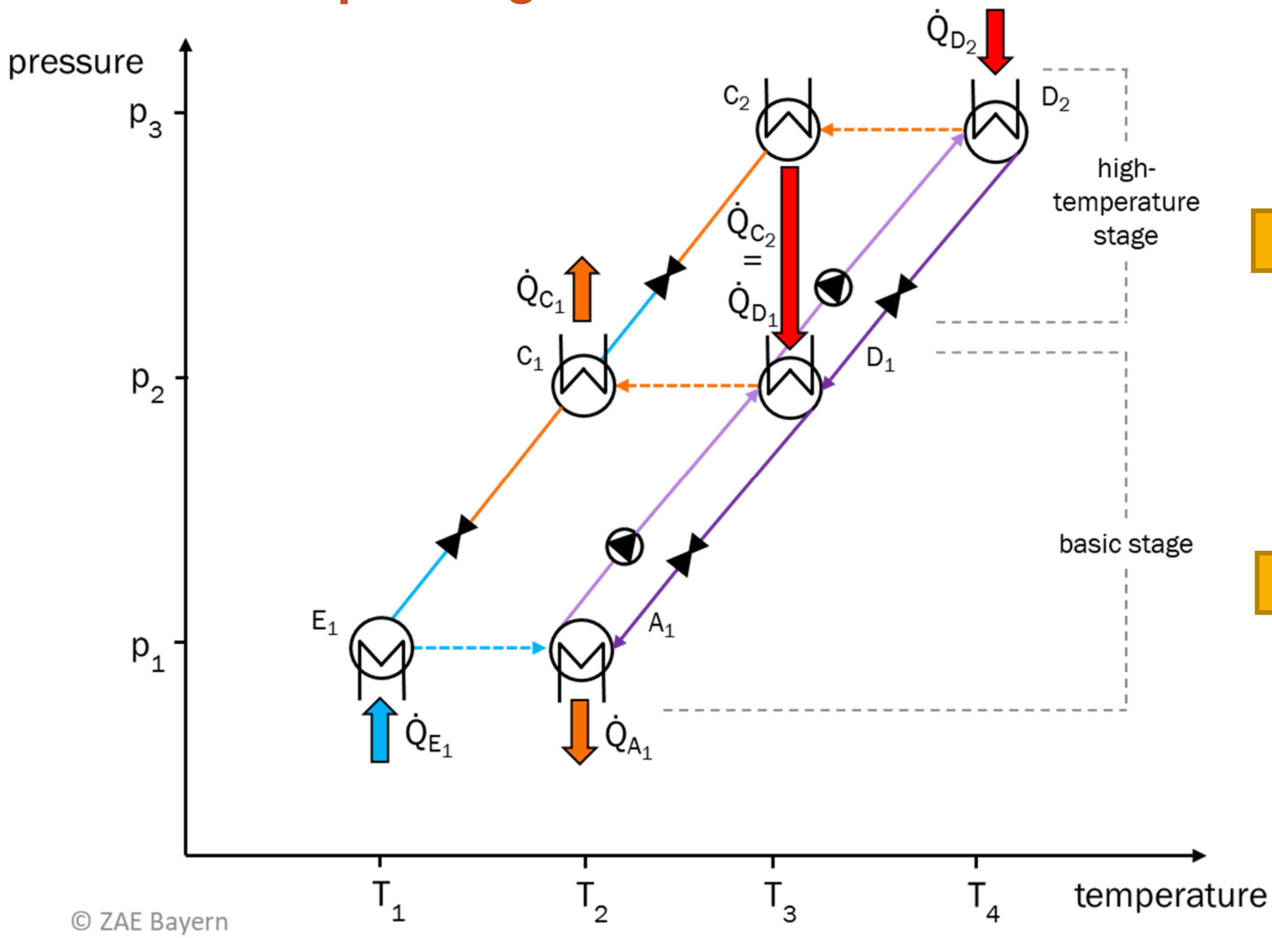
Operating principles of the drive types commonly used for heat pumps and cooling systems

ZAE BAYERN

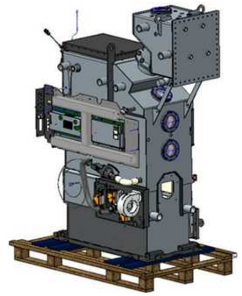




Highly efficient, two-stage absorption heat pump process in schematic p-T-diagram



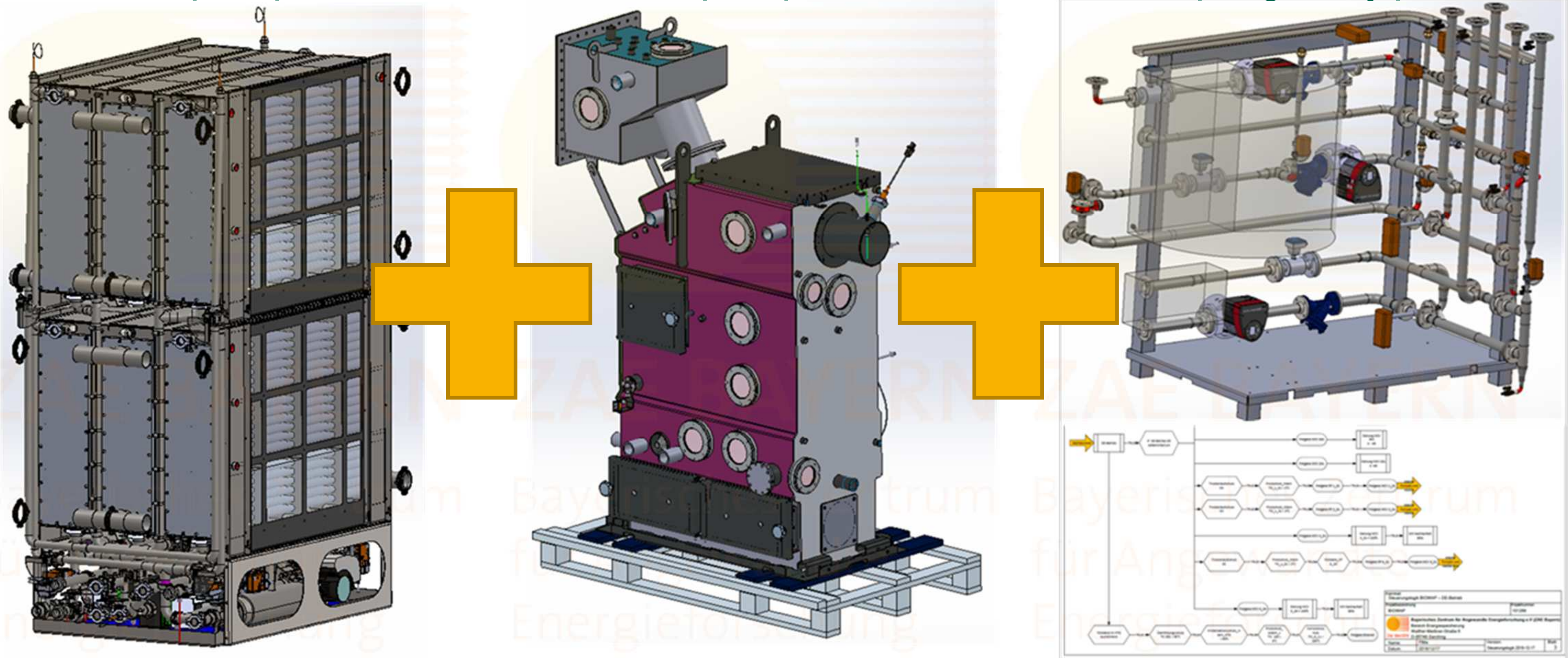
Hightemperaturedesorber (HTD)



Single-stage "absorption heat pump" (AHP) designed as a tube bundle

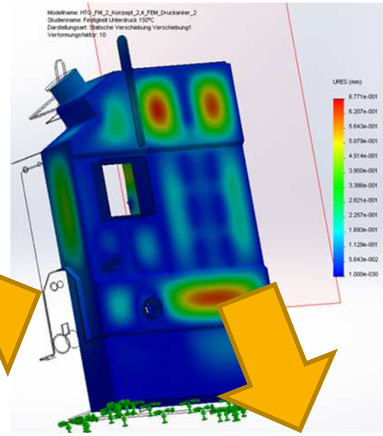
Developed plant and test-rig setup

Absorption Heat Pump (AHP) | **High Temperature Desorber (HTD)** | **Hydraulics & Control (Plug&Play)**

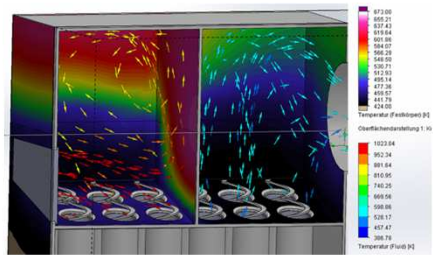


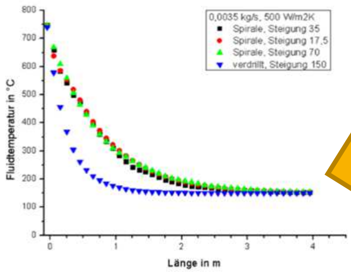
Core piece: wood-pellets-directly-fired High Temperature Desorber (HTD)

Stress analysys

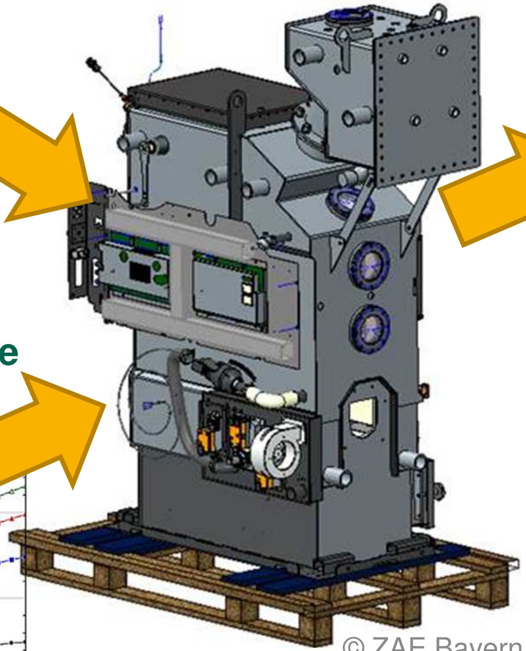


Heat transfer fluegas-side

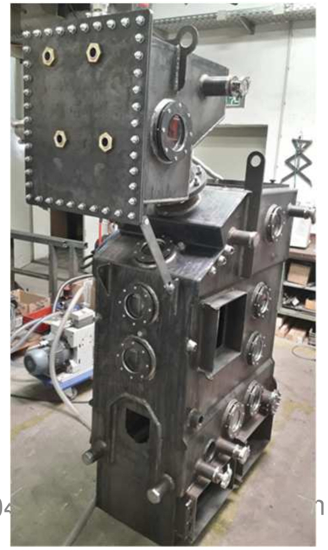




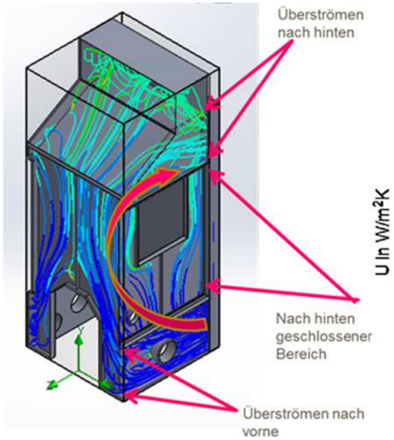
Construction

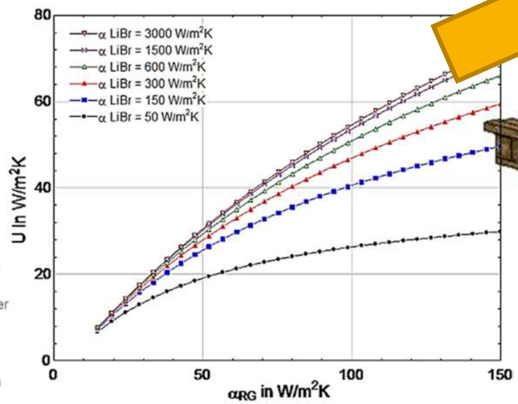


Fabrication

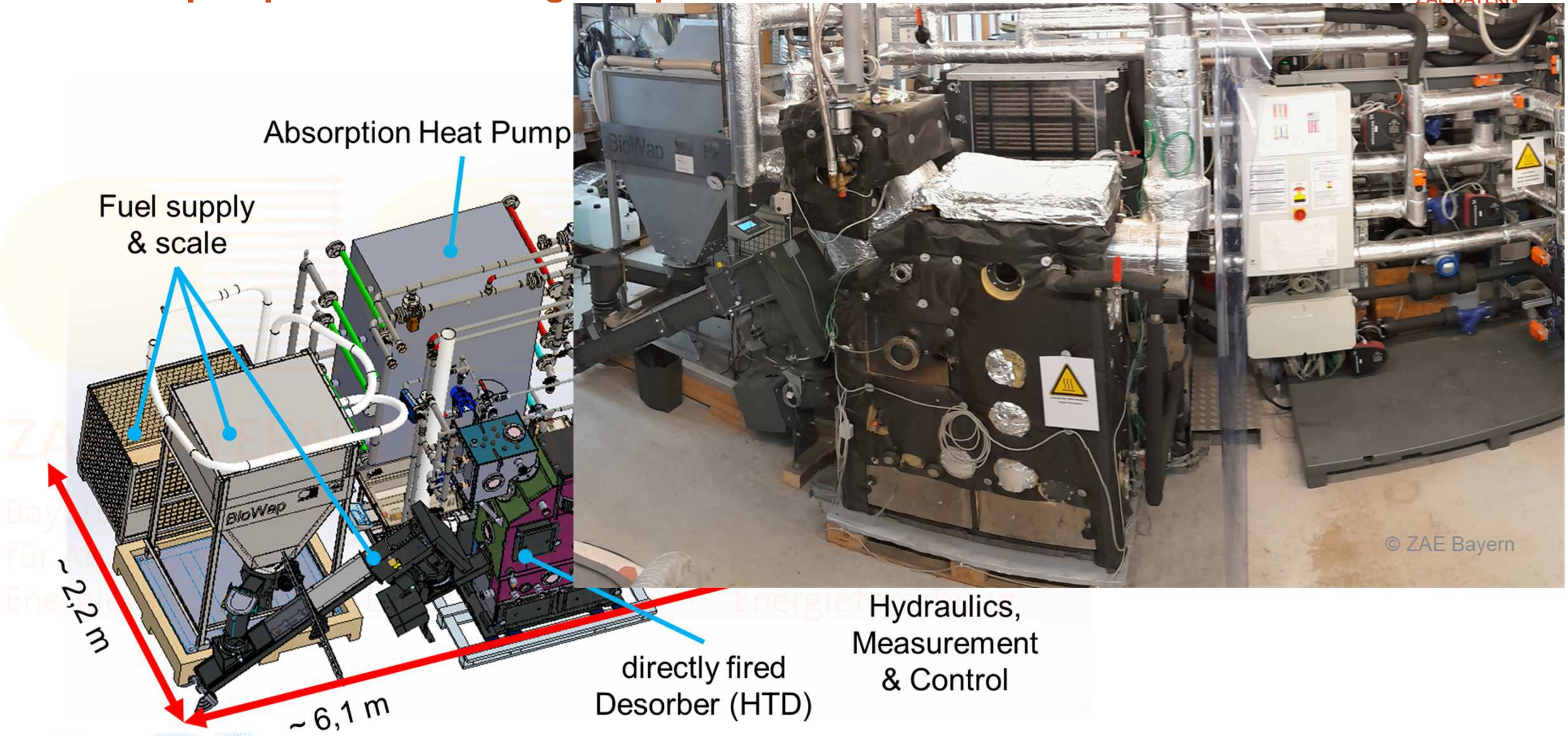


Natural convection & heat transfer solution-side

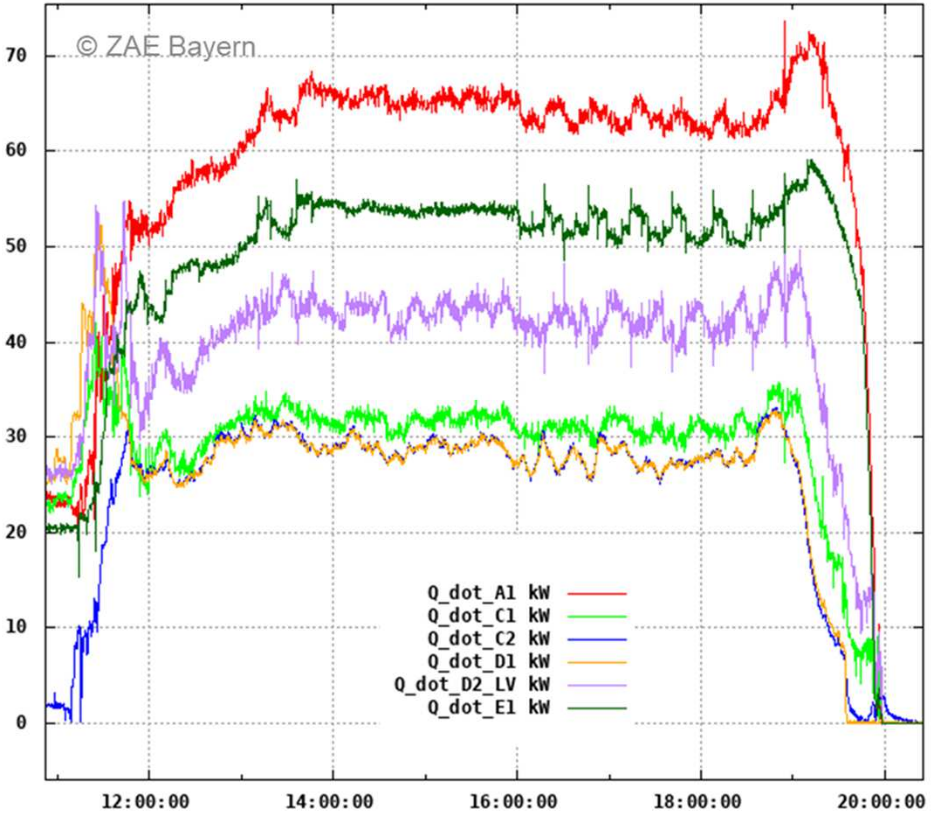


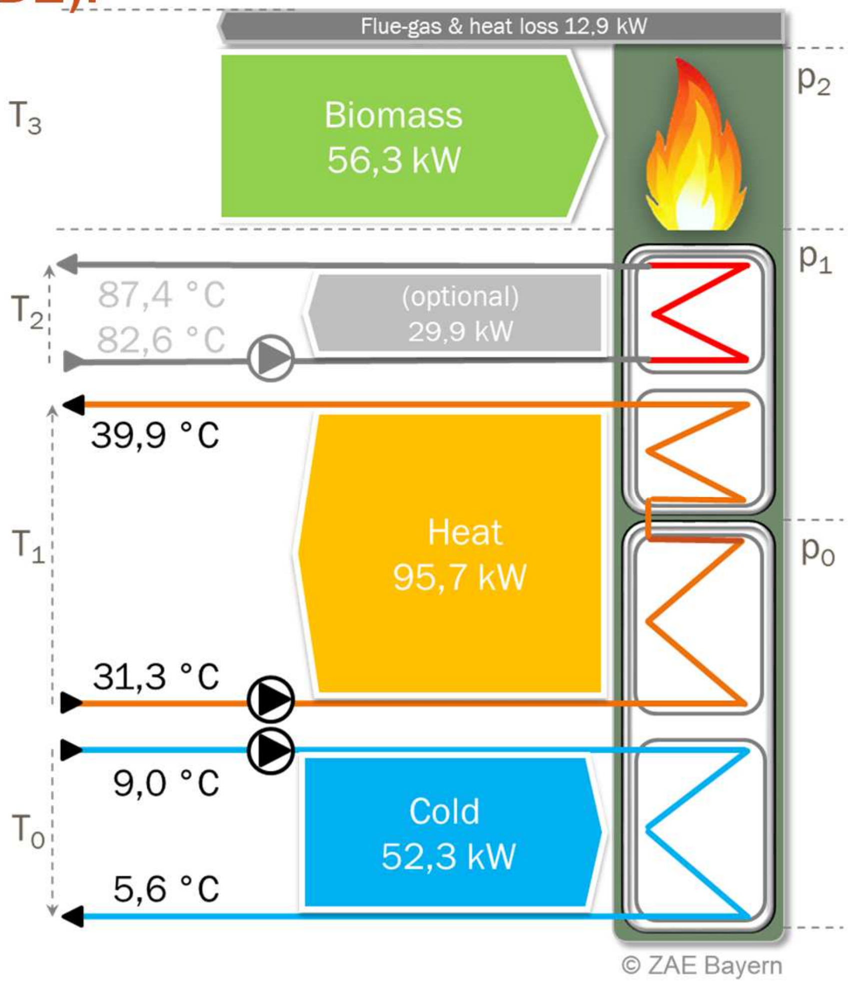


Developed plant and test-rig setup



Test results for the double effect mode (DE):

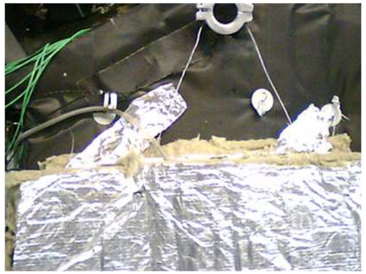


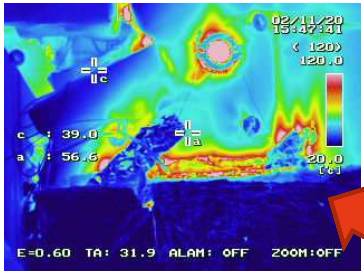


ZAE BAYERN

Thermal losses lower the performance significantly – example from the double effect results:

ZAE BAYERN





- Thermal losses caused by the measurement setup lowers Q_{HTD} , therefore η_{HTD} and BUE_h.

Process based figure:

ζ_{heat} = 2,2 $\quad \dfrac{\text{heat}}{\text{driving heat } (Q_{HTD})}$

Fuel based figures:

η_{HTD} = 77 % $\quad \dfrac{\text{driving heat } (Q_{HTD})}{\text{fuel energy}}$

Biomass**U**tilization**E**fficiency "heat"

BUE_h = 1,7 $\quad \dfrac{\text{heat}}{\text{fuel energy}}$

	Simulation	Test result	Uncertainty
T_{cold} (supply)	4 °C	5,6 °C	±0,10 K
T_{cold} (return)	8 °C	9,0 °C	±0,09 K
T_{heat} (supply)	41 °C	39,9 °C	±0,17 K
T_{heat} (return)	31 °C	31,3 °C	±0,19 K
T_{lift}	37 K	34,4 K	±0,19 K
$\dot{Q}_{E1}$	61,5 kW	52,3 kW	±2,10 kW
$\dot{Q}_{A1}$	77 kW	64,1 kW	±2,86 kW
$\dot{Q}_{C1}$	34,1 kW	31,6 kW	±2,65 kW
[illegible]	33,6 kW	29,9 kW	±2,21 kW
$\dot{Q}_{C2}$	33,6 kW	29,9 kW	±2,58 kW
$\dot{Q}_{R}$	111,1 kW	95,7 kW	±3,90 kW
$\dot{Q}_{HTD}$	50 kW	43,4	±3,3[illegible] kW
ζ_{cold}	1,23	1,21	±0,01
ζ_{heat}	2,22	2,21	±0,12
$\dot{Q}_{B}$	56,8 kW	56,3	±0,30 kW
T_{AG}	-	189,8 °C	±4,19 K
η_{HTD}	88 %	77 %	±6,2 %
EER	-	83,4	±2,89
COP		152,4	±4,83
BUE_h	1,96	1,70	±0,07
BUE_c	1,08	0,93	±0,04

Conclusions and outlook

ZAE BAYERN

the directly biomass-fired absorption heat pump system for capacities around 100 kW...

- ✓ is technically **feasible**, whilst **economically justifiable**
- ✓ **doubles the heat-output & halfs emissions** compared to conventional bio-boilers
- ✓ enables upgrading **low temperature heat** reservoirs **at ~ 4 °C**
- ✓ **suits** especially to **medium-sized enterprises** or **residential areas**
- ✓ highly efficient **converts** (waste-)**biomass** energy into useable cold **for cooling**
- ✓ as a **"two-stager"** enables multiple modes of operation: **DE, DL, DE/SE, ...**

... prospective work:

- ❖ system optimization and pilot plants
- ❖ further applications such as extracting heat from flue gas by condensing
- ❖ Scientific discussion!

BioWap at a glance:

- **Combustion capacity** **~ 55 kW**
- **Heating capacity** **~ 111 kW**
- **Cooling capacity** **~ 62 kW**
- **Temperatures** **~ 4/8 & 31/41 °C *up to 95 °C***

Project BioWap

ZAE BAYERN

HDG
Komfortabel heizen. Mit Holz!

FKZ **03KB127**

Gefördert durch:

Bundesministerium für Wirtschaft und Klimaschutz

aufgrund eines Beschlusses des Deutschen Bundestages

Manuel Kausche

ZAE Bayern
Bavarian Center for Applied Energy Research
Division: Energy Storage

Walther-Meißner-Straße 6
D-85748 Garching

biowap@zae-bayern.de
http://www.zae-bayern.de

Sponsored by
Bavarian Ministry of Economic Affairs, Regional Development and Energy

Bayerische Klima-Allianz

BVES GERMAN ENERGY STORAGE ASSOCIATION

FVEE ForschungsVerbund Erneuerbare Energien Renewable Energy Research Association

ZUSE-GEMEINSCHAFT

ZAE BAYERN

Efficiency lead – conventional systems *vs.* BioWap:

ZAE BAYERN