Waste & surplus heat

Opportunities, obstacles & potentials for CO_2-emission reduction

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
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Financial Aspects

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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
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Overview I

- **General information:** Introduction & waste heat recovery in Europe
- **Basic principle** of waste heat utilisation
- **Important steps for waste heat utilisation in Europe**
- **Benefits of utilising waste heat**
  - Ecological benefits
  - Economic benefits
- **Terms and definitions**
  - Temperature levels
  - Quality of waste heat sources
  - Quality of heat sinks
  - Additional waste heat sources

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Overview II

- **The data situation** regarding the utilisation of waste heat
- **Prices, potential and obstacles**
- **Costs involved** in utilising waste heat and creating added value
- **Waste heat projects** in Europe

General information: waste heat recovery in Europe

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Potentials of waste heat utilization:

- **increasing energy efficiency** in the corporate sector
- **Reaching the CO2 reduction targets** set for 2030 and 2050
- **Savings of primary energy**
- Waste heat can be used either **to replace** or **supplement** heat generated using conventional methods
- **heating networks are particularly suitable** for the utilisation of waste heat
  → capable of **combining** heat obtained from a variety of sources

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Basic principle of waste heat utilisation

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- Waste heat / surplus heat is generated is during a **variety of industrial processes**
- Heat can be utilised for **space heating or cooling** as well as **hot water preparation**
- Depending on the process, there are **different temperature levels**
  - In case of very low temperature levels **auxiliary heating** is necessary (e.g. by a heat pump)
- The only losses that arise are **heat transfer losses** – therefore, the **distance between heat source and heat sink** is important for the **efficiency of waste heat utilization**
- **financial costs are <u>relatively low</u> in relation to the energetic benefit**

Source: pixabay

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Basic principle of waste heat utilisation

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HOWEVER: Regardless of the potential and the high efficiency of waste heat utilisation, it is important to note that…

- …**not producing** waste heat is more efficient than utilizing it.
- …**analysing all opportunities** to avoid or minimize generated waste heat, **should always be the first step!**

The following stages of analysing waste heat utilization are therefore important to mention:

1. **Avoiding** waste heat
2. **Reducing** waste heat, designing processes to be more efficient
3. **Reutilisation**; preparation and utilisation of heat within the process or other processes
4. **Disposing of or displacing** the heat into a heating network

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Basic principle of waste heat utilisation

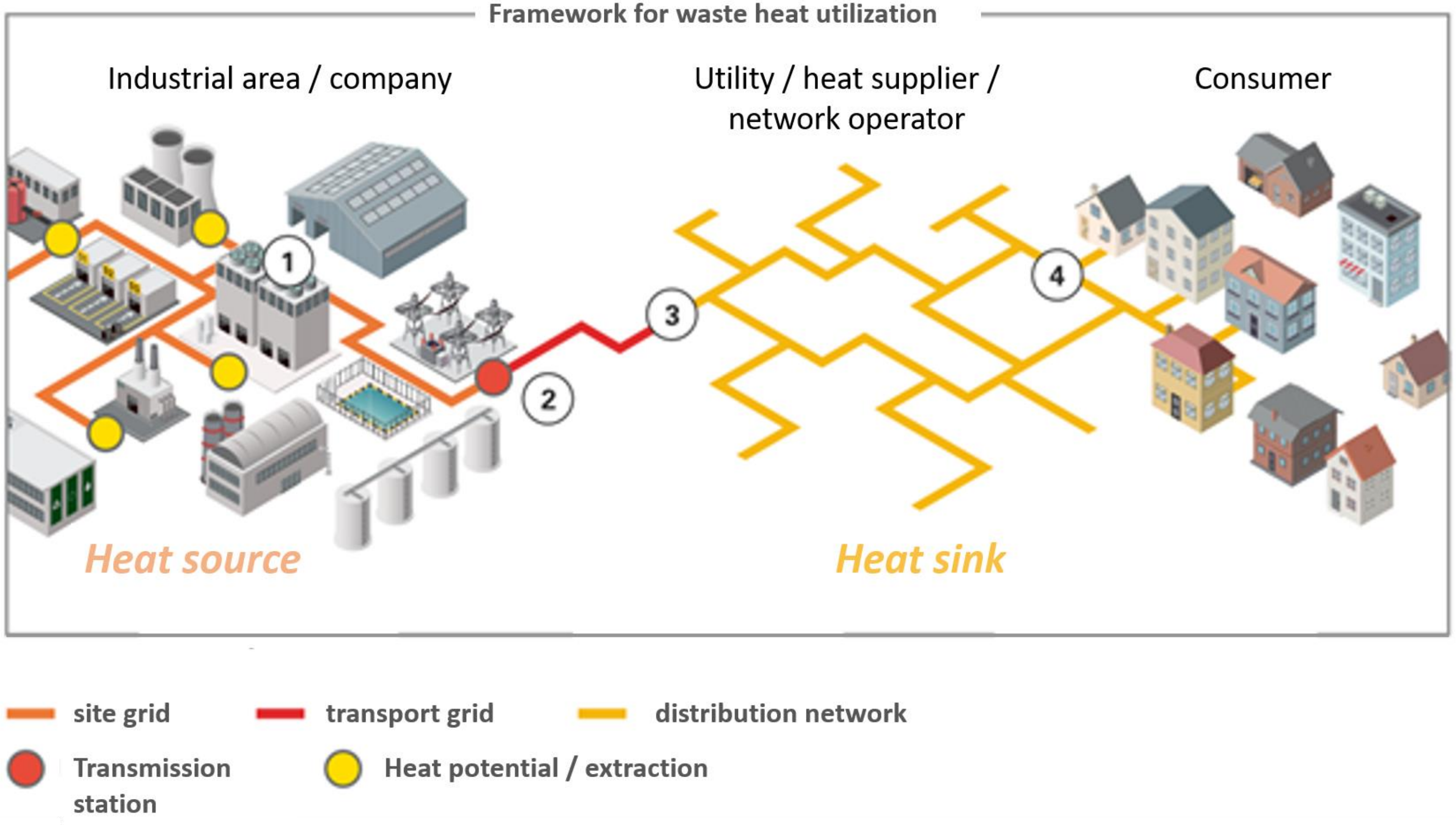

Figure 1: Different levels of waste heat integration (Source: AGFW)

1. **the waste heat is extracted** e.g. from a stream of exhaust gas via heat exchanger and transferred to heat transfer fluid (for DH usually water)
2. **For industrial purposes** fluids such as thermal oil, steam or another gaseous fluid may be used.
3. **Heat transfer** through transport grid to the heat sink (thermal separation by a transmission station)
4. **Heat is distributed** to consumers.

Important steps for waste heat utilisation in Europe

- Waste heat utilization needs a **clear political and legal framework**, because…
  - …**several different actors are involved** (companies, utilities, network operators, consumers, etc.)

Following aspects are important for an effective and efficient waste heat utilisation on a European and national scale:

- **Creating** a suitable political framework that provides incentives for increasing the utilisation of waste heat on a European and national level
- **Developing** national waste heat registers (e.g. mapping possible heat sources)
- **Accelerating** the creation of heat plans on a municipal and regional level
- **Ensuring and intensifying** the transfer of know-how, by means of transfer points or funding agencies, or via energy efficiency networks
- **classify waste heat as 100% CO_2-free** (e.g. important for funding options)

Benefits of utilising waste heat

- **Waste heat utilization supports the replacement of conventional heating plants**
- However, waste heat occurs at different locations:
  - **Industrial processes & thermal waste-to-energy plants**:

    → important sources, but usually **big distance from existing heating networks or heat sinks**
  - **Waste heat from the service sector**:
    - generated in much smaller quantities usually lower temperature levels
    - close to the point of consumption and therefore interesting for urban areas

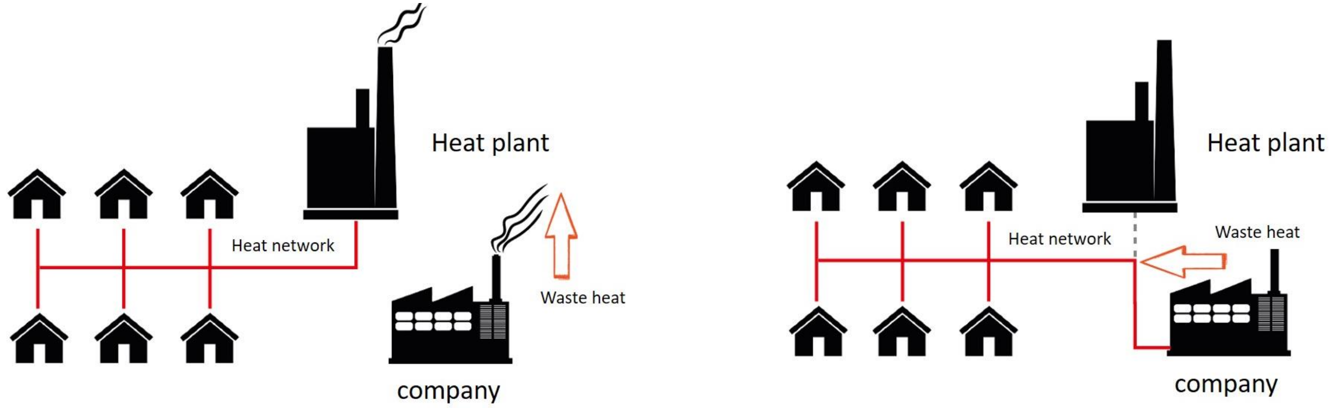

Figure 2: The displacement of fossil fuel by waste heat (Source: AGFW)

Benefits of utilising waste heat

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Ecological benefits

- **No additional emissions** (CO_2, fine particulate, NOx, etc.)
- hardly **any additional resources** are used and no additional space is consumed, as the industrial plant already exists
- **reduction in occasional heat emissions** into the environment
  - maximum permissible heating of lakes and rivers is more and more often reached in hot summers as an impact of climate change
- **microclimatic aspects** in cities → reducing local heat inputs is becoming more and more important

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Benefits of utilising waste heat

Economic benefits

- no additional primary energy sources are required to convert waste heat energy into useful energy
- Companies can reduce their fuel and electricity costs

- **Lower energy costs** could significantly influence the competitiveness of manufacturing companies in the marketplace
- **Less dependency** on the energy market (lower risk of unpredictable increases in the price of fossil fuels)
- **Fewer CO_2 certificates** being required, which in turn leads to savings in operating costs

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Definitions relating to the utilisation of waste heat

- Existing definitions of waste heat are still inconsistent and exclude one or more of the relevant sub-areas that relate to district heating!
- For that reason, AGFW e. V. is proposing the following definition:

Waste heat[1]:
Heat that occurs during a process, the main objective of which is to manufacture a product or perform a service (including waste disposal) or to perform an energy conversion, and which would have to be disposed of due to the fact that it forms an unused by-product.

[1]This definition is currently being laid down in a supplementary sheet to AGFW FW 309-1 and is in the process of publication.

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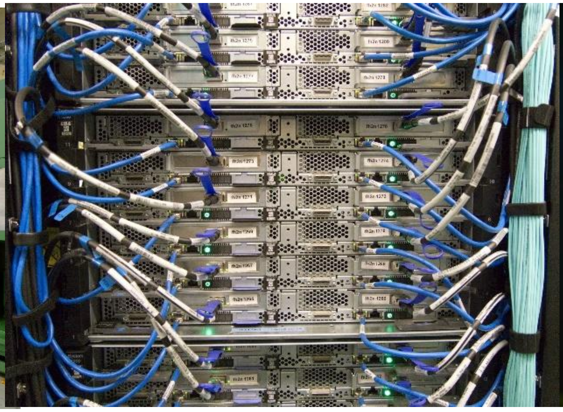
Differentiation according to the source of waste heat

Potentially viable sources of waste heat are covered by the categories listed below:

- **Production** (e.g. refineries, steel processing, chemical industry)
- **Services** (e.g. computer centres, laundries, cold stores and wastewater and water resources management)
- **Waste disposal** (e.g. thermal processing of waste, closing material cycles within individual companies)
- **Energy conversion** (e.g. condensing power plants, waste gas heat derived from combustion processes).






Source: pixabay

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Differentiation according to (utilisation) temperature levels

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Classification of temperature levels of the Institute for Energy and Environmental Research [1]:

- according to their (utilisation) temperature level, different technologies can be employed in order to utilise or convert the heat

High temperature range (> 300 °C):

- **Conversion into electricity** using the Clausius-Rankine or Stirling process

Medium temperature range (80-300 °C):

- **Conversion into electricity** using the ORC or the Kalina process
- **Passive heat utilisation** (internally, locally/adjacently or externally by feeding into a district heating network or by means of mobile transportation using a heat container)

NOTE: *Generating electricity by means of high-temperature waste heat is technically possible. Nevertheless, the conversion of waste heat into electricity represents a very broad expansion in the utilisation of waste heat, which, given today's low electricity prices, is only commercially viable in rare cases.*

[1] https://www.ifeu.de/wp-content/uploads/Schlussbericht_EnEffW%C3%A4rme-NENIA.pdf

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Differentiation according to (utilisation) temperature levels

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Low temperature range (< 80 °C):

- **Proportional coverage** of the internal or local/adjoining requirement for room heating and hot water
- **Preheating** of heating water within the heating network (external)
- **Active heat utilisation** by means of electrical/thermal heat pumps or heat disproportionation (locally/adjacently or externally (see above))
- **Thermal heat pumps** are powered using integrated process heat at a high temperature level or by separate fuel-fired system (heat synproportionation). [...]
- **Refrigeration** (for internal or local/adjacent users)
- **Passive heat utilisation** in cold (low-ex) heating networks:
- In order to **increase the utilisation temperature level** that is necessary in each case, **integrated heat pumps** are deployed in the individual domestic substations.

[1] https://www.ifeu.de/wp-content/uploads/Schlussbericht_EnEffW%C3%A4rme-NENIA.pdf :

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Quality of waste heat sources

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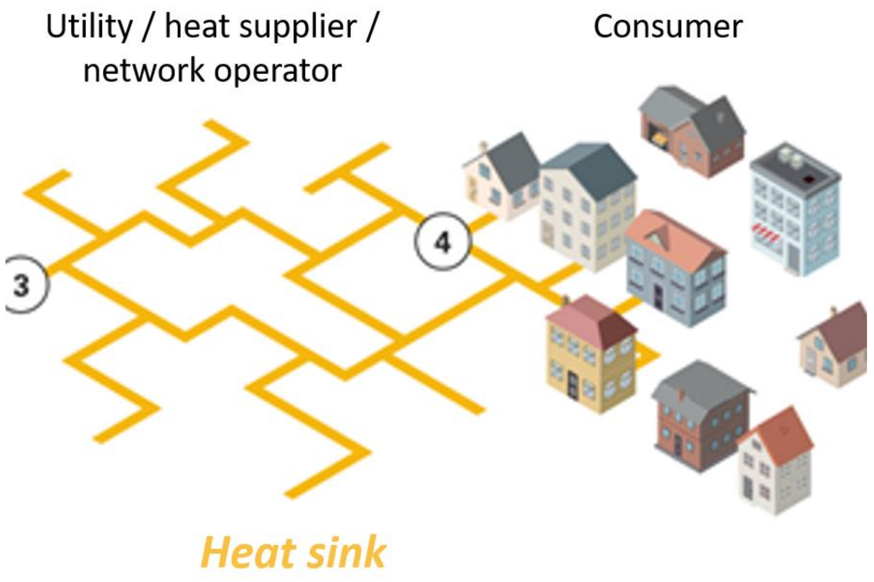
Following parameters are relevant when evaluating the potential / "quality" of a waste heat source:

- **The physical state** of the waste heat carrier medium
- **The temperature level**
- **The chronological course of heat conduction** (relative to the reference temperature of the waste heat stream once heat dissipation has taken place)
  - If this is unknown, the available heat quantity/unit of time and the minimum and/or maxi-mum heat outputs can be used if applicable
  - Company holidays, shutdowns due to over-hauls or shift-working, etc. should be taken into account
- **Chemical composition**, foreign matter, **Sector/process**, etc.

Quality of heat sinks

Potential heat sinks must also demonstrate specific characteristics:

- suitable for the utilisation of waste heat for purposes such as space heating or the preparation of domestic hot water? (**Heat demand / individual load profiles / consumer behaviour etc.**)
- analysis of the **necessary supply temperatures**
- Estimation of the **required operating pressures** of the network
- **distance to the waste heat source** (due to heat losses)
- the simultaneous supply of adjoining or nearby industrial plants with cooling could be of interest



Example of potential heat sinks (Source: AGFW)

Additional waste heat sources

- Alongside the major heat sources that are conventionally used for the utilisation of waste heat, **further methods are available** that allow surplus heat to be used efficiently
- **Urban wastewater treatment plants** located inside or within 2 km from urban district heating areas (see figure 4)

→ **opportunity for urban areas to use low-temperature heat sources more efficient in future**

→ **Approximately 1.2 EJ (or 340 TWh) per year are possible to recover from:**

- data centres
- metro stations
- service sector buildings
- and wastewater treatment plants

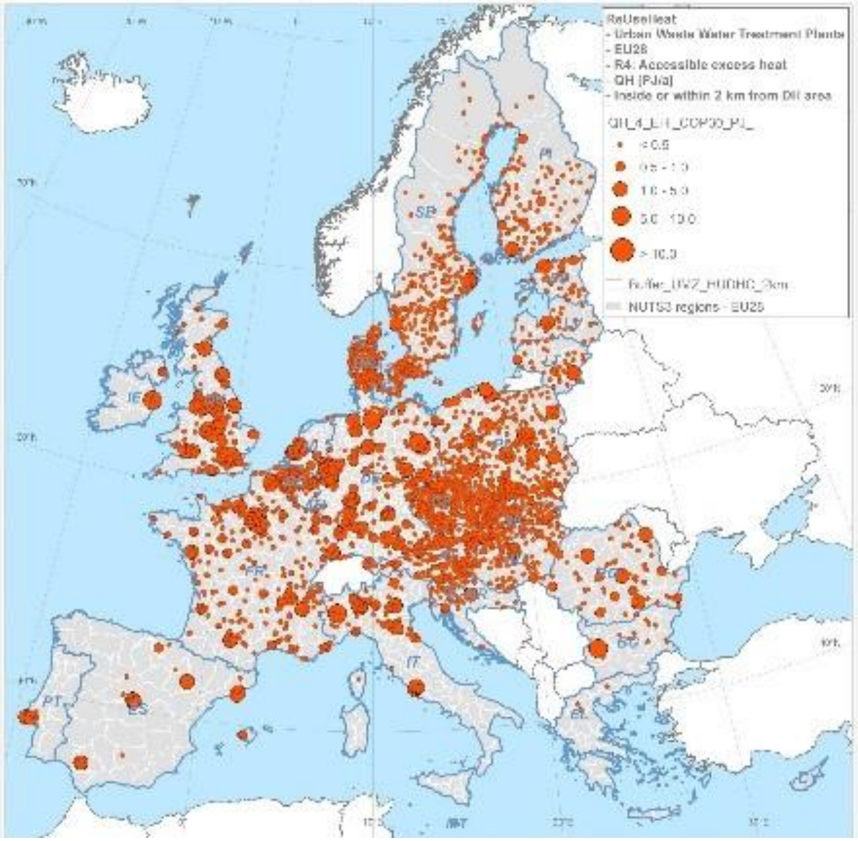
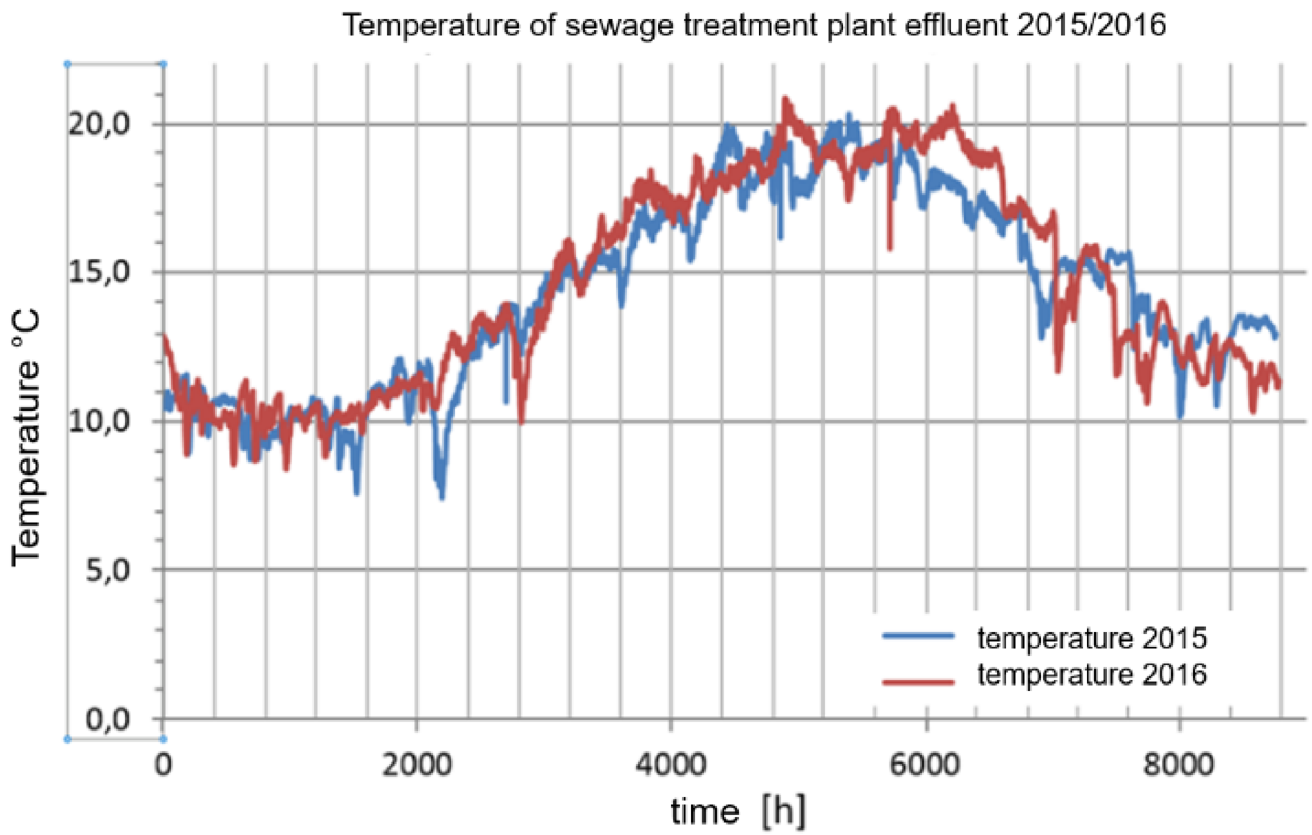


Figure 3: Accessible excess heat from 3982 EU28 urban wastewater treatment plants located inside or within 2 km from urban district heating areas (Source: Persson U, Averfalk H. [1]).

Additional waste heat sources – utilising waste water



- **Residual heat of cleaned sewage water** in sewage treatment plants is used as heat source
- **Annual constant** temperature of over 10 degrees (auxiliary heating necessary, e.g. by a heat pump)
- **Quality** of cleaned sewage water is important
  - e.g. iron phosphate deposits on the heat exchanger
  - Filter systems or special cleaning processes required (e.g. plate heat exchangers rather unsuitable)

Figure 4: Illustration of the temperature curve of the wastewater treatment plant outflow of a combined wastewater sewer (Source: Stadtwerke Lemgo [2])

Data situation regarding the utilisation of waste heat

- **comprehensive data is currently not being captured** in a systematic way (either Europe-wide or within individual EU Member States)
- **the precise potential that exists** in each region for the utilisation of waste heat in district and local heating systems is often difficult to estimate
- **Data would be extremely important** or many potentially important actors (companies, urban planners, municipalities, utility companies, etc.)
- **Sources of waste heat at low temperatures**, which are available in large numbers and which also offer considerable quantities of energy due to their high quantity flows, are often not included

Data situation regarding the utilisation of waste heat

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Proposal for the expansion of a systematic data collection program:

- **Records** of potentials for waste heat utilisation should be compulsory
- **Inclusion as an ongoing criterion** within the relevant certification systems (DIN EN ISO 50001, EMAS)
- An obligation, for certified companies, to **publish aggregated data on an ongoing basis**:
- **Utilisation and further development of regularly recorded data as…**
  - … the quantity of heat, the average temperature weighted by quantity, the power output or operating hours, the load profile
  - … the additional recording of large, diffuse sources and waste heat that does not form part of waste gas flows
  - … the recording of large-scale cooling of product streams

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EXAMPLE: Data collection of waste heat potentials/sources in Vienna

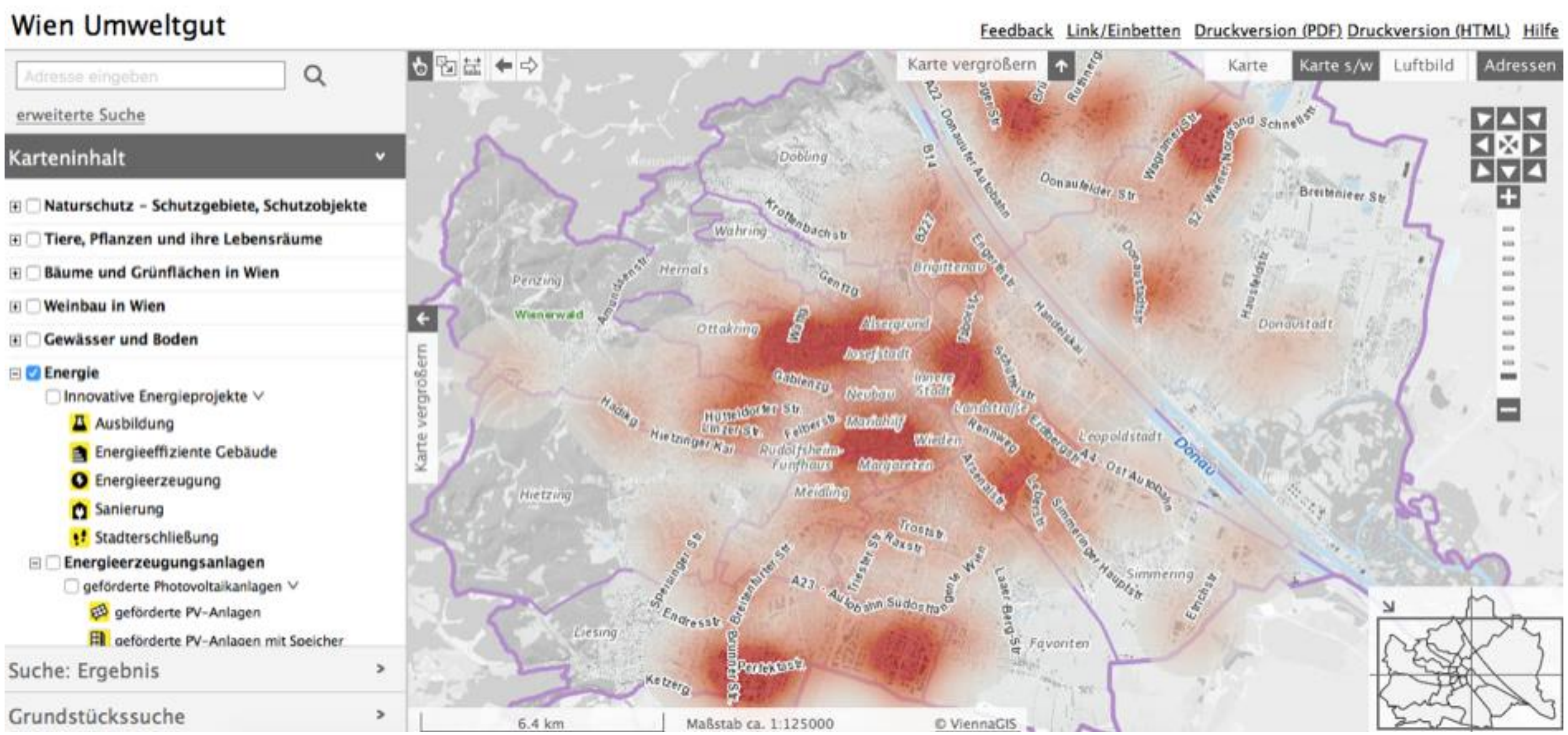

Figure 5: Exemplary heat register for waste heat potentials of the City of Vienna [3]

Prices, potential and obstacles

General obstacles:

- the **higher the temperature level**, the more **frequently, regularly and predictably** the heat is available, the more effectively it can be utilised by heating supply companies
- Waste heat occurs at different temperature levels, at different frequencies and at differing degrees of continuity (→ different qualities of heat source)
- the **lower the quantity of waste heat** and the more i**rregularly and less predictably** it occurs, the greater **the necessity for heat storage facilities** and for measures to ensure the **security of supply**

Prices, potential and obstacles

Obstacles for heat partnerships:

- **Waste heat projects** usually have…
  - …a **long planning lead time** due to numerous technical, legal and contractual issues
  - … the **business models of DH-companies** generally extend across periods of 10 to 20 years, due to large-scale investments in DH-infrastructure with long depreciation times

In comparison:

- **industrial companies** typically expect significantly shorter investment cycles, which means that…
  - … **new location decisions** can usually occur within short-term periods
  - … such partnerships could be a potential for **conflict, or for increased uncertainty** in the case of the district heating suppliers

Prices, potential and obstacles

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Possible solutions for long lasting heat partnerships and reduction of obstacles:

- Creation of financial incentives **on both sides** (heat sources & heat sinks)
- Incentives could **reduce the costs and project risks** to be borne by the companies involved
- **Pricing of CO_2 emissions** is an option that would affect both partners and competitors in equal measure
- **far-sighted political view** of the opportnities of waste heat utilization

→ A clear political framework would give both sides planning security & security of investment!

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The costs involved in utilising waste heat

(see number 1-4 in figure)

1. **Production costs**
   (including CAPEX, OPEX)
2. **Costs of useful heat**
   (waste heat source)
3. **Costs of useful heat**
   (heat sink)
4. **Price to end-customer**

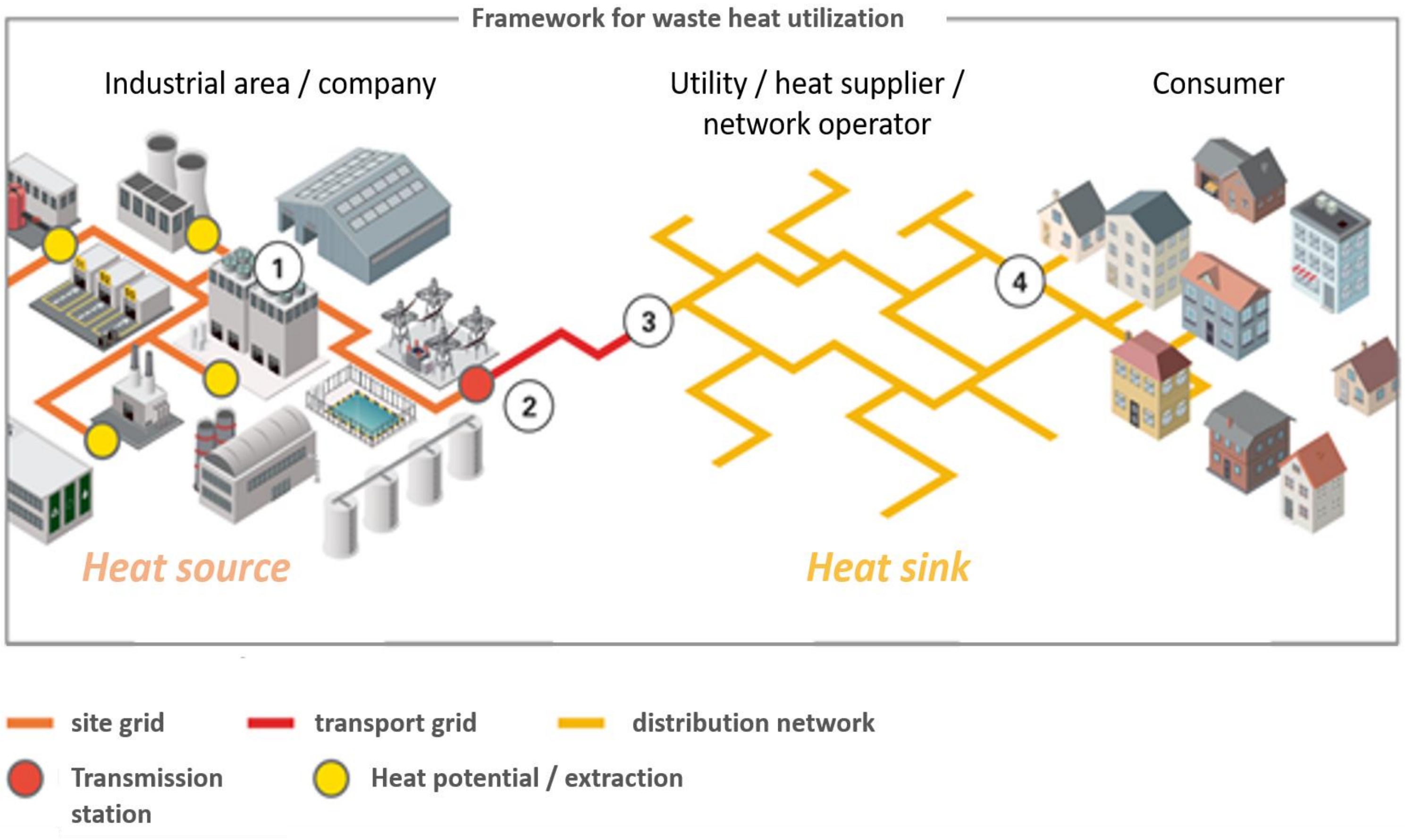

Figure 6: Framework for waste heat utilization (Source: AGFW)

Current waste heat projects in Europe & further information

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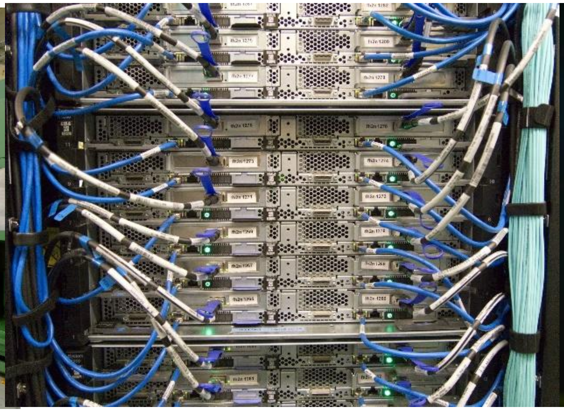
- **Mäntsälän Sähkö, Finland:** https://www.nivos.fi/en/recovery-of-waste-heat-launched
- **Turku, Finland:** https://www.turku.fi/en/carbon-neutral-turku/climate-actions
- **Gelsenkirchen, Germany:** https://www.uniper.energy/news/industrial-waste-heat-for-the-district-heating-supply/
- **Interreg European project CE-HEAT:** https://www.interreg-central.eu/Content.Node/CE-HEAT.html






Source: pixabay

References

- [1] Persson U, Averfalk H. 2018. Accessible urban waste heat. Deliverable 1.4. ReUseHeat. Recovery of Urban Excess Heat.
- [2] Stadtwerke Lemgo; quoted in AGFW 2020: "Praxisleitfaden Großwärmepumpen" p.7
- [3] City of Vienna. www.wien.gv.at/stadtentwicklung/energie/themenstadtplan/abwaerme/

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