



# Tri-generation concepts

31.01.2020, Workshop

## Tri-generation concepts: A lab-facility for combined heat, power and cooling generation

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## Outline

- Introduction/Overview on Demand
- Combined cooling heating power systems
- Lab-facility at HS-Koblenz

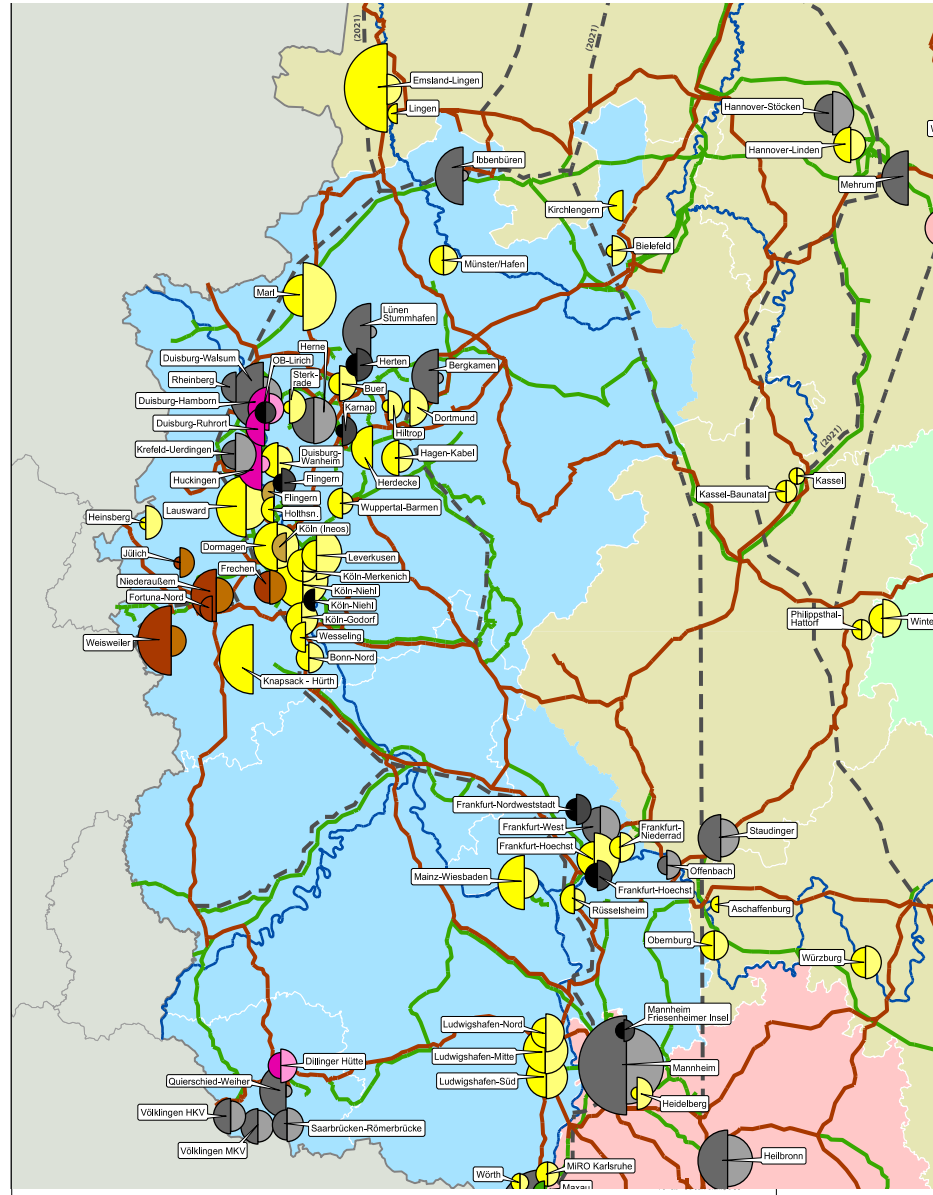


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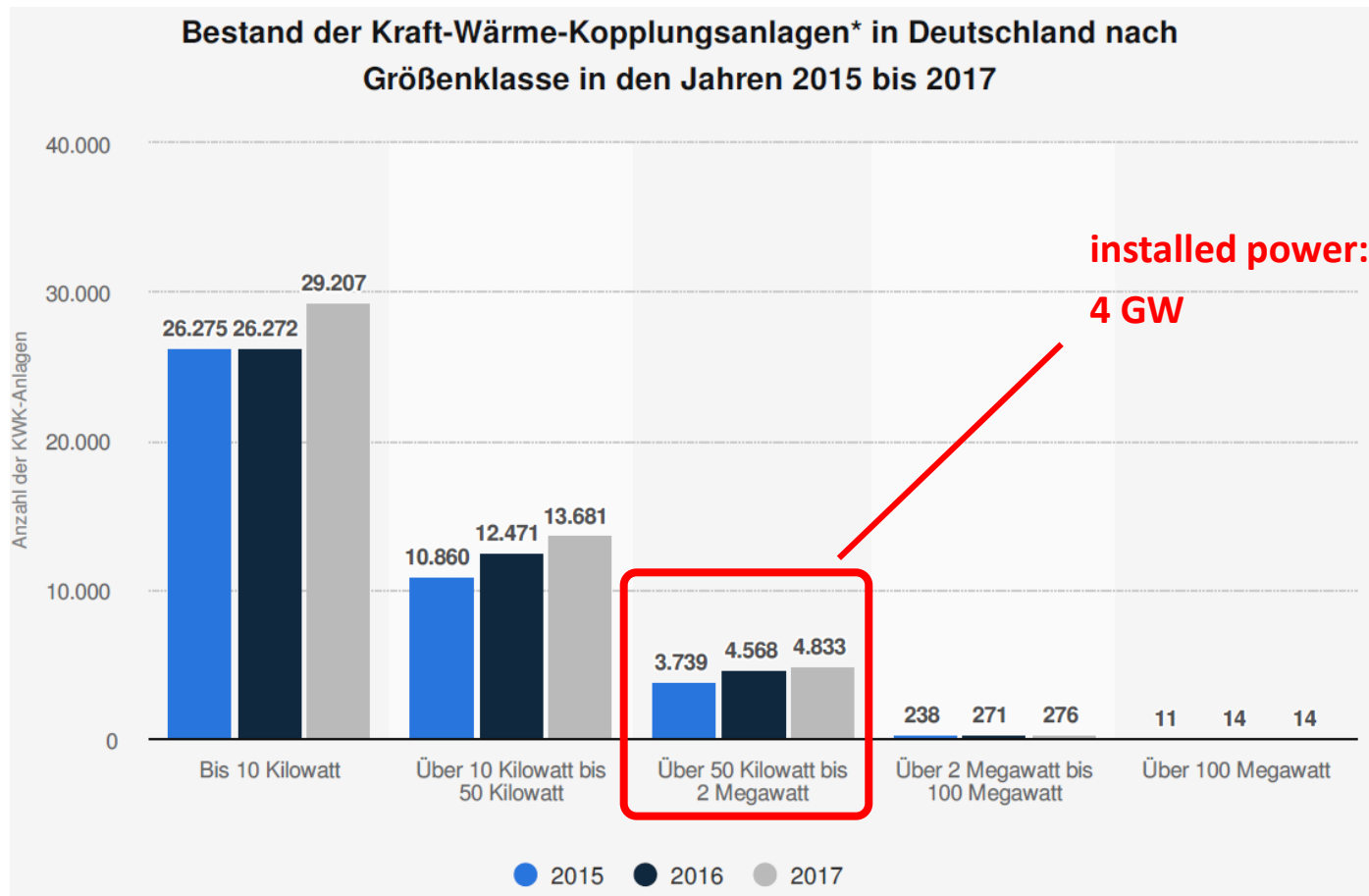
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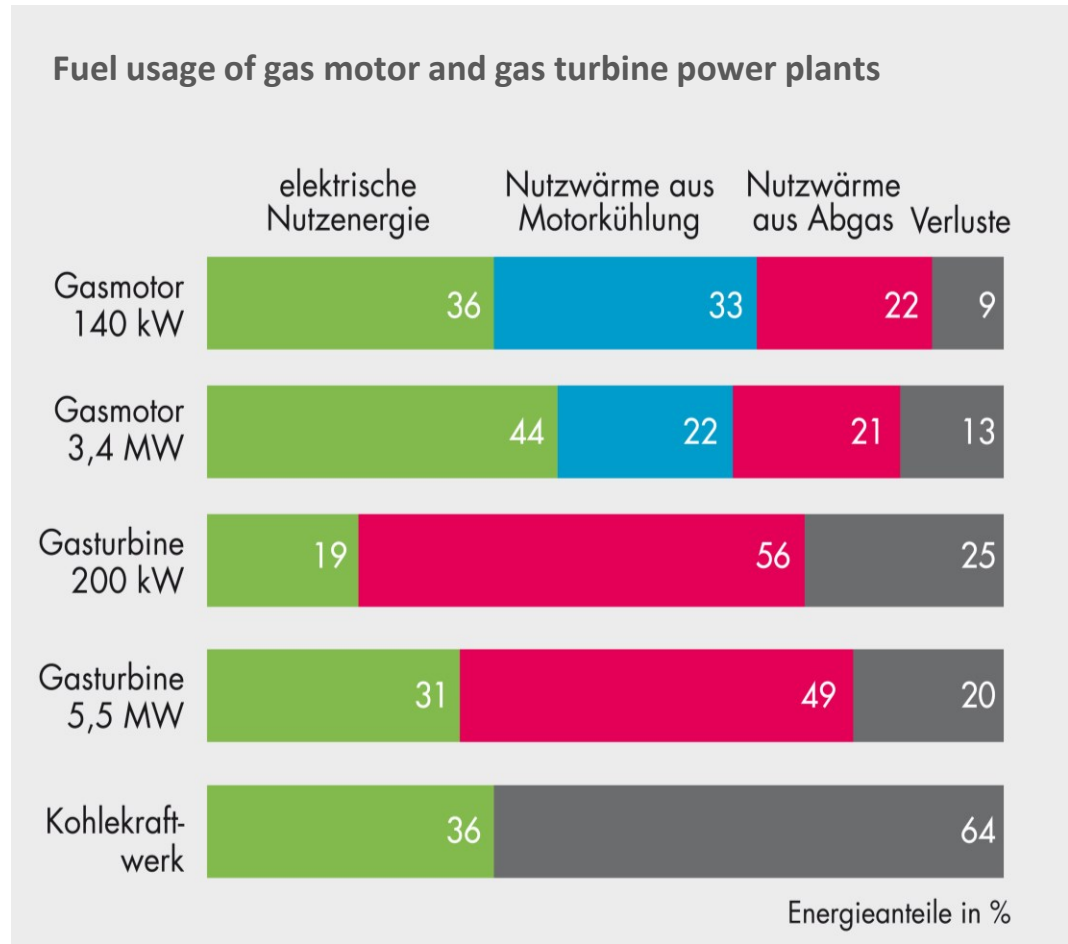
## CHP-Plants > 50 MW in Germany in 2019



## Quantity of existing CHP-Plants in different size categories Germany 2015 - 2017

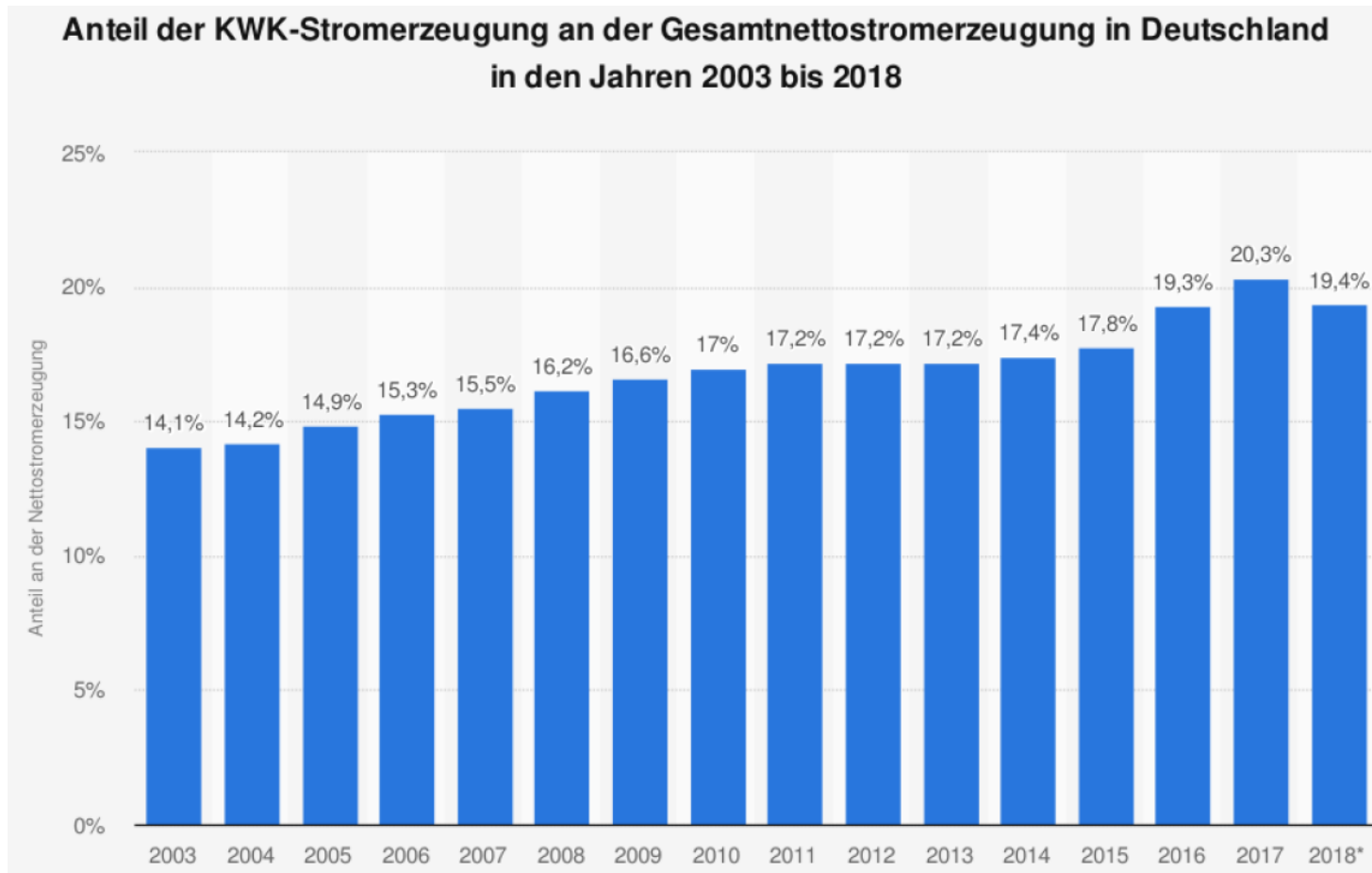


## Comparison of efficiencies depending on power range



[www.asue.de]

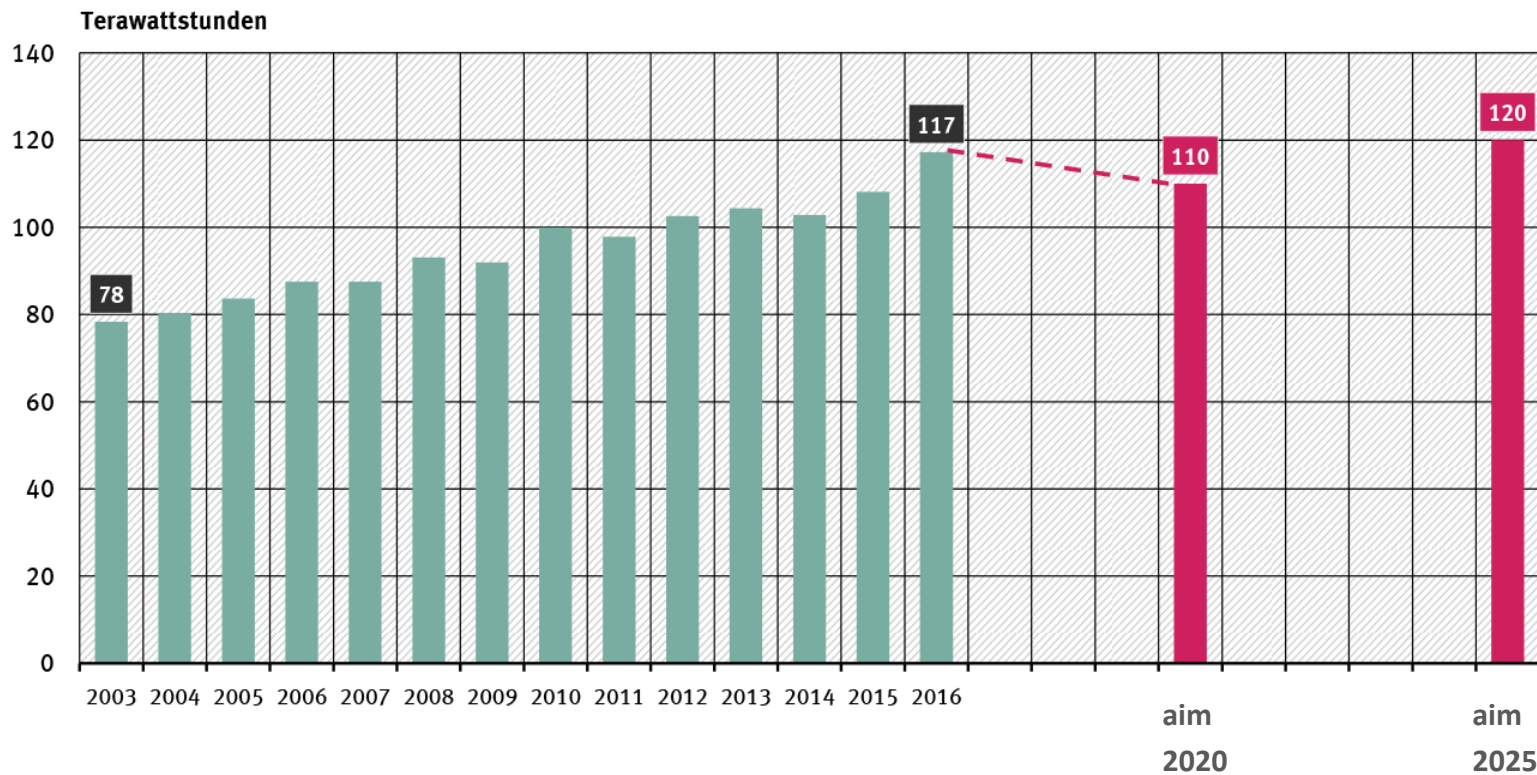
## Share of power generation by CHP in Germany 2003 to 2018



## Power generation by CHP in Germany 2003 to 2018

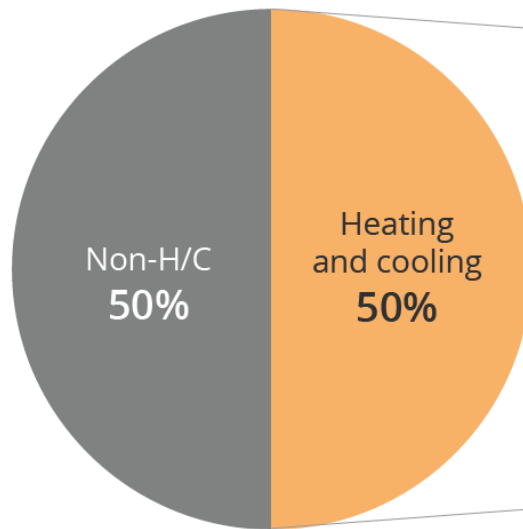
### Nettostromerzeugung mit Kraft-Wärme-Kopplung (KWK)

Vergleich der Entwicklung der KWK-Nettostromerzeugung mit den Zielen der Bundesregierung\*

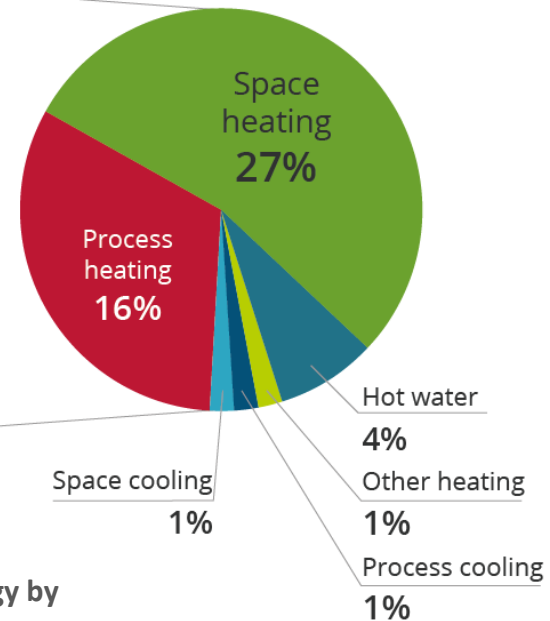


[Statistisches Bundesamt; Ökoinstitut, Umweltbundesamt 11/2017]

## Energy usage EUROPE



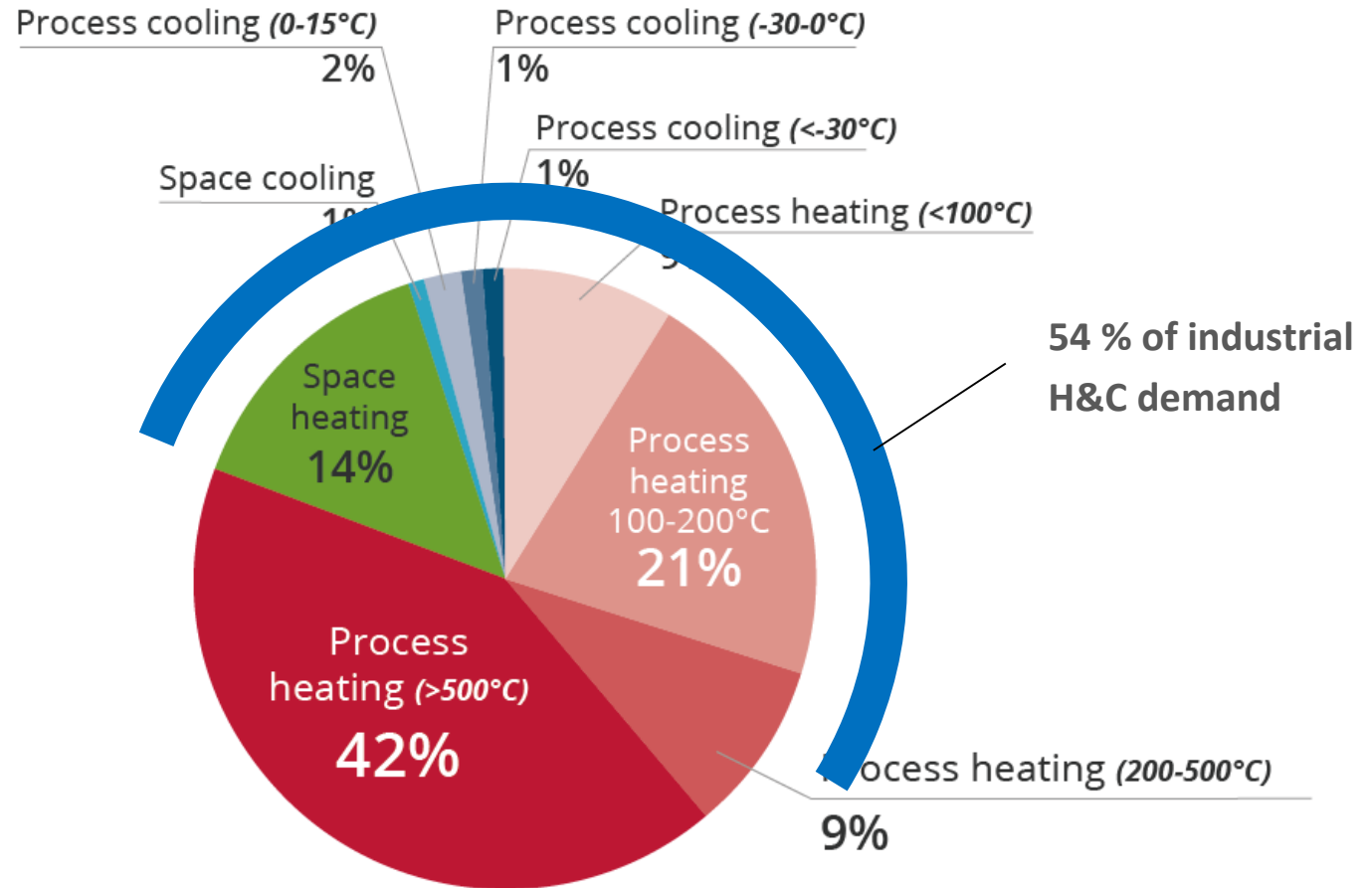
Total final energy in 2015 (EU28)



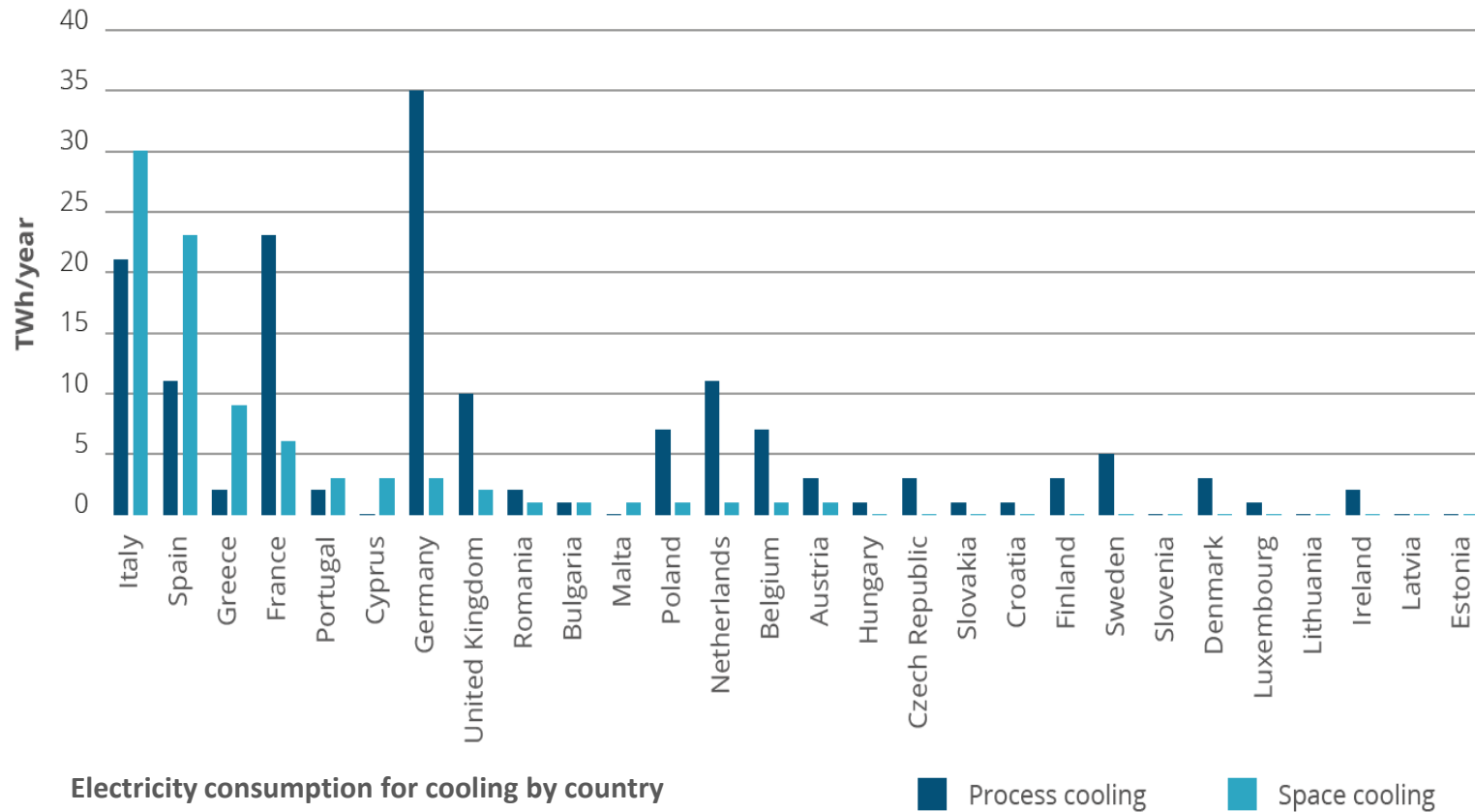
H&C final energy by end-use in 2015 (EU28)



## Zoom into the *industrial* sector

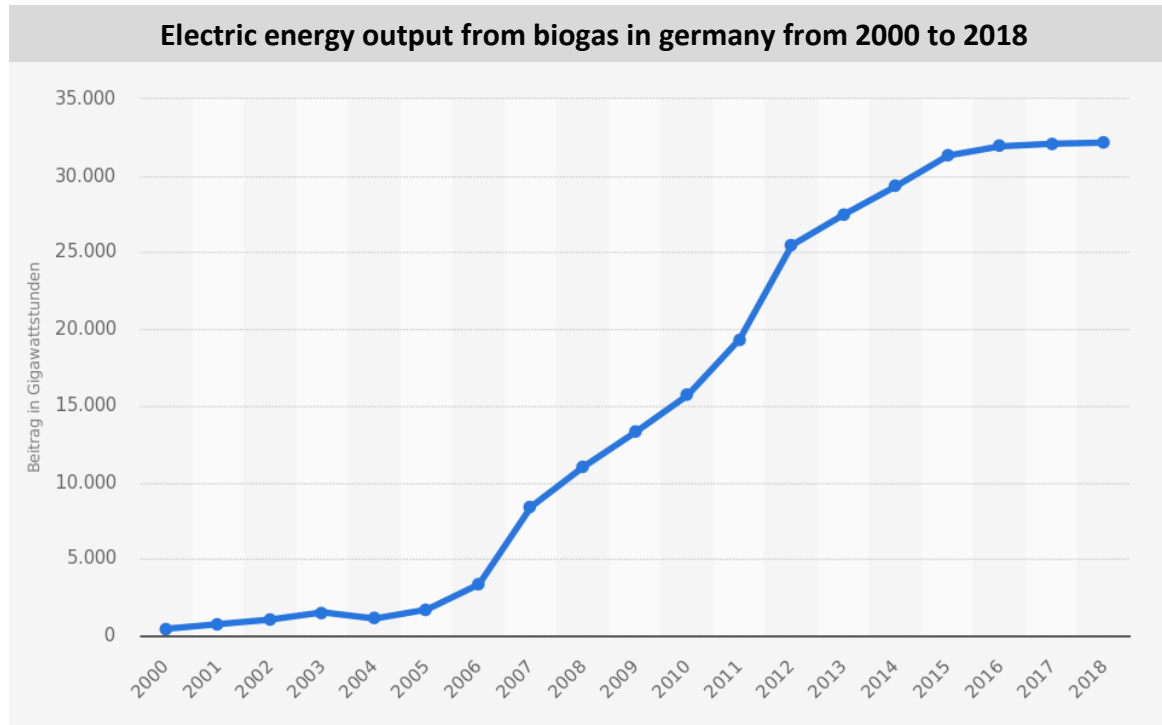


## Consumption for cooling by countries in EUROPE





## Non natural gas usage / germany



landfill, sewage and mine gas:           => 394,2 MW (0,182 % of installed power in Germany)

but biogas production is different:

production in 2018 represents 5,9 % of the overall production of electricity or  
30,5 % of the share of CHP-Power Plants

[AGEE-Stat, Statista 2019]



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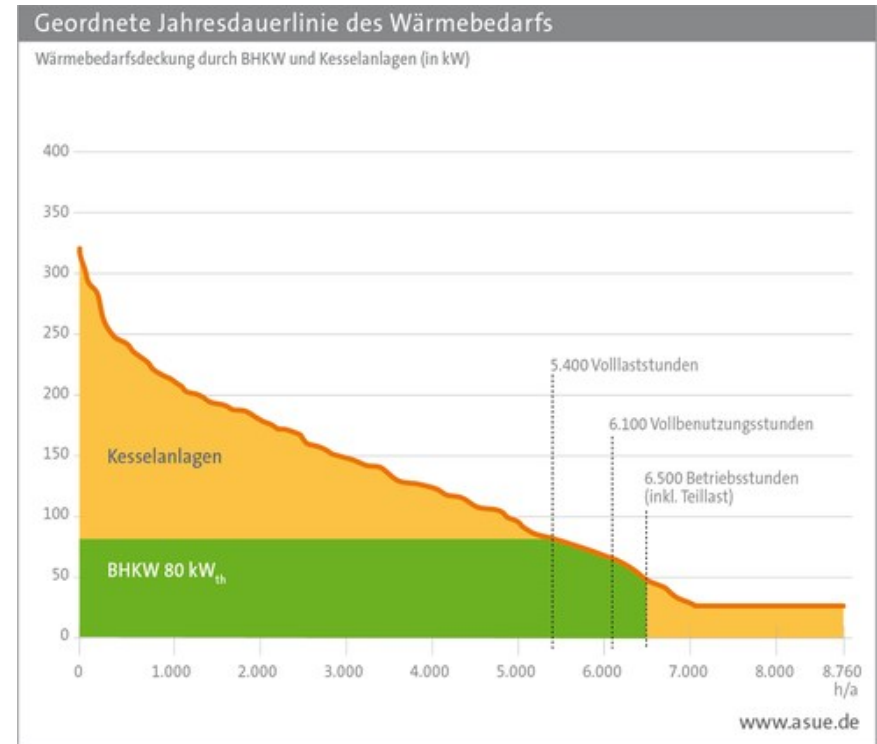
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## Main Applications of natural Gas Engines:

- base load, medium load and peak load power plants
- green house
- emergency power systems

## Standard Design Criteria:

- full load working hours > 4500 h resulting from a duration curve
- Power range of engines 50% up to full load
- Launching requirements
- Suitable for low voltage 400 V up to 10 kV or 30 kV
- Exhaust gas limitation depending on application



[AGEE-Stat, Statista 2019]

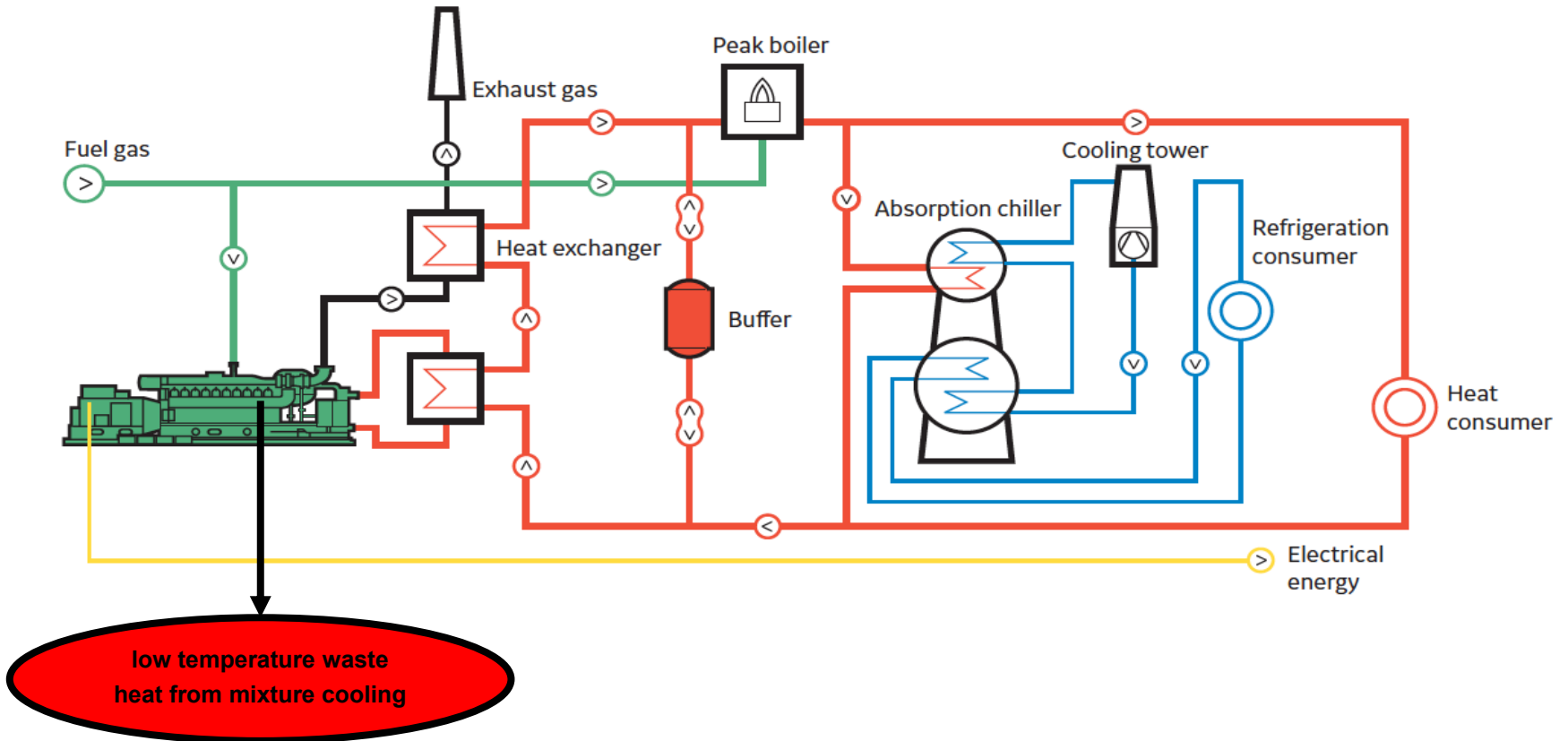


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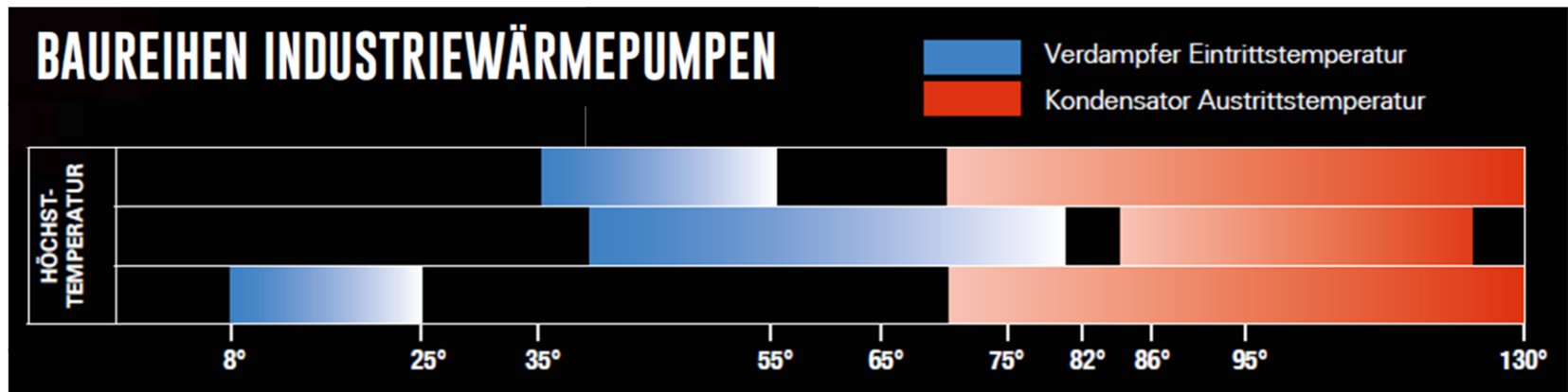
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## Combined Cooling Heating Power Systems/Plants



## High temperature heat pumps – possible applications

- heat recovery from exhaust gas and mixture cooling
- increase district heating, district boost
- primary control power, PtH



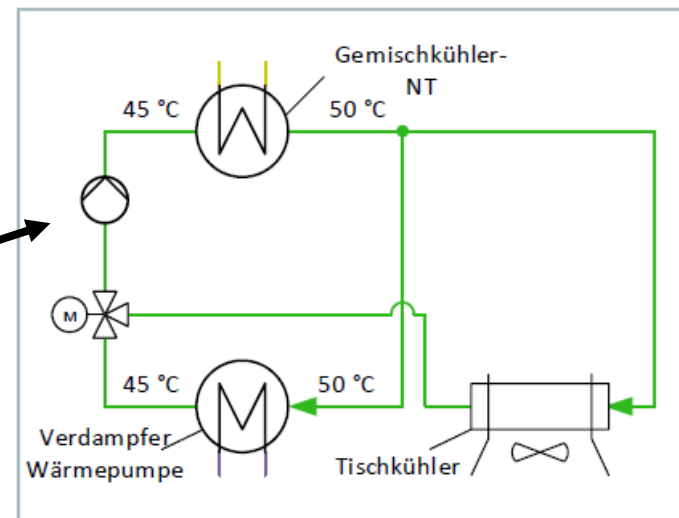
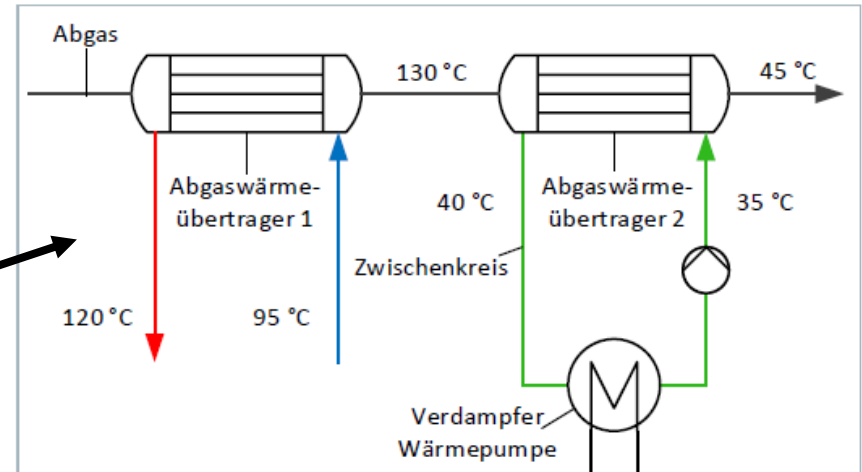
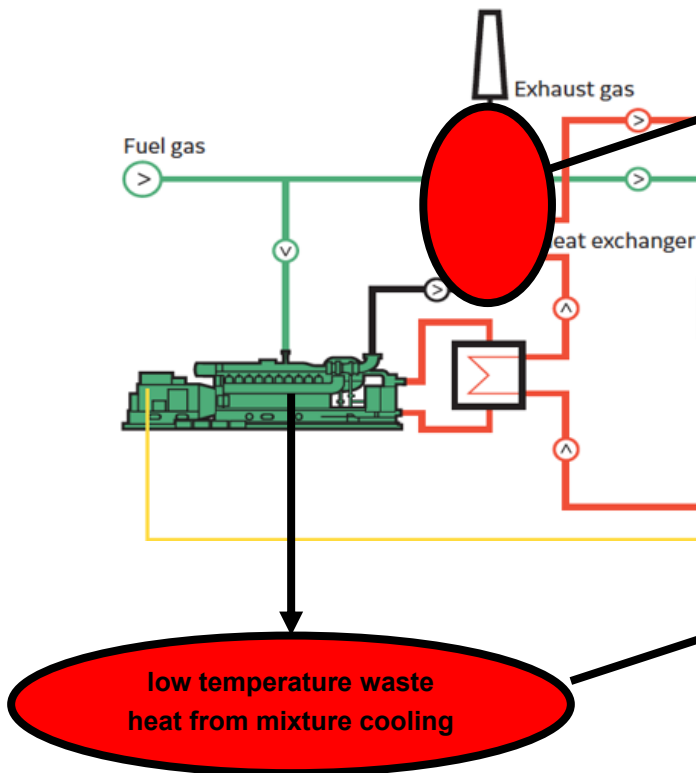
[Prospekt – Industrierärmepumpen; Ochsner Energietechnik, 2020]

## High temperature heat pumps – integration in CHP

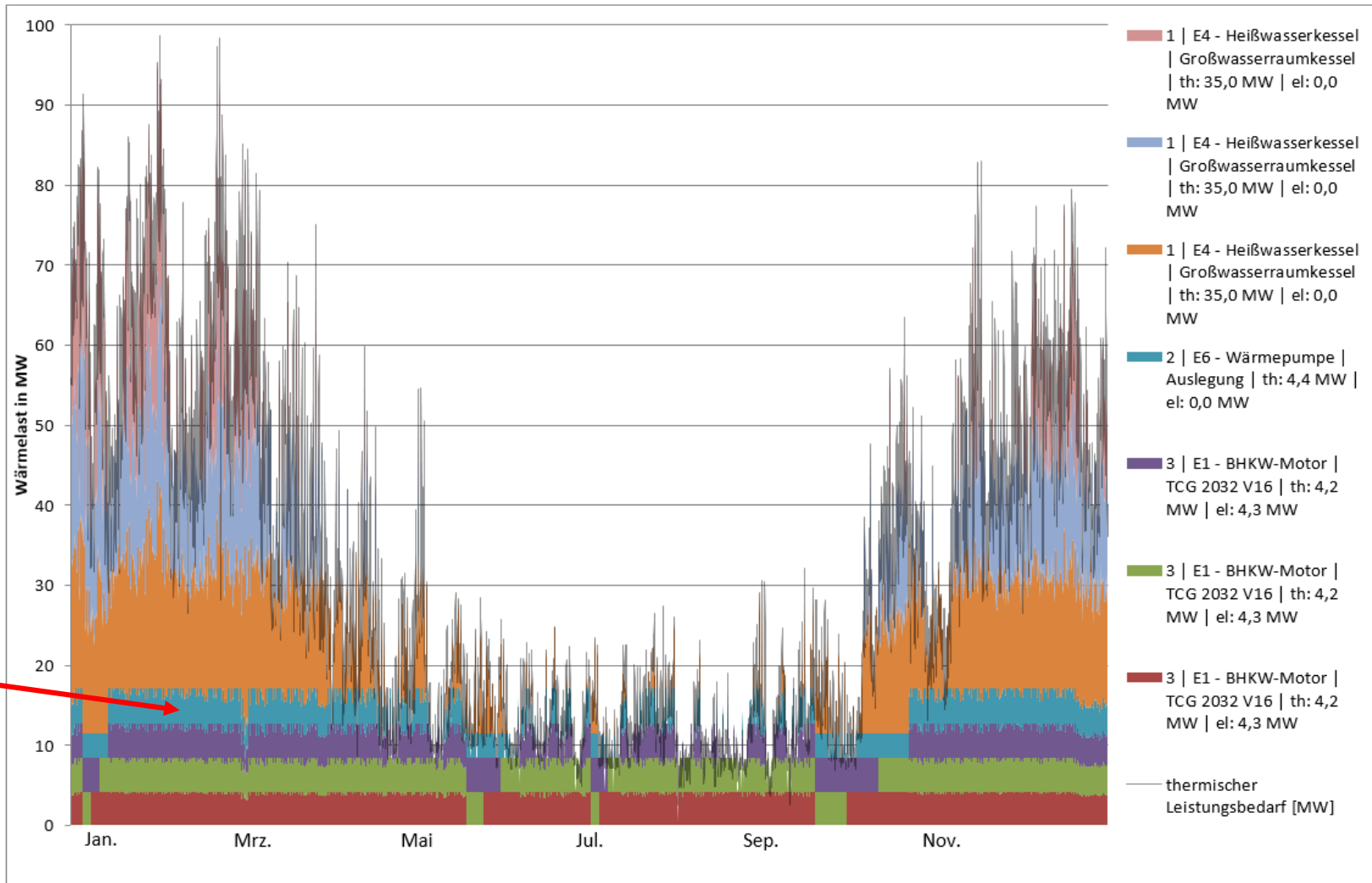
Additional  $P_{th}$  from waste heat:

Exhaust gas: 6%

Mixture cooler: 3-4 %



## Load simulation with a HT-heatpump





## List of components of all project partners

- 2x heat pumps (one reversible)
- 3x adsorption chiller
- 3x CHP (e.g. stirling engine)
- 1x solar heating system
- several heat and cold storages and more ...



## Lab-facility at HS-Koblenz



pipes to dry  
cooler (outside)

cold water  
storage (1 m<sup>3</sup>)

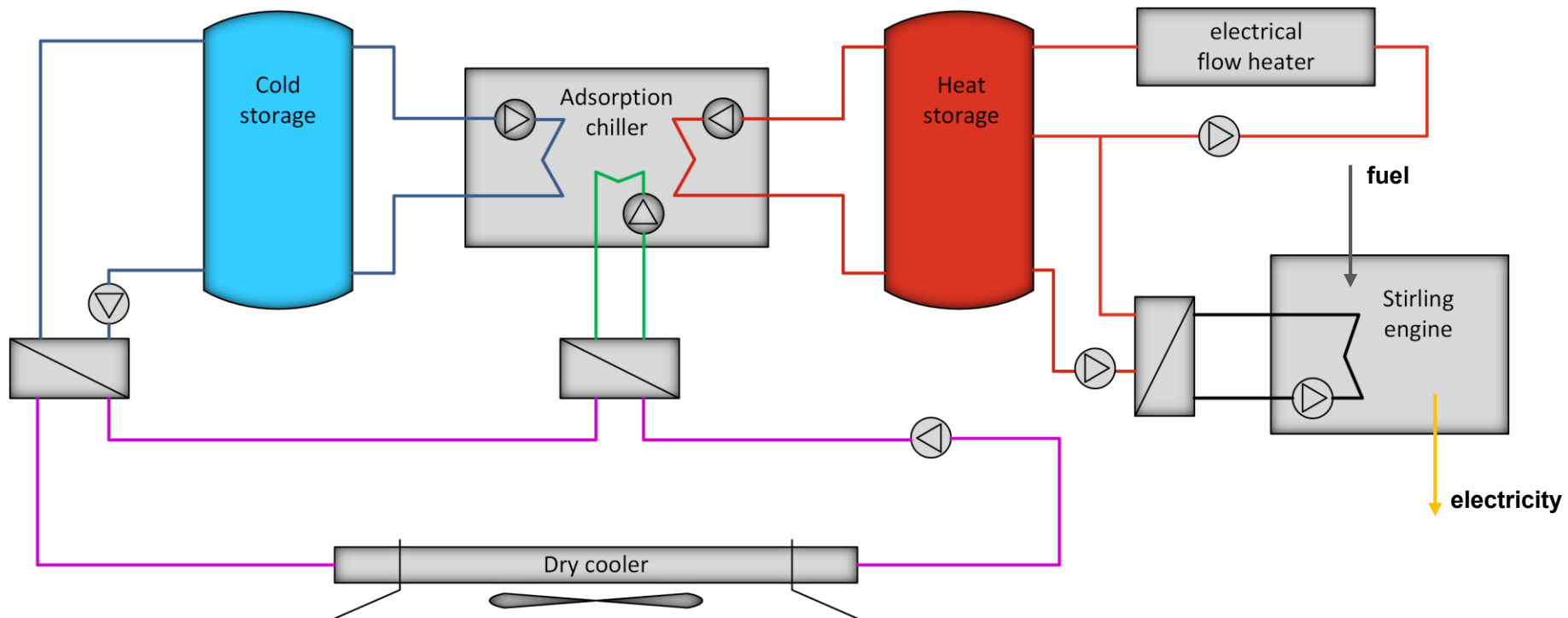
adsorption chiller  
(10 kWth)

stirling engine  
(CHP, 0.8 kWel,  
7 kWth)

hot water  
storage (1 m<sup>3</sup>)

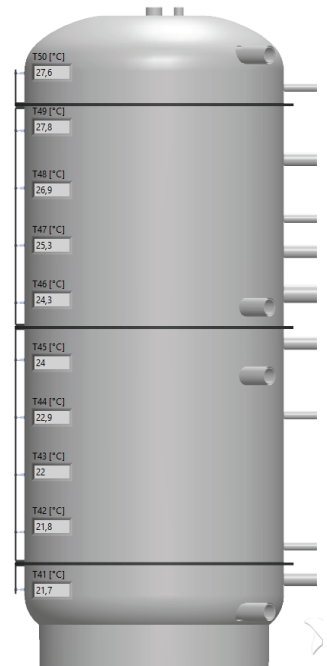
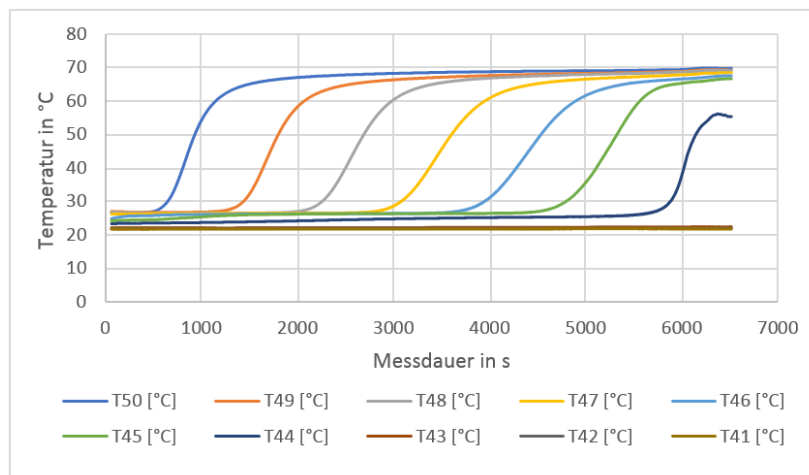
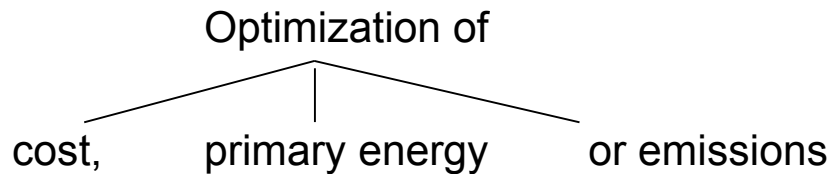
## Lab-facility at HS-Koblenz

### Vereinfachtes Fließschema des Labors



## Examination aims

- optimal design of storage size
- part load behaviour and control of pumps, temperature levels of heat exchangers



# Thank you for your attention!



Dépasser les frontières :  
projet après projet  
Der Oberrhein wächst zusammen,  
mit jedem Projekt



Fonds européen de développement  
régional (FEDER)  
Europäischer Fonds für regionale  
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Baden-Württemberg  
MINISTERIUM FÜR WISSENSCHAFT, FORSCHUNG UND KUNST



Rheinland-Pfalz  
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