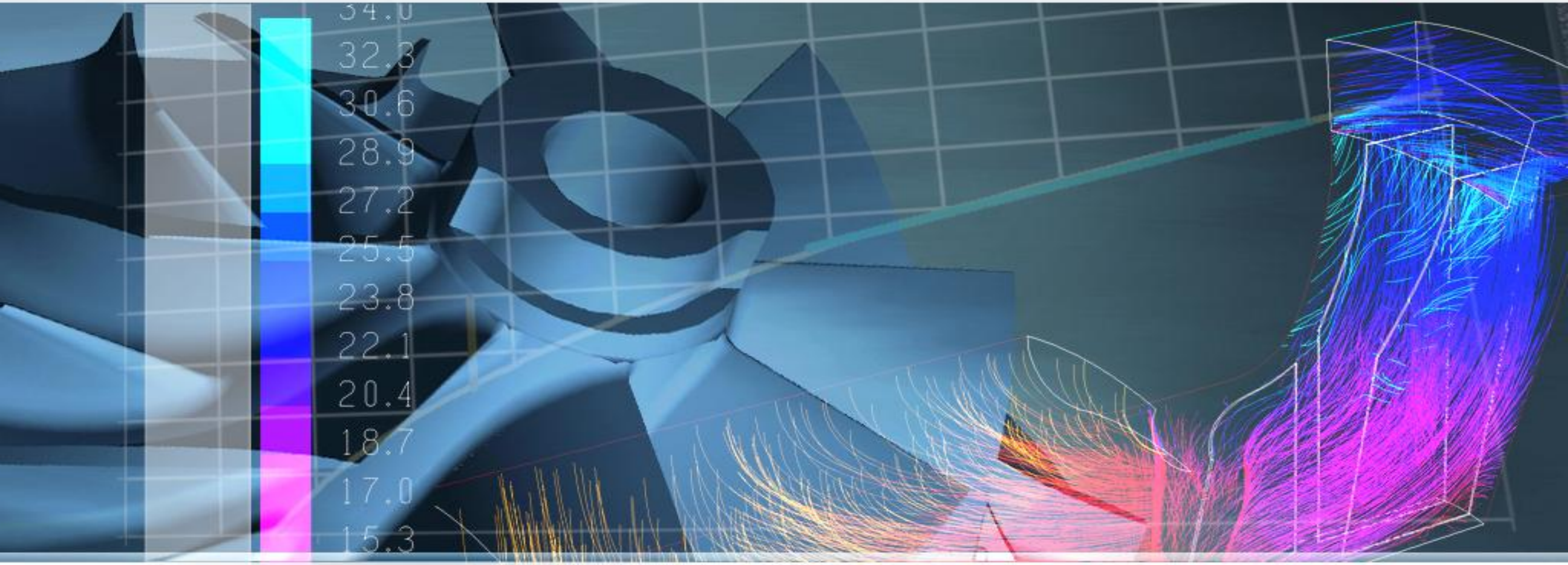
ILK Dresden



Institute of Air-handling and Refrigeration (ILK Dresden)

Experimental experiences with an enhanced directly air-cooled water/LiBr absorption chiller

6th International Conference Solar Air-Conditioning, Rome, 2015

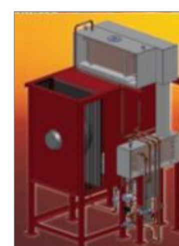
ILK Dresden – R&D company

- **Founded in 1964**
- **Re-established as independent research institute in 1990**

- **Employees: 145**
- **Academics: 72 %**
- **mean age: ~44**
- **Laboratory area: ~3000 m²**
- **Test rigs: ~56**
- **Phys. / Chem. Laboratories: 25**





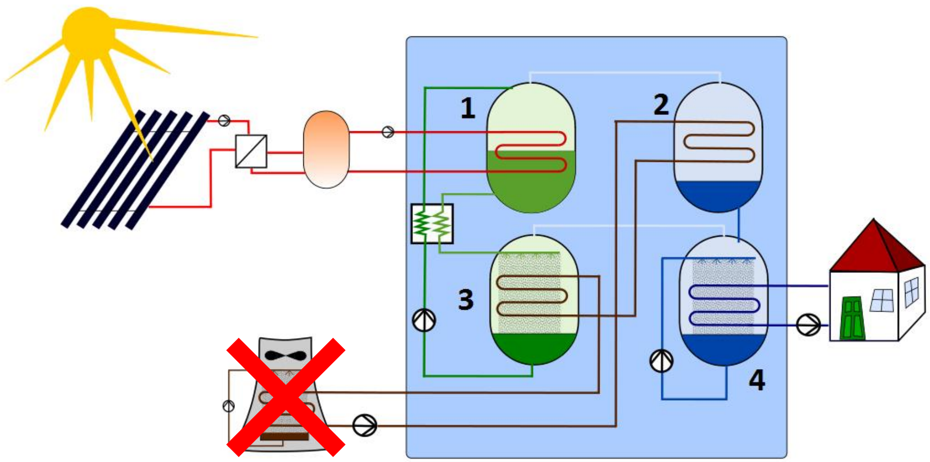



Introduction

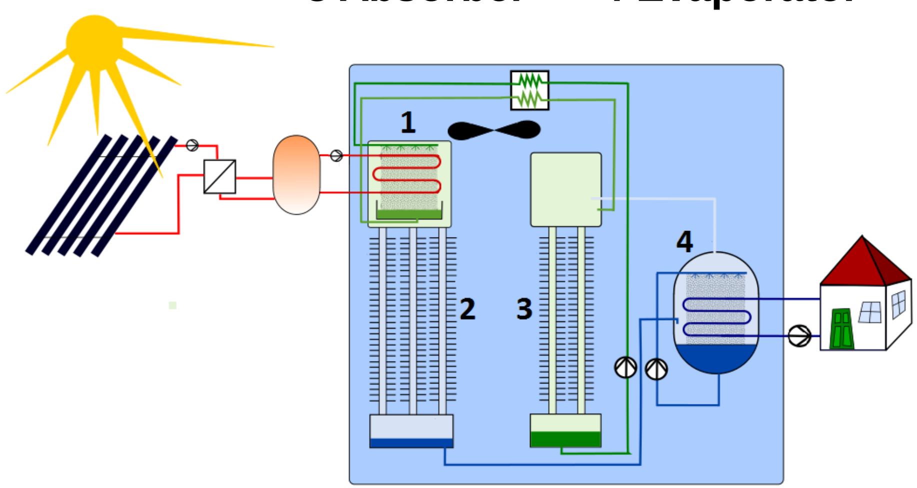
Problems in systems with small scale chillers

- Complexity of the systems
- Auxiliary energy demand of the system
- Investment cost
- Interface problems because of different crafts (might be) involved
- Possibly high error rate during installation
- Limited applicability of evaporative re-cooling systems but high re-cooling sensibility of the cycle

Directly air-cooled absorption chiller



1 Generator **2 Condenser**
3 Absorber **4 Evaporator**



- Reduction of the auxiliary energy demand by using directly air-cooled absorber and condenser
  ⇨ no cooling water circuit
- Less system components
- Lower complexity
- Lower installation effort
- Free cooling at ambient temperatures < 12 °C

Aimed specifications for the development

External Fluid	Nominal Condition	Operating Range
Chilled water temperature (water w. 20 % Glycol)	18 °C / 13 °C (in/out)	6 °C … 20 °C (out)
Heating water temperature (water w. 20 % Glycol)	95 °C / 87 °C (in/out)	75 °C … 105 °C (in)
Ambient air (for re-cooling)	32 °C / 42 °C (in/out)	10 °C … 32°C (in)
Cooling capacity	8 kW	Up to 11 kW

- Condenser and Absorber directly air-cooled
- Frost resistance
- Auxiliary energy consumption at nominal conditions < 60 W_{el}/kW_0 („EER“ > 16)

Directly air-cooled components

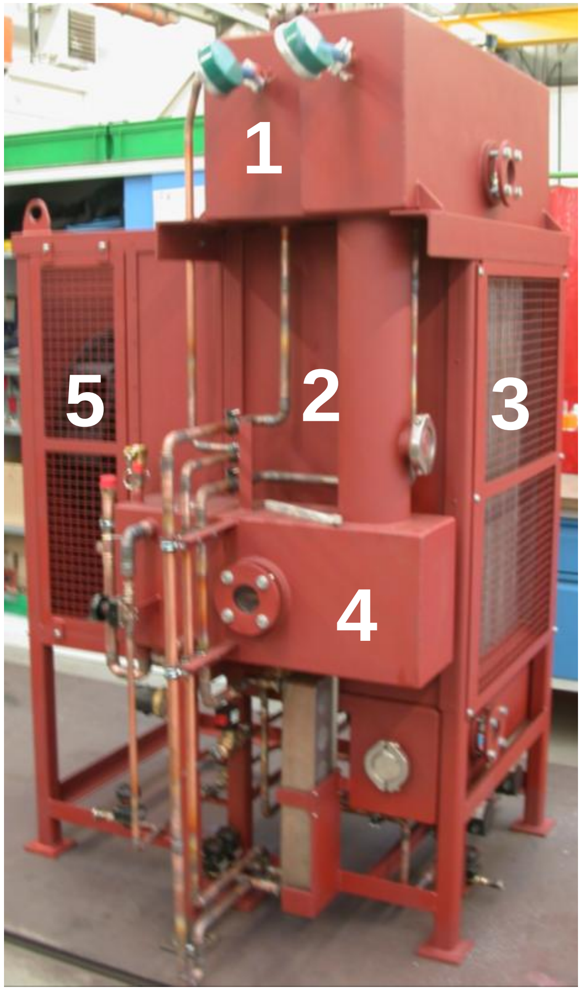
Air-cooled absorber and condenser needed

- Water as refrigerant and air as cooling medium
  ⇨ big free section needed
- Falling film heat exchangers with vertical, highly finned tubes most suitable option
- Absorber-Tubes additionally structured inside

Outdoor installation

- **Influence of weather and solar radiation**
  - Risk of freezing
  - higher and more variable cooling temperature
- **Special arrangement of heat exchangers**
  - At critical temperatures all refrigerant flows into LiBr-solution in the sump of the absorber
- **Anti-freezing additives**
- **speed of ventilation directly coupled to the performance of the chiller**

Directly air-cooled absorption chiller

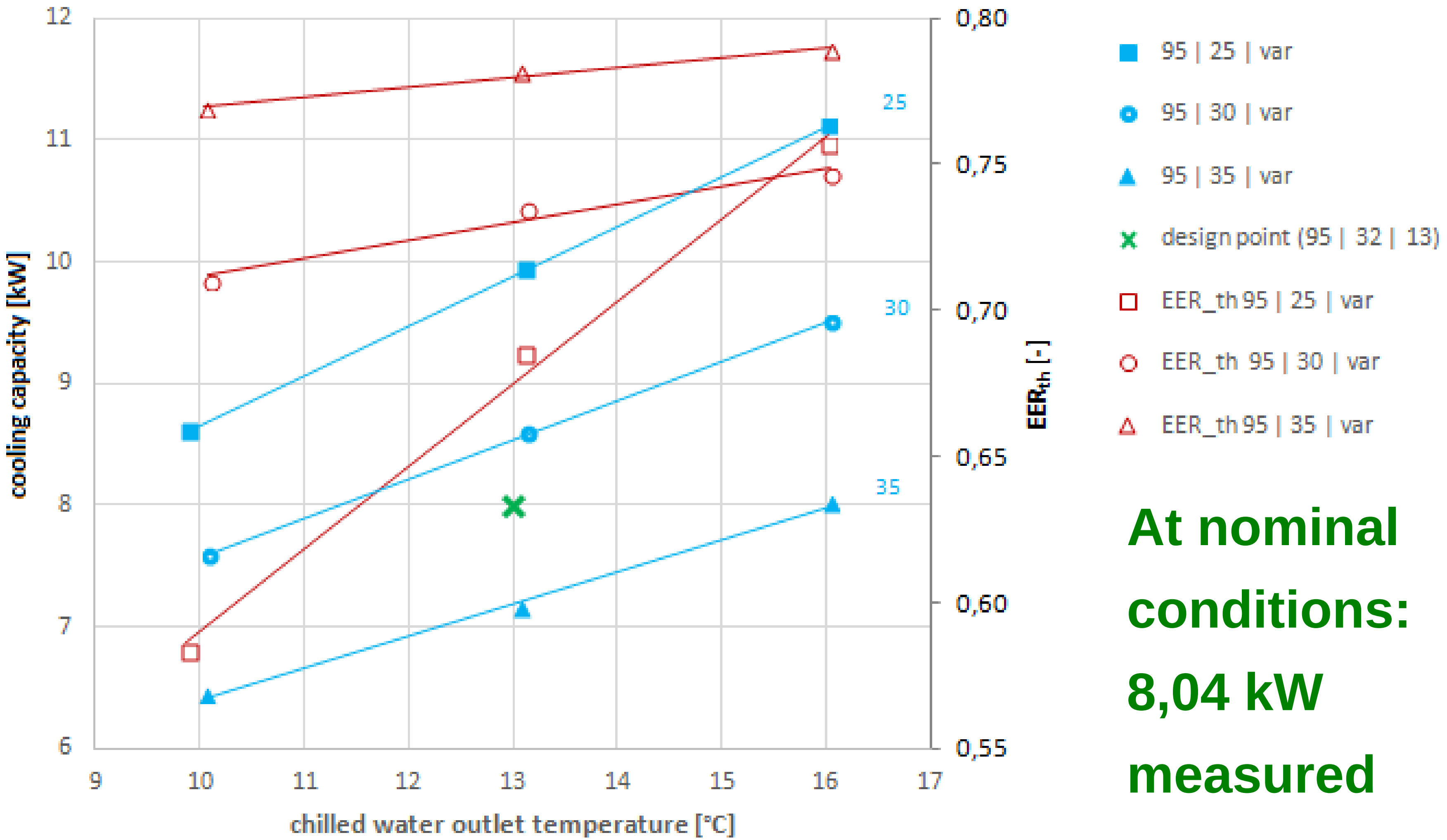


Previous functional model

1 = generator
2 = condenser
3 = absorber
4 = evaporator
5 = fan

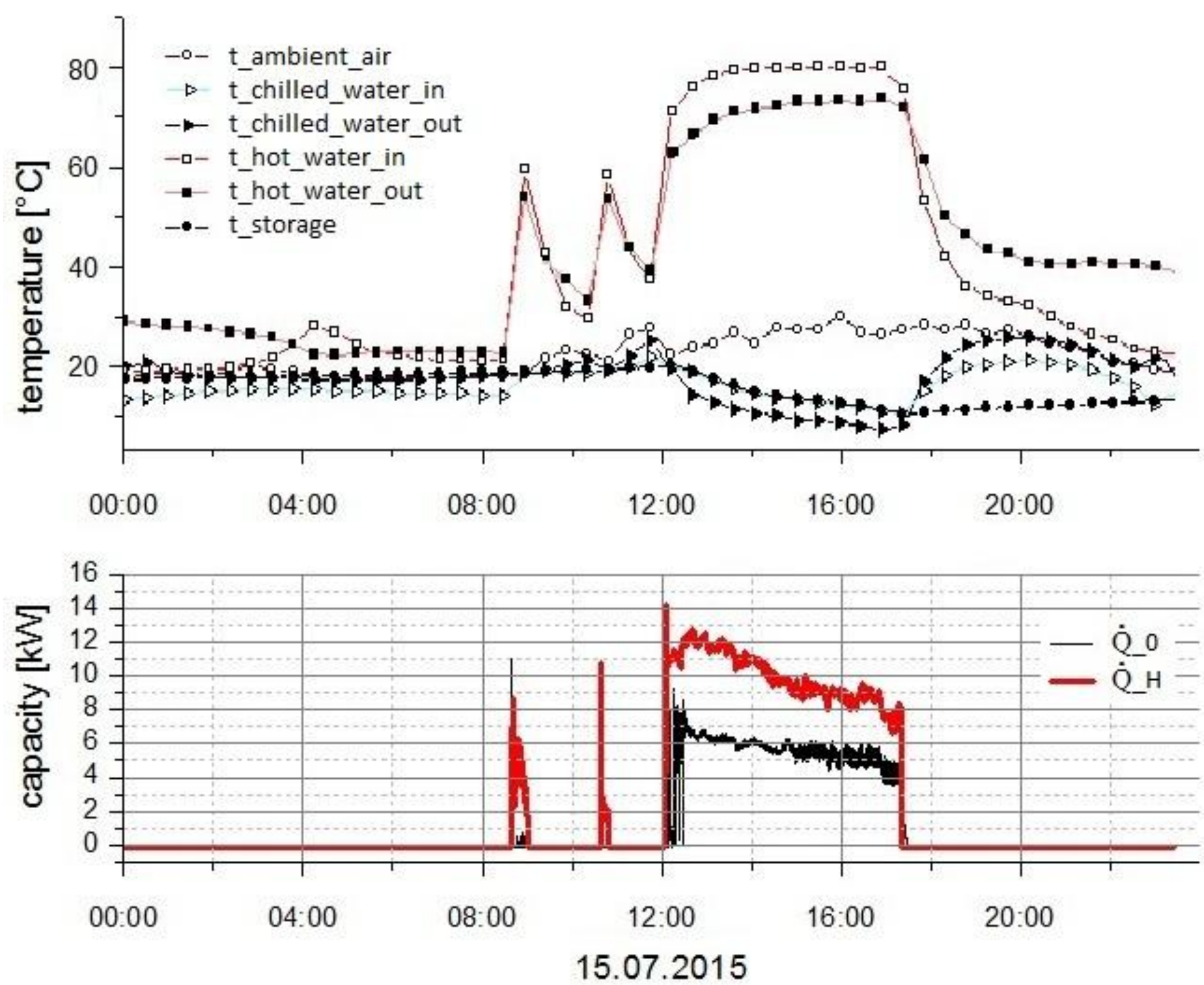
The enhanced chiller

Results: Performance in the test facility



At nominal conditions: 8,04 kW measured

Results: Exemplary load profile over a day



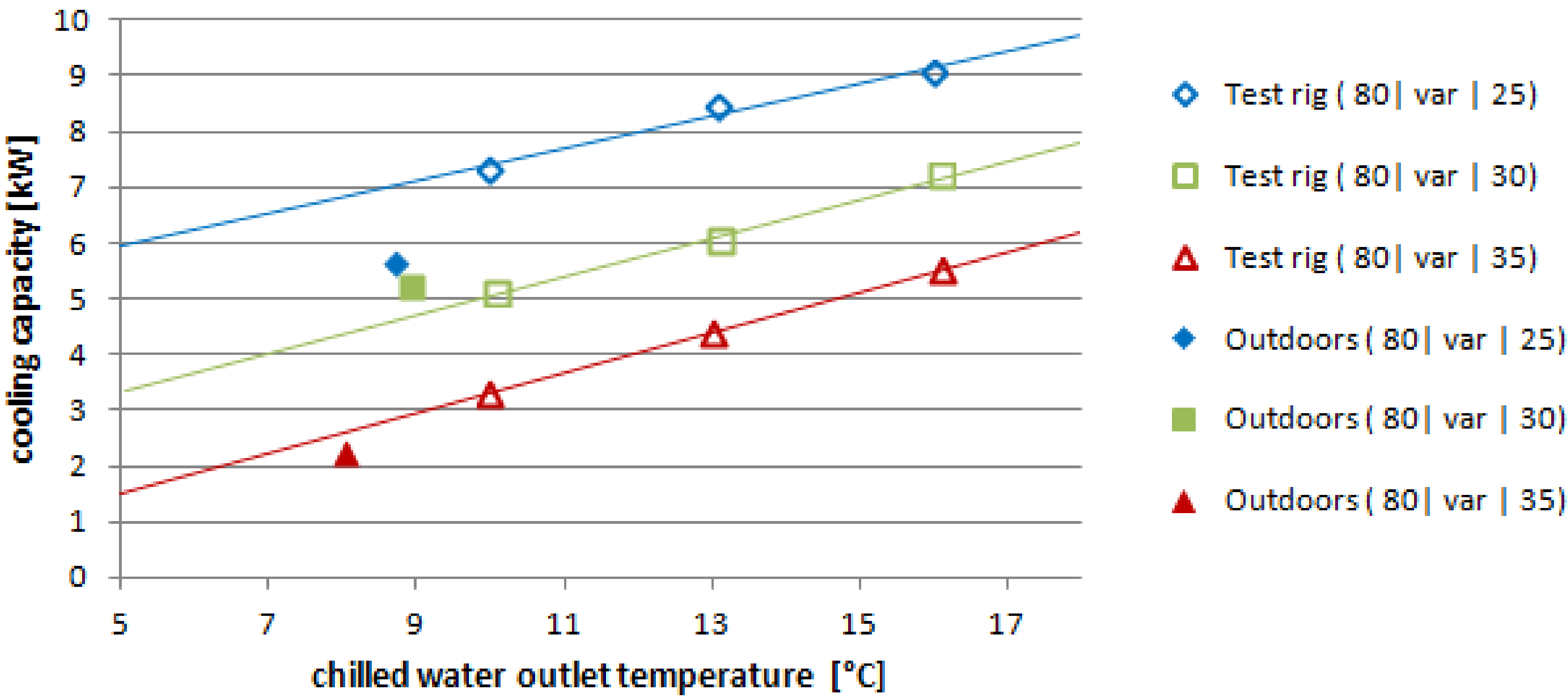
- $t_{\text{ambient air}} \leq 31$ °C
- before 12:00

  $t_{\text{hot water, in}} < 60$ °C

  and $\dot{Q}_0 < 2$ kW

  ⇨ shut down
- 5,5 h operation, providing cold for AC of offices
- $\dot{Q}_0$ from 8 to 4 kW, chilling water storage from 20 °C to 10 °C

Results: Influence of weather



- **Solar radiation and external flow rates affect performance**
- **Wind and rain can increase cooling capacity**

Results: Comparison with design conditions

Criteria	Design target	Reached so far
Cooling capacity	8 kW with inlet temperatures: 95 °C; 32 °C; 18 °C	8,04 kW with inlet temperatures: 95 °C; 32 °C; 18 °C
Thermal EER	0,71	0,73
Auxiliary energy demand at nominal conditions	0,50 kW 62,5 W_{el}/kW_0 EER_{el}: > 15	1,04 kW 129 W_{el}/kW_0 EER_{el}: > 7,5

- Cooling capacity and thermal efficiency as designed
- EER_{el} of 7.5 quite good for a low capacity chiller but below expectations
- Axial fan is by far the biggest power consumer Several improvements identified (e.g. speed control of the fan)
- In field test EER_{el} of 15 at $\dot{Q}_0$ = 7 kW with 78 °C hot water inlet / 21 °C ambient / 8 °C chilled water outlet

Further results

Varying ambient temperatures

- **Challenging speed control of the fan**
  good EER_{el}-values ⇔ required cooling capacity
- **Air-cooled chiller generates cooling immediately after start in the morning**
  ⇨ LiBr-solution is cooled by low night-time ambient temperatures and absorption process starts promptly when solution is distributed in the absorber even without operation of the fan.

Summary and outlook

- A directly air-cooled water/LiBr-absorption chiller with a nominal capacity of 8 kW was developed
- Successful and stable operation stable as well in lab as in field under variable ambient conditions
- Electrical EER-values of up to 15 have been achieved
- Decrease of air side pressure drop
  ⇨ optimization of air flow (e.g. flow grids and baffles)
  ⇨ further reduction of the electrical power demand
- More data and optimisation for part load conditions is needed

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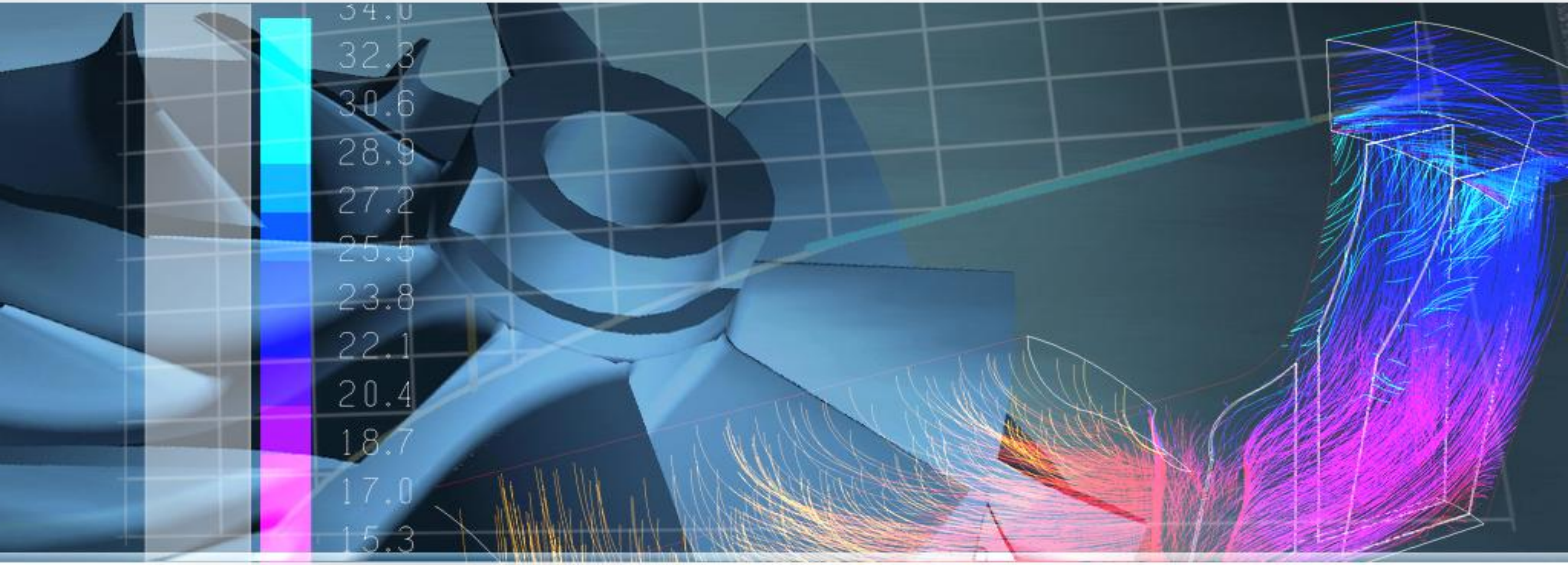

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Thanks for your attention!

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