Thermal-driven cooling plants

Fraunhofer UMSICHT

C. Pollerberg

IUSE
Fraunhofer Institut
Umwelt-, Sicherheits-,
Energietechnik UMSICHT

Motivation to use thermal cooling

Cooling power produced environmental friendly by a heat source.

- Combined Cold, Heat and Power generation (CCHP)
- Utilisation of “waste heat”
- Realisation of solar cooling

Cold power supply without supplementary electrical load for the existing power grid.

- Relieve power load of the power grid
- Alternative where the possible power load of the grid is limited

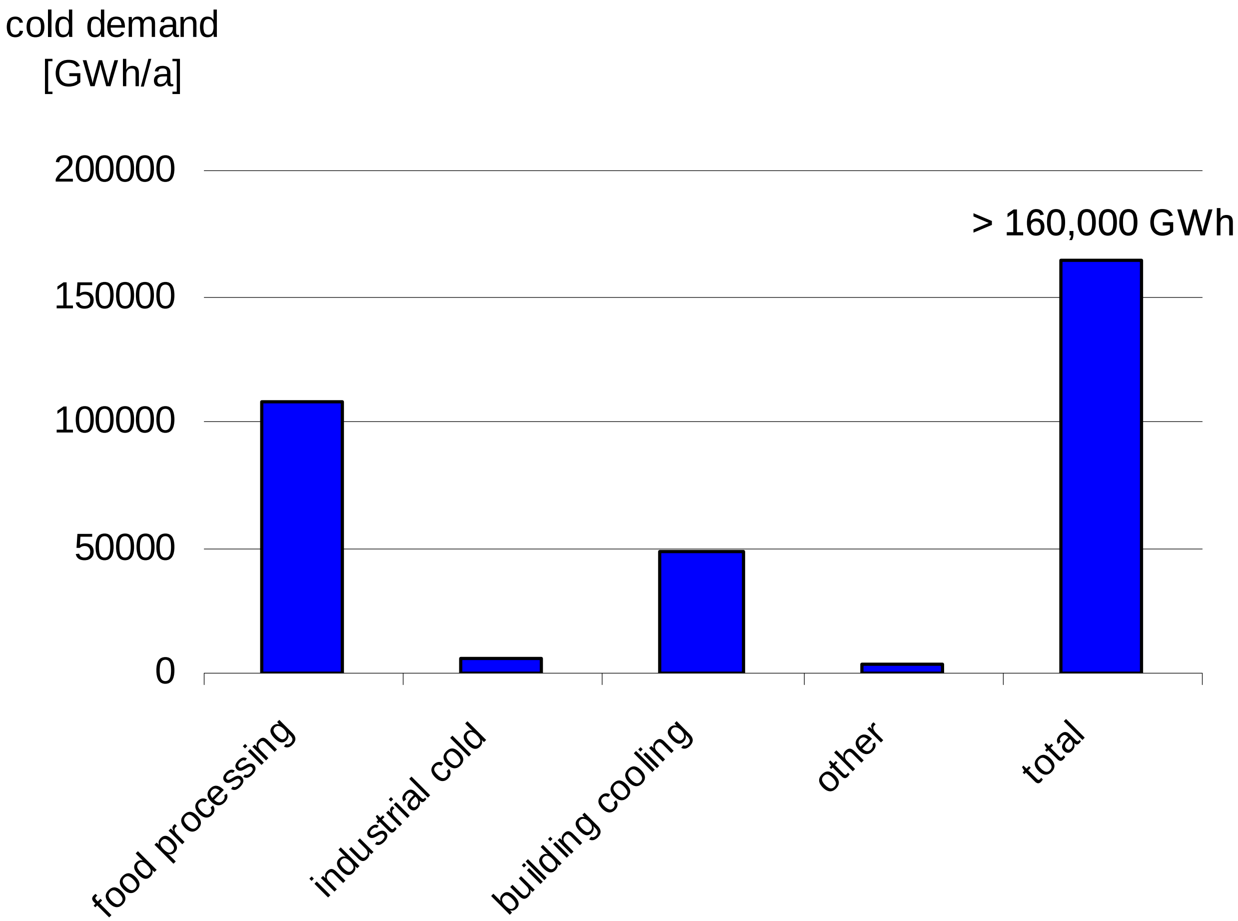
Cold demand in Germany

Energy demand for cold generation in Germany:

12 % of the electricity consumption à 66,000 GWh_{el}/a

5.9 % of the primary energy consumption à 230,000 GWh/a

Demand of building cooling is increasing due to higher living standard, transparent architecture, more electrical devices,… etc..



Source: DKV-Statusbericht Nr. 22, 2002

Heat sources in Germany

The total usable heat power potential in Germany is estimated with 85 GW_{th}*:

- 6.7 GW_{th} industrial “waste heat”,
- about 1.2 GW_{th} heat from Combined Heat and Power (CHP) plants,
- 63 GW_{th} geothermal heat (drilling depth 1,500 to 3,000 m) and
- 14 GW_{th} solar thermal heat.

* source: FhI UMSICHT. Potential für Strom aus Abwärme. market study for . Aqua Society, Inc., Herten in Germany

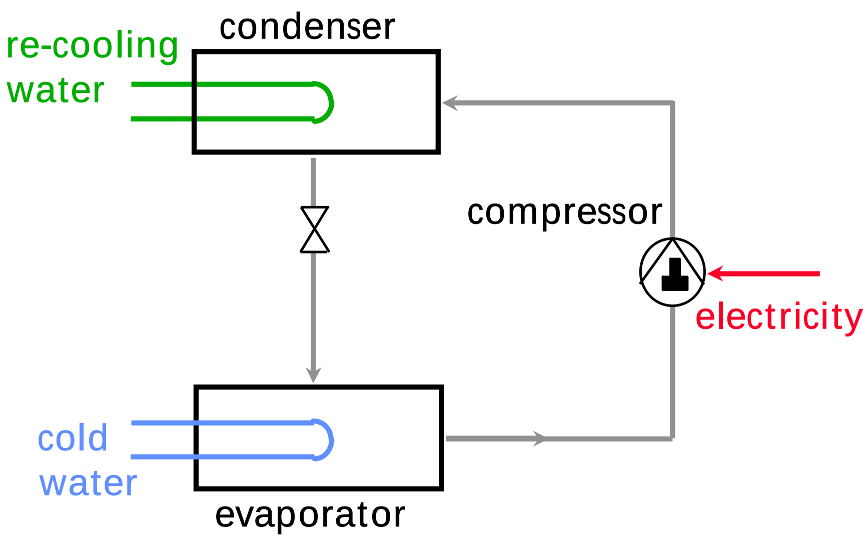
Process of thermal cooling

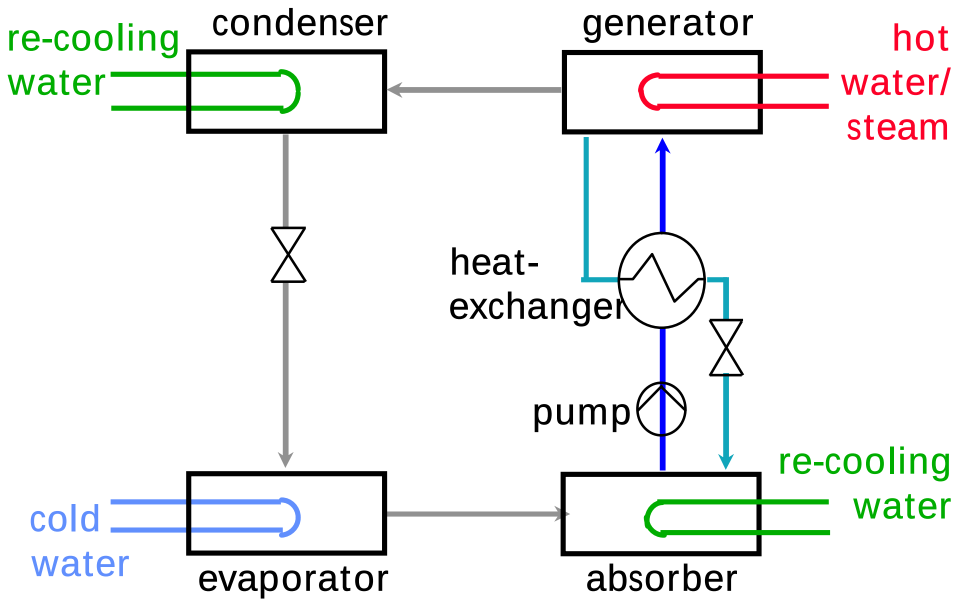
Compression Chiller

conventional technology,
COP: 2-5 (depends on chiller type)
refrigerant: CFCs, FCs, CO_2, NH_3

Absorption Chiller

$LiBr/H_2O$ (SE), COP: 0.55-0.75, T_{heat}: 70-130 °C
$LiBr/H_2O$ (DE), COP: 1-1.3, T_{heat}: 135-180 °C
H_2O/NH_3, COP: 0.4-0.6, T_{cold}: < 0 °C

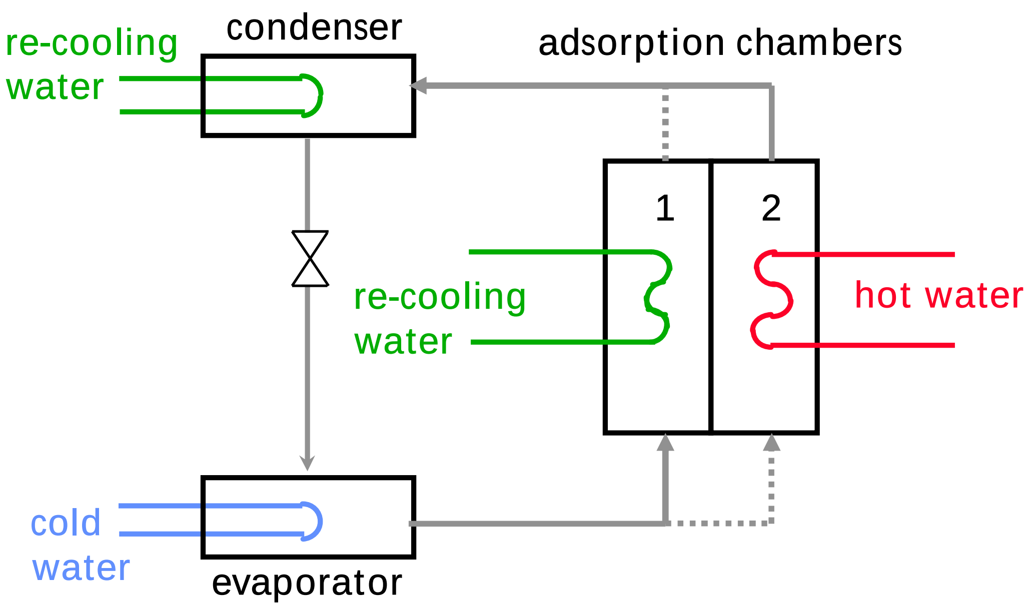




Process of thermal cooling

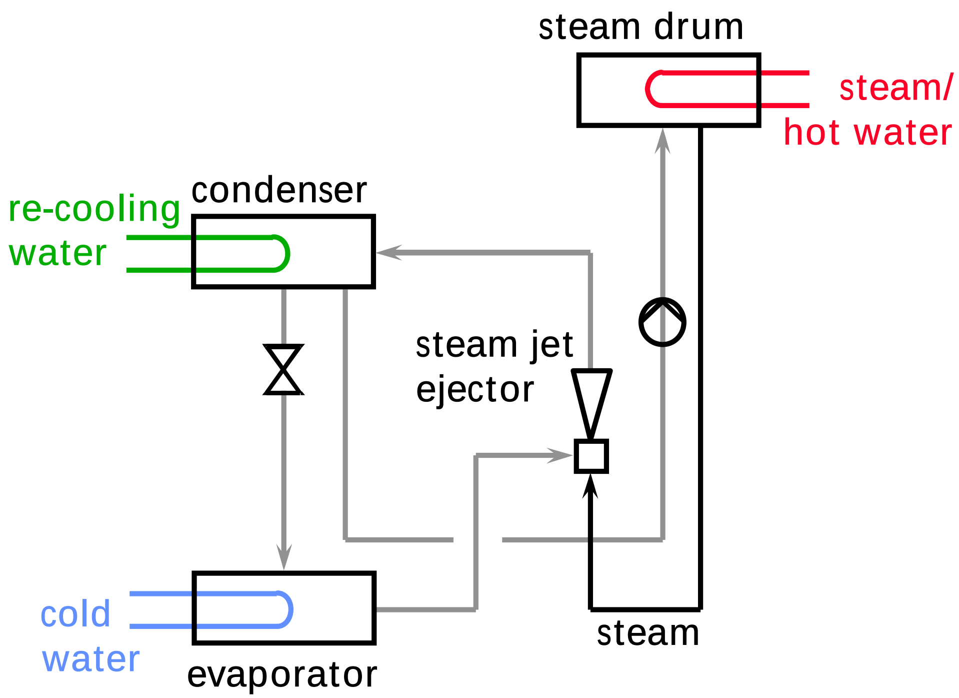
Adsorption Chiller

COP: 0.4-0.65, T_{heat}: 55-95 °C
refrigerants: water
not a continuously operating system



Steam Jet Ejector Chiller

COP: 0.3-0.7, T_{heat}: 100-200 °C
water as refrigerant and motive steam
high COP > 1 in part load

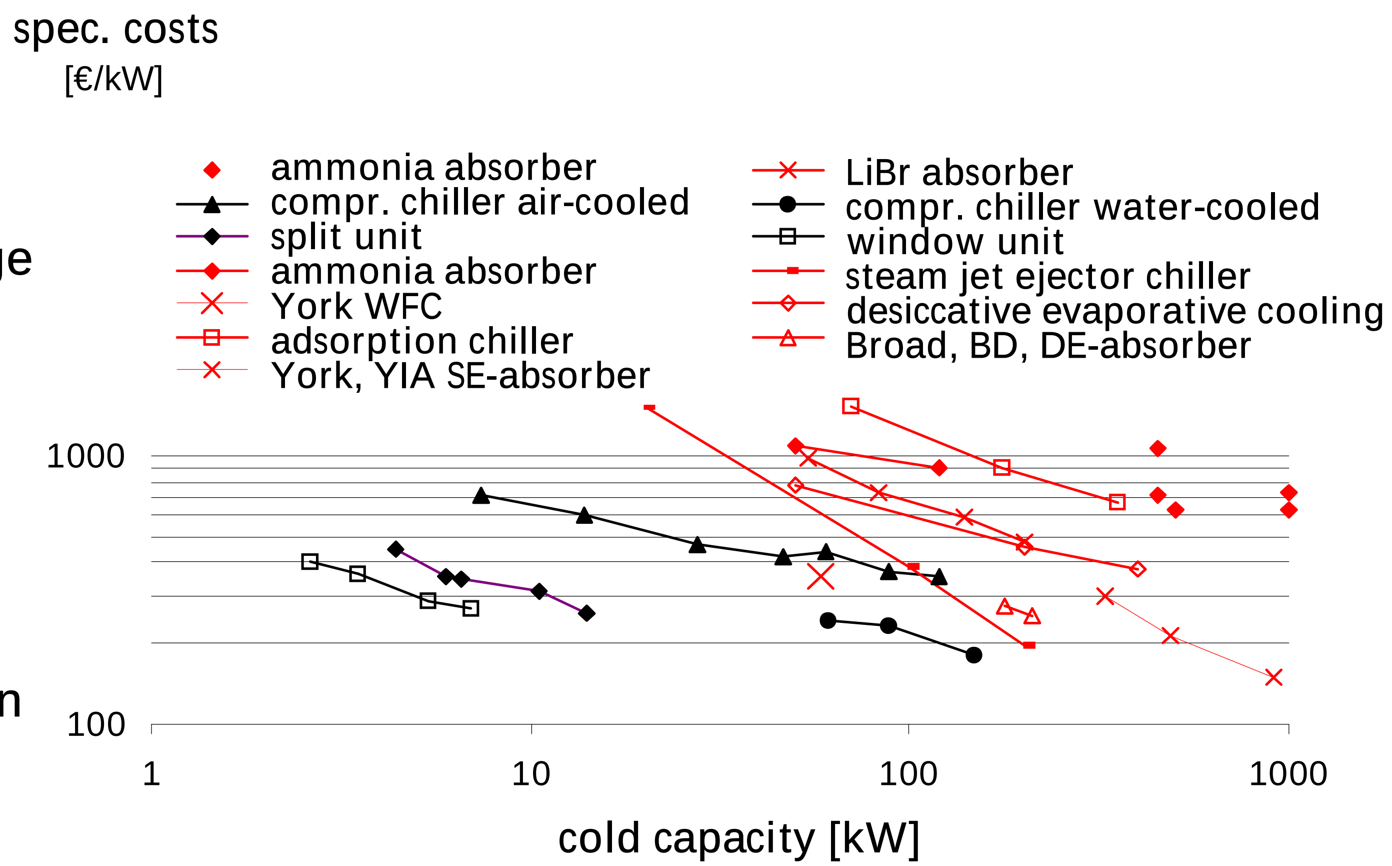


Investment Costs

Thermally driven chillers have higher investment costs than electrically driven chillers.

In the small cold capacity range (<100 kW_{th}), investment costs rise up over 1,000 €/kW_{th}.

- à Higher investment costs must be compensated by lower operating costs.
- à Needed cold capacity divided on thermally driven chiller (base load) and electrically driven chiller (peak load).

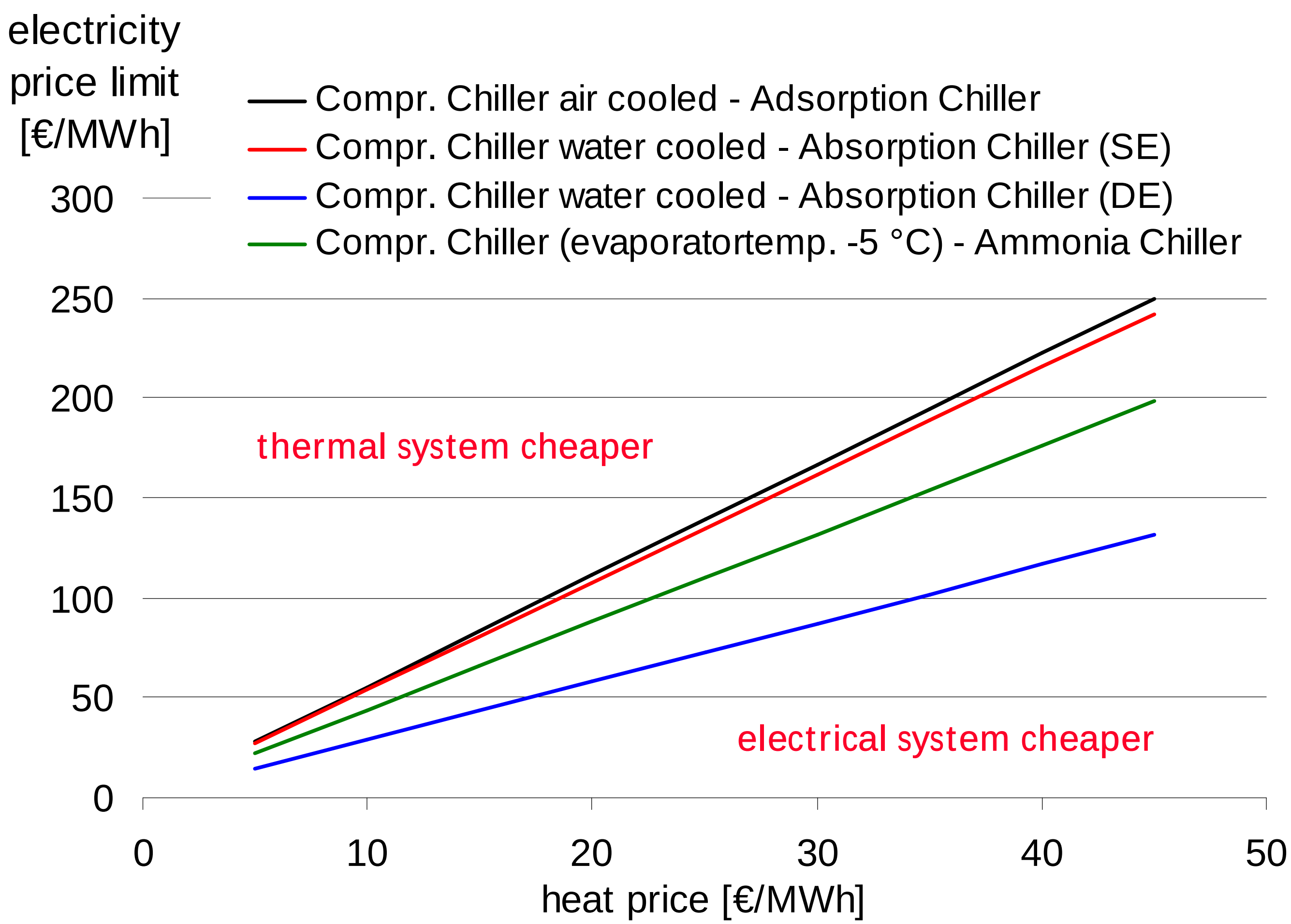


Operation Costs

Important for the decision to use a thermal chiller is the relation of electricity price to heat price.

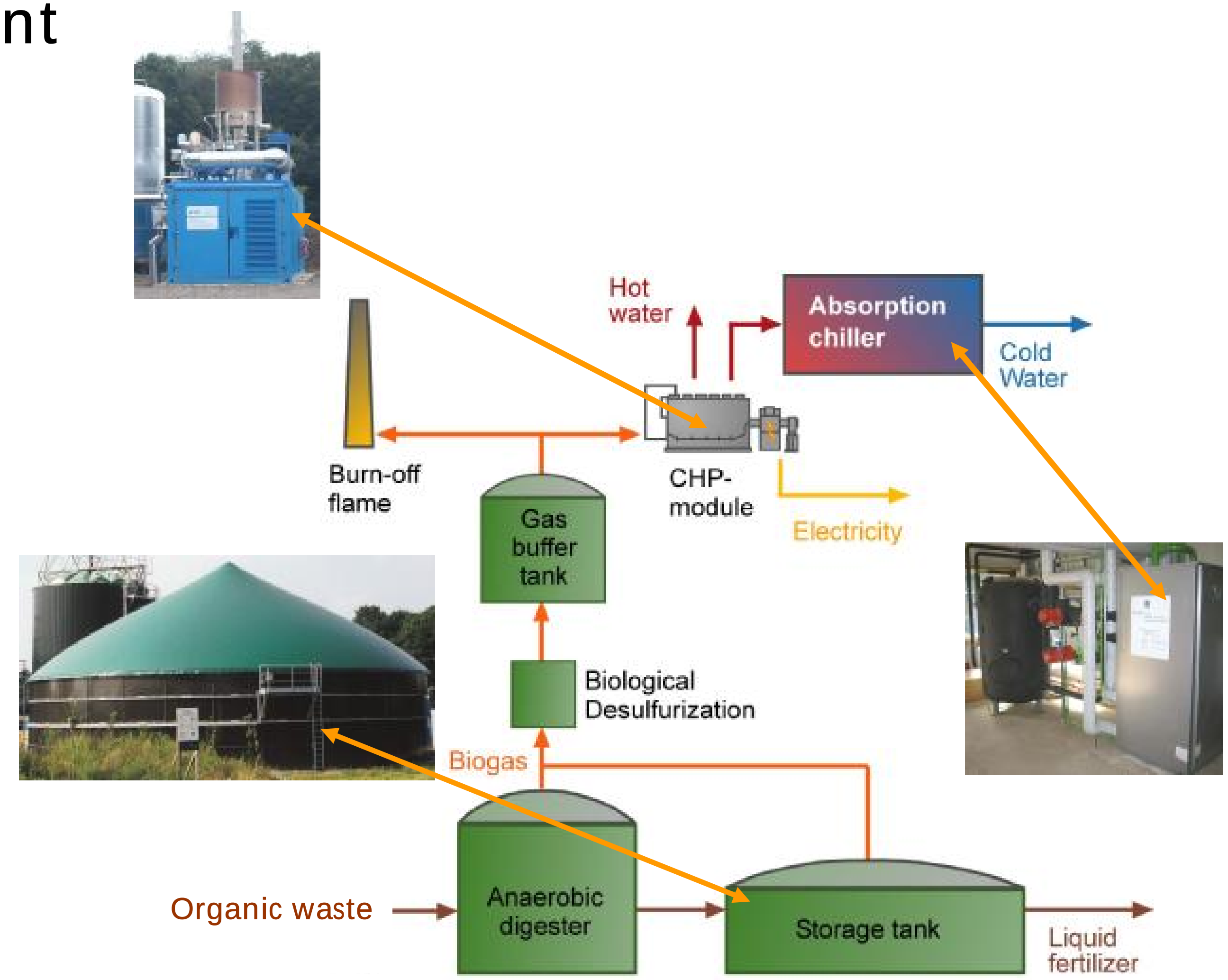
There is lower electricity price limit, when thermal systems are cheaper than electrical systems.

Considering the higher investment costs of the thermal chillers, the electricity price must still be higher!



Example: CCHP Biogas Plant

- Biogas plant Dorsten-Lembeck, Germany
- Container sized CHP-module:
  $P_{el} = 250\ kW_{el}$ à 2000 MWh_{el}/a
  $Q_{th} = 370\ kW_{th}$ à 2960 MWh_{th}/a
- driving heat provided by the CHP-module with 90°C to 95°C
  à cold water with 10 °C
- LiBr/water-absorption chiller (SE), manufacturer Yazaki, type WFC-10:
  $Q_0 = 55\ kW_{th}$ à 400 MWh_{th}/a



Obstacles of Implementation

- There is often a big distance between the heat source and the cold consumer (biogas plants in rural areas).
- Economical conditions are not given to operate the thermal chiller with profit ("waste heat" not really for free and electricity too cheap).
- Availability of small thermally driven chillers (cold power < 150 kW_{th})
- Operation effort of thermally driven chillers is higher than of compression chillers (often open re-cooling towers).

Summary

- There is a big cold demand of more than 160,000 GWh/a in Germany. At the same time, there is also a heat source potential of 85 GW_{th}, which could be used.
- Different thermally driven chiller types are available – Operational conditions are important for the chiller choice.
- The investment costs of the thermally driven chillers are higher than of compression chillers. Relation of the electricity price to the heat price is important.

Thank you very much for your attention!!!

C. Pollerberg

Fraunhofer Institute for Environmental,
Safety and Energy Technology UMSICHT

Osterfelder Straße 3

46047 Oberhausen, Germany

Tel.: +49 (0) 208/85 98-14 18

Fax: +49 (0) 208/85 98-12 90
E-mail: clemens.pollerberg@umsicht.fraunhofer.de