LowTEMP

Power-to-Heat & Power-to-Gas in District Heating systems

Potentials, sector coupling and an important component of the heat transformation

Interreg Baltic Sea Region
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

LowTEMP training package - OVERVIEW

Introduction

- Intro Climate Protection Policy and Goals
- Intro Energy Supply Systems and LTDH
- Energy Supply Systems in Baltic Sea Region

Energy Strategies and Pilot Projects

- Methodology of Development of Energy Strategies
- Pilot Energy Strategies – Aims and Conditions
- Pilot Energy Strategy – Examples
- Pilot Testing Measures
- CO_2 emission calculation
- LCA calculation

Financial Aspects

- Life cycle costs of LTDH projects
- Economic efficiency and funding gaps
- Contracting and payment models
- Business models and innovative funding structures

Technical Aspects

- Pipe Systems
- Combined heat and power (CHP)
- Large Scale Solar Thermal
- Waste & Surplus Heat
- Large Scale Heat Pumps

Power-2-Heat and Power-2-X

- Thermal, Solar Ice and PCM Storages
- Heat Pump Systems
- LT and Floor heating
- Tap water production
- Ventilation Systems

Best Practice

- Best Practice I
- Best Practice II

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Content

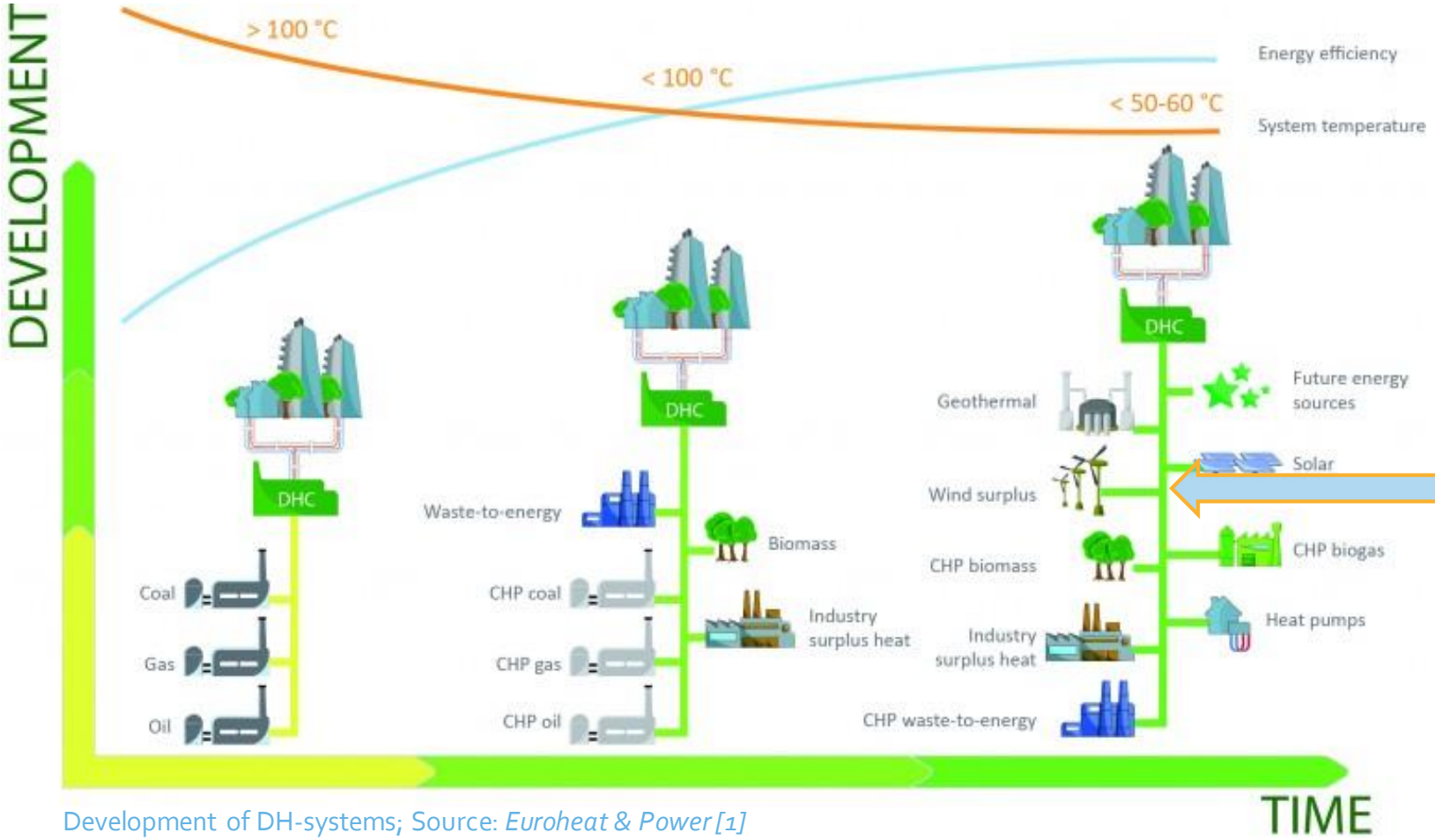
- Introduction to this module
- The basic principle behind Power-2-Heat technology
- The integration of power-to-heat within the electricity and heat sectors
  - Digression: The balancing power market
  - Utilising P2H applications instead of reducing capacity
- Power-to-Heat applications – an overview
- Summary: Potentials of P2H applications
- Basic principle of Power-to-Gas
- Comparing P2H & P2G technologies
- Possible uses of P2H & P2G applications

The basic principle behind Power-2-Heat technology

- **P2H applications are capable of converting electrical current into thermal energy**
- **Smaller private applications:**
  - night storage heater
  - heat pump heating system
- **Large-scale applications:**
  - central electric or electrode boilers
  - Large-scale heat pumps
- Usually such applications are integrated into a heating network

→ **Sector coupling:** interconnecting the electric sector with the heating sector

The integration of P2H within the electricity and heat sectors



Development of DH-systems; Source: *Euroheat & Power [1]*

- Today P2H is already contributing to the constant balance between power supply and power demand
- Possible future potentials for P2H-applications

Digression: The balancing power market

- The balancing power market is constantly stabilizing the targeted 50 Hz frequency within the power network:

  - **positive balancing energy** (e.g. by a CHP-plant) = surplus of electricity to balance out peaks in the consumption

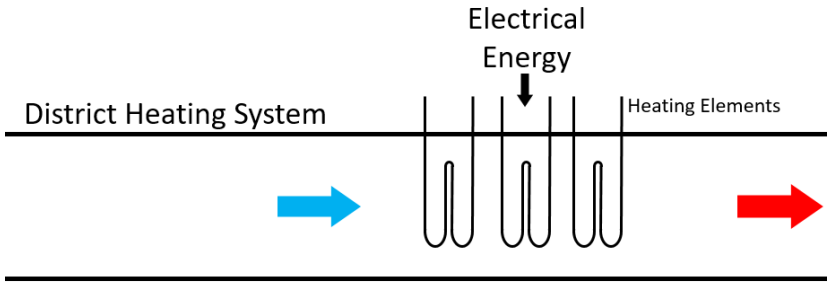
  - **negative balancing energy** = higher output than consumptiom makes the usage of the surplus of electricity necessary (e.g. through P2H, storages, DH-networks)

  - Due to the increasing amount and integration of mostly volatile renewables energies into the power market, power-to-heat technologies could have an important impact as an important instrument for the balancing power market in future

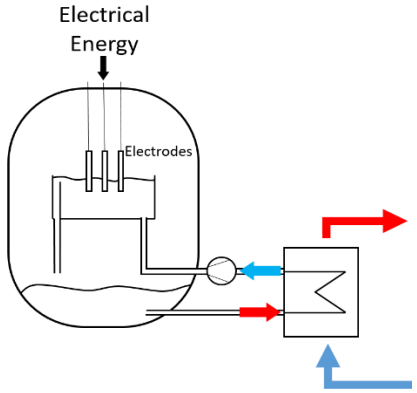
Power-to-Heat applications – an overview

Three different technologies are primarily being used as P2H converters

- Electric (heating element) heaters
- Electrode boilers
- Electrically operated compression heat pumps



Source: AGFW



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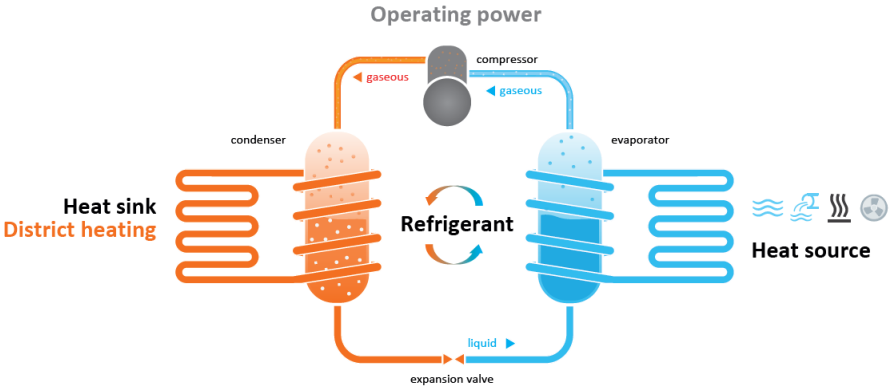


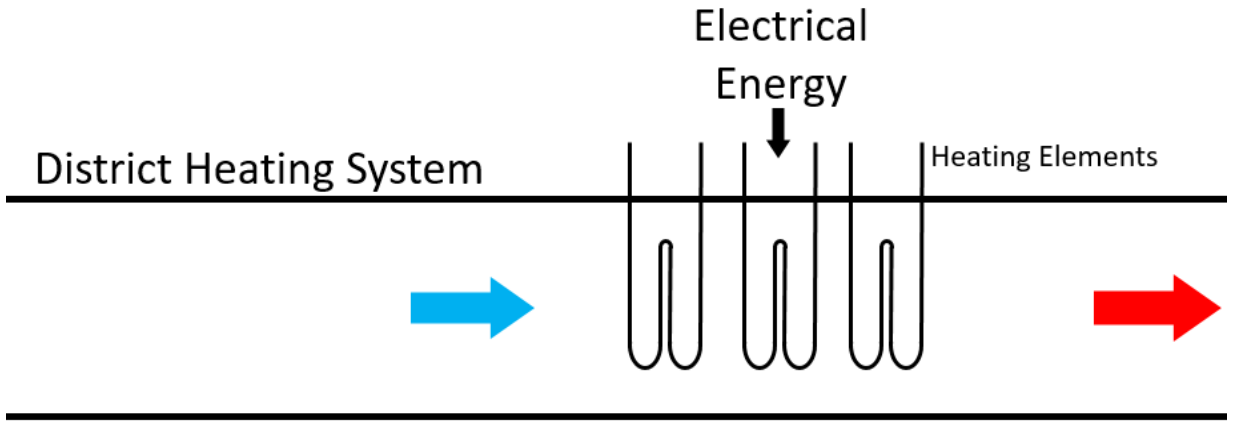
Source: AGFW

Power-to-Heat applications – an overview

Electric (heating element) heaters

- **electric flow heaters**
  - Applications used in the industrial sector and within DH-systems operate within an electrical output range of 50 KW to 15 MW, at voltage up to 690 V

- **heating rods (immersion heater principle)**
  - use in households and businesses usually have a power output in the single-digit kW range, at voltages of 230/400 V

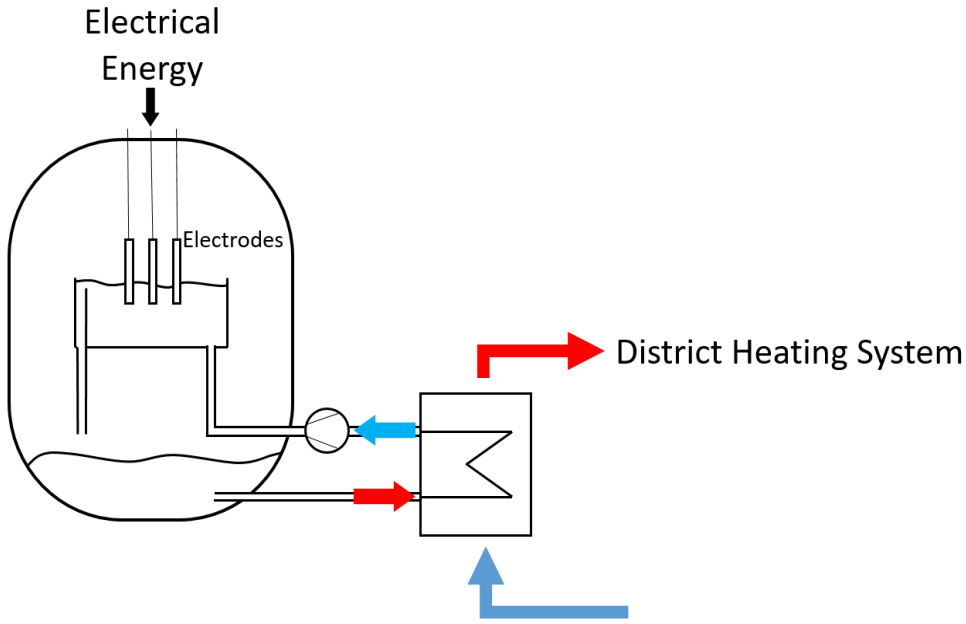


Scheme of an electric flow heater (Source: AGFW)

Power-to-Heat applications – an overview

Electrode boilers

- main components of electrode boilers are their electrodes surrounded by water
- If the electrodes are energised, the ohmic resistance of the water causes it to heat up
- With an additional heat exchanger, this heating energy can be transmitted into the DH system
- **capacities of electrode boilers vary between 5 MW and 50 MW**

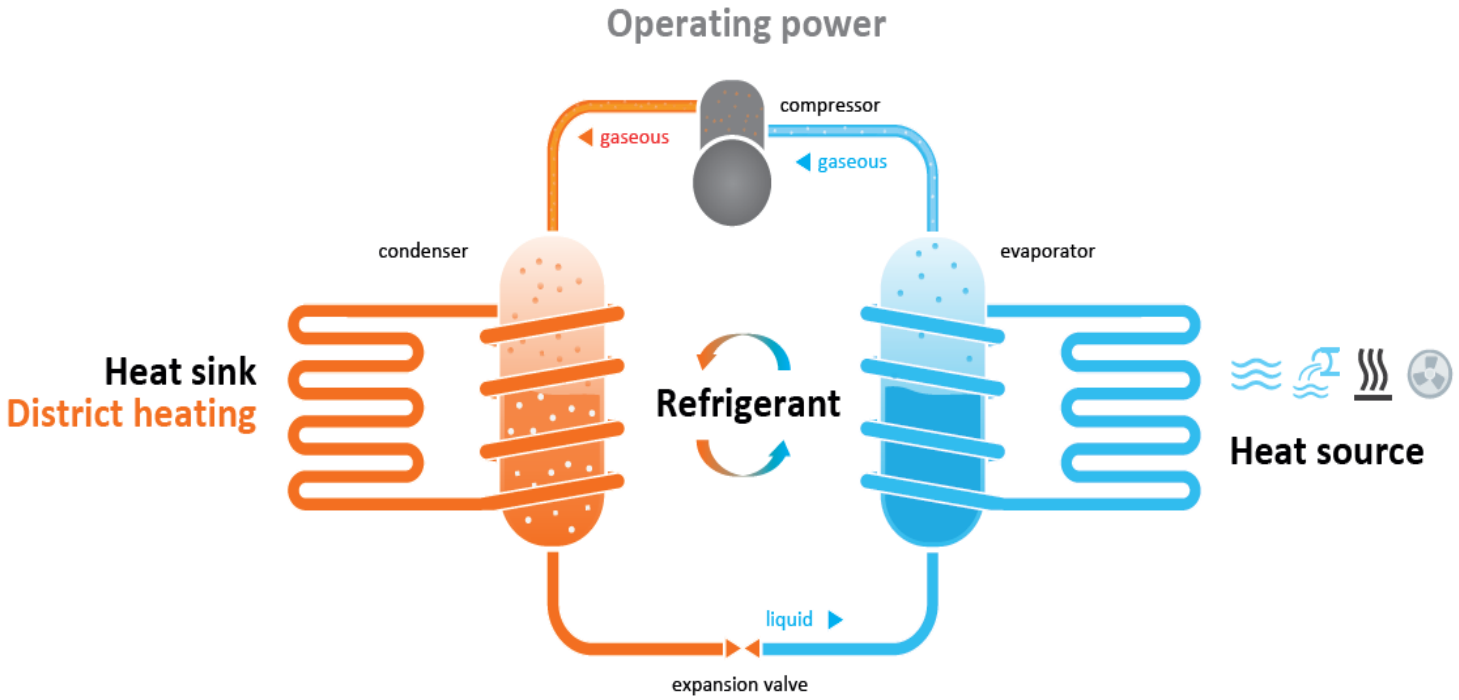


Scheme of an electrode boiler (Source: AGFW)

Power-to-Heat applications – an overview

Compression heat pump

- highly efficient in increasing the temperature on required temp. level
- Flexible solutions for DH-systems
- any HP capacity seize available
- extracts and provides heat from a medium such as surrounding water or air
- uses much less electrical energy than direct electrical heaters
- High investment costs

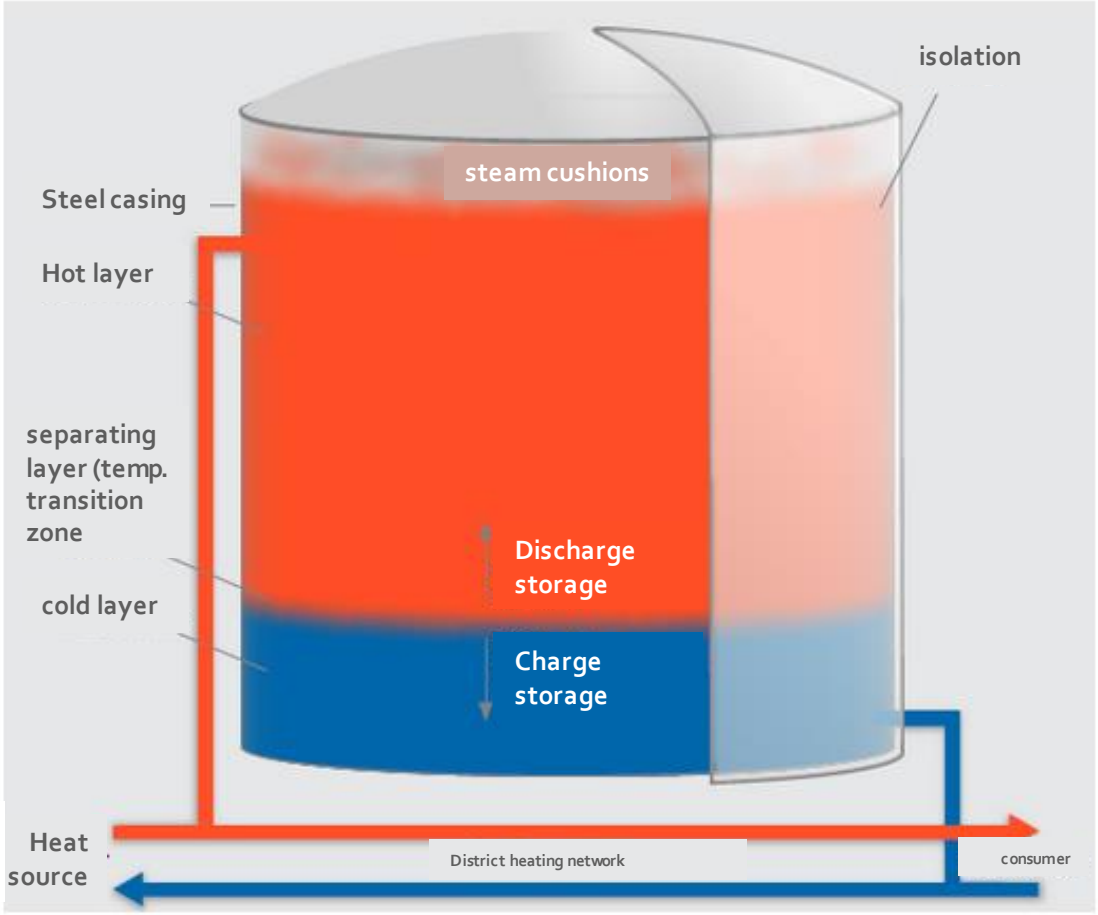


How a compression heat pump works (Source: AGFW)

Power-to-Heat applications – an overview

Heat storage in combination with P2H

- Heat accumulators are usually combined with P2H systems
- E.g. stratified storage systems are most common applications within DH-systems (see figure)
- heat can be stored for later consumption for a few hours to a few days or weeks, depending on the size of the storage unit



Scheme of thermal heat storage (Source: vattenfall; translated & adjusted) [2]

Potentials of P2H applications

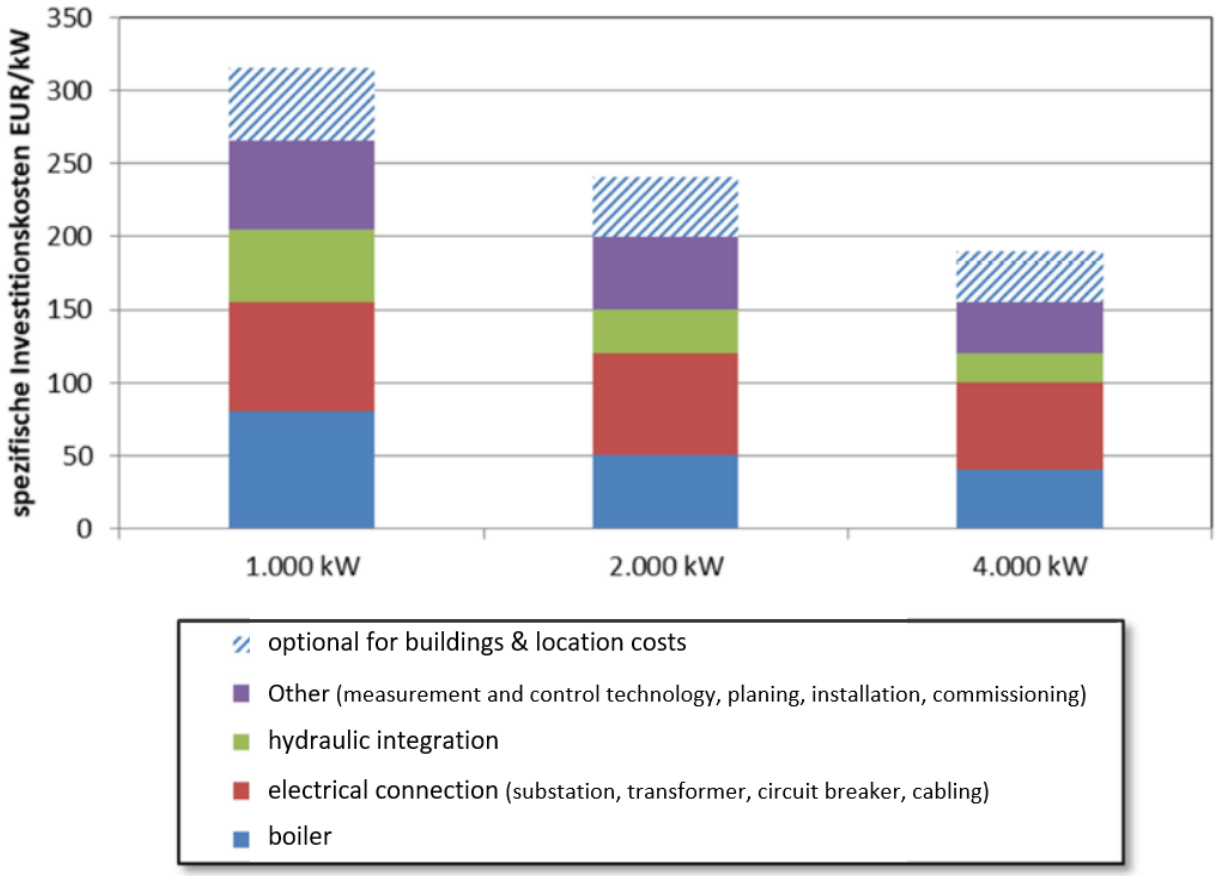
Analysis of ecological potential

- If generated **from renewable energies** …
- …electrically generated heat can make a significant contribution to reduce **and** replace the use of fossil in future systems
- **Positive sideeffect:** using "green" surplus electricity produced in more rural areas, "green" heat could be supplied to densely populated urban areas
- **General potentials**:
  - Increasing energy efficiency
  - Decreasing CO2-emissions

Potentials of P2H applications

Economic aspects & investment costs

- investment costs for **direct electrical P2H** applications depend very much on the existing infrastructure and the required temperature level
- a plant that is mainly used in a district heating networks, approximate investment costs are in the range of €150-270 per kilowatt
- For LHP investment costs are usually much higher



Specific investment costs in EUR/kw for a direct electrical P2H application (Source: EEB ENERKO, 2017/2020;) [3]

The basic principle of Power-to-Gas

- Power-to-Gas refers to the technical conversion process which uses electrical energy (power) to produce gas
- the gas produced is hydrogen (***electrolysis***)
- this hydrogen can be converted to methane (***methanation***)
- the idea of this technology is to use renewable power for these processes in order to produce renewable (CO_2-free) gas
- **This technology is another instrument for the decarbonisation process within the heating sector**

Simplified Power-to-Gas process (AGFW, 2019)

The basic principle of Power-to-Gas

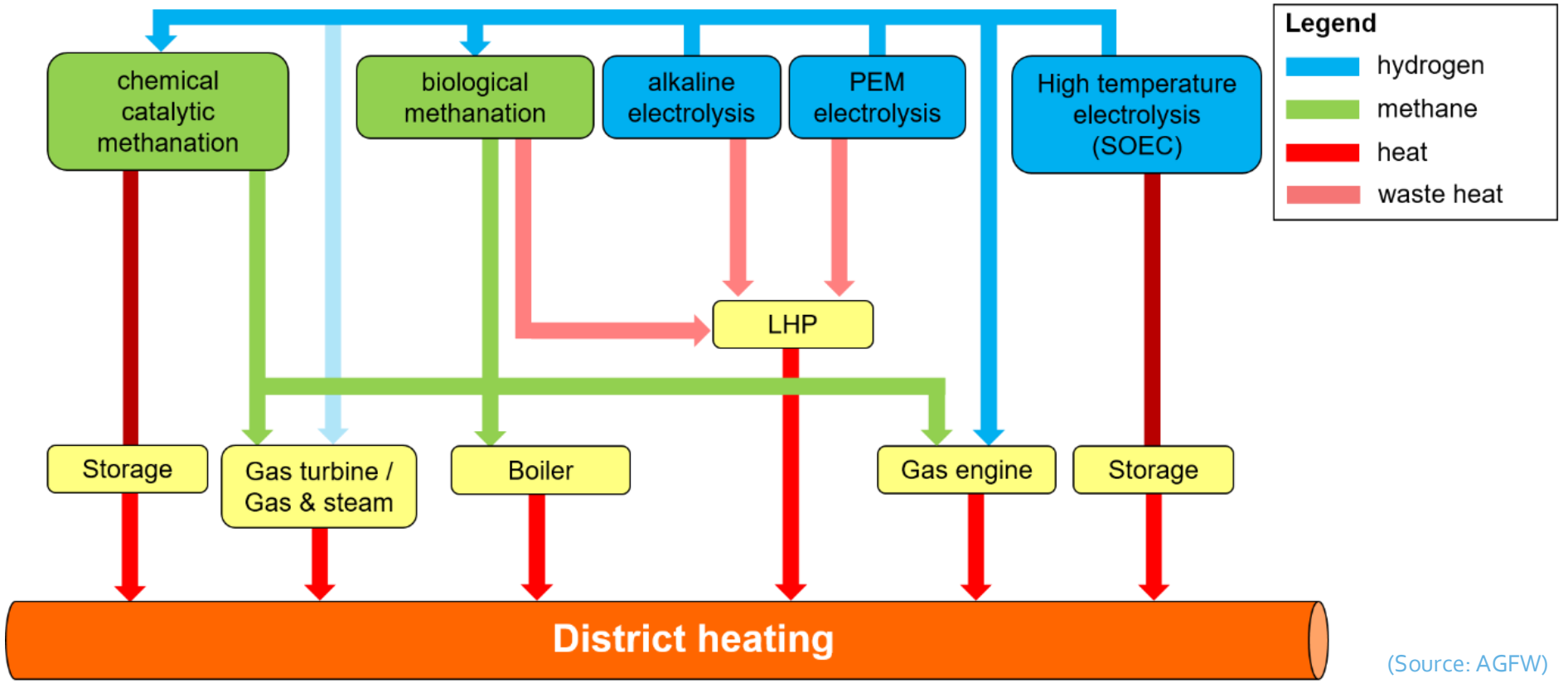
Main advantage of this technology

- high energy storage density of hydrogen and methane
- Both are of primary energy sources, that have already been in use for a long time, and have proven their functionality
- **Methane** has similar properties to natural gas
  - can **be stored** and transported with the already **existing gas network**
  - **can replace** the use of natural gas in all **previous applications**
  - **the storage of electricity** as gas can be an economically attractive option for a secure, flexible and climate-friendly energy supply

Simplified Power-to-Gas process (AGFW, 2019)

The basic principle of Power-to-Gas

Overview of P2G processes using methanation and electrolysis



(Source: AGFW)

Comparing P2H & P2G technologies

- In general, **Power-to-Gas** with the usage of the synthetic gas in the heating sector also competes with direct **Power-to-Heat** technologies

Power-to-Heat:

- direct utilisation is more efficient compared to the combustion technologies
- disadvantage with regard to long-term energy storage

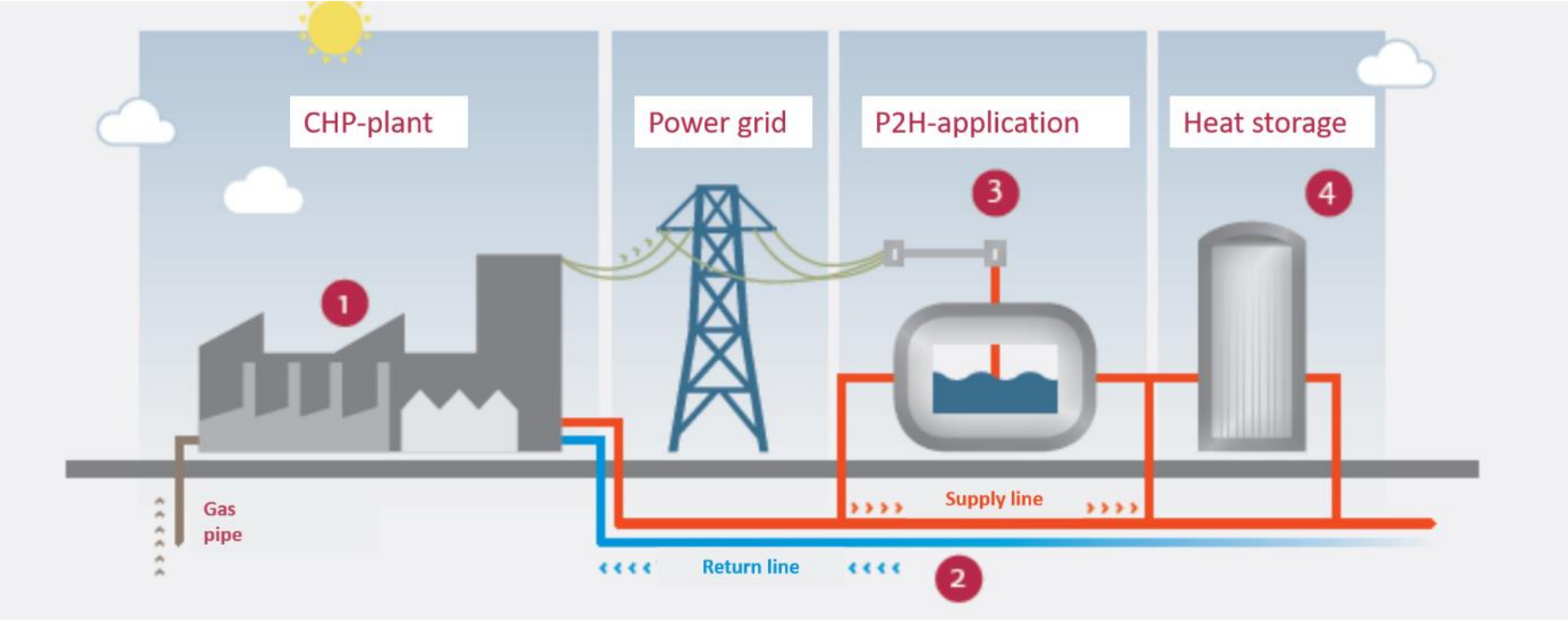
Power-to-Gas:

- Gas has a higher energy storage density compared to batteries or water (thermal storage)
- the production of synthetic gas represents an unnecessary conversion process (low efficiency)
- However it it adds more flexibility (in terms of time between supply and demand), but also for further fields of application of the synthetic gas

Possible uses of P2H & P2G applications

P2H in combination with a CHP plant:

- Almost continuous heat utilisation possible
- additional accumulator can be integrated easily
- In case of surplus electricity, the P2H system provides heat for the heating network or the accumulator



Flexible CHP/heat grid system with heat storage and Power-to-Heat module (Source: bdew, 2016; translated) [5]
https://www.bdew.de/media/documents/Factsheet_PowerToHeat.pdf

Possible uses of P2H & P2G applications

P2G in combination with a CHP plant:

- Example from Haßfurt, Germany
- surplus electricity from the nearby wind farm and solar energy is converted into renewable hydrogen
- The hydrogen is then combusted in a hydrogen CHP plant

The Silyzer 200 (1.25 MW output) electrolyser from Siemens at the Stadtwerk Haßfurt is used to produce hydrogen with excess electricity from renewable energy generation plants.
Image source: Stadtwerk Haßfurt GmbH

Image Source: Press release: https://www.2-g.com/module/designvorlagen/downloads/100_green_electricity_with_power_to_gas_.pdf

References

- [1] Euroheat & Power. https://www.euroheat.org/group-documents-category/dhc-and-buildings-g5/
- [2] Vattenfall; translated & adjusted); quoted from https://www.smarterworld.de/smart-energy/sonstige/fernwaerme-ein-zuverlaessiger-energiewende-baustein.108753.html
- [4] EEB ENERKO, 2017/2020;). https://enerko.de/
- [5] bdew 2016; translated. https://www.bdew.de/media/documents/Factsheet_PowerToHeat.pdf

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