Best Practice No. 2

Implementation of LTDH concept in new urban developments and local heating systems

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

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- Pilot Energy Strategies – Aims and Conditions
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Best Practice

- Best Practice I
- Best Practice II

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Motivation and Goal

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On the road to LTDH

- The main motivation and goal is to present various possible roads to low temperature (4. Generation) district heating implementations
- Here we concentrate on the issue of possible LTDH implementation in new urban developments, surplus heat and heating/cooling systems

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Content

- LTDH network with solar feed-in in new residential area – „Living on Campus“, Berlin (DE)
- 4Gen city heating/cooling system – Ectogrid, E.ON in Lund (SE)
- Alternative to LTDH: energy self-sufficient buildings – Sonnenhäuser, Cottbus (DE)
- Innovative low temperature district heating from surplus heat – Brunnshög in Lund (SE)
- Waste heat utilization in small/medium companies – TERMA, Gdansk suburb (PL)
- Waste heat utilization in Kalundborg (DK)
- Industrial waste heat utilization from Hamburg Aurubis plant – HafenCity Hamburg (DE)
- Geothermal heat utilization in Geotermia Podhalańska (PL)

1. “Living on Campus“, Berlin (DE)

LTDH network with solar feed-in in new residential area

Project profile

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Topic	**LTDH network with solar feed-in in new residential area**
Year of construction	ongoing, start in 2013
Project leader	BTB GmbH Berlin (energy company)

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"Living on Campus", Germany

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Project background

- new residential area: about 19 ha
- 1200 apartments in single-family homes, terraced houses and apartment blocks
- 62 buildings with low heat demand, including 5 low energy and 3 plus energy buildings

Goal

Implementation of a low-temperature network with bidirectional house connection and network feed-in stations

Figure 1: Plan of the area. Source: A. Reinholz , BSM – Beratungsgesellschaft für Stadterneuerung und Modernisierung mbH

“Living on Campus”, Germany

Pilot Project

- developed by energy company BTB Berlin

Initial situation

very little energy demand, less than 15 W/m², small low and passive energy buildings

Solution

low temperature grid 60/40 °C with participation of consumers who are encouraged to feed-in renewable energy

Figure 2: "Wohnen am Campus" I. Source: Jan Gerbitz, ZEBAU, Germany

“Living on Campus”, Germany

Pilot Project: Approach

- establishment of a low-temperature district-heating network (60/40 °C) linked to the district return flow after heat exchange from upstream district heating grid (110/55 °C)

- allowing the owners to feed-in self-produced energy from renewable sources e.g., thermal solar panels

- district heating supplier enables any surplus thermal energy produced by the solar thermal system to be fed into the district heating network and use it later during 2-year period of clearing

Figure 3: The heating node in the basement. Source: Stefan Simonides, BTU Cottbus-Senftenberg, Germany

“Living on Campus”, Germany

Pilot Project: Results

- three solar feed-ins realized so far
- integration of a battery system for photovoltaic panels increases the amount of electricity that is self-consumed
- LTDH can save 65% in primary energy compared to decentral (individual) building heating systems

Figure 4: "Wohnen am Campus" II. Source: Stefan Simonides, BTU Cottbus-Senftenberg, Germany

2. 4Gen city heating/cooling system – Ectogrid, E.ON in Lund (SE)

4 generation systems for new cities

ectogrid™

POWERED BY e·on

Project profile

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Topic	**4 Gen. heating and cooling**
Year of construction	2017 - 2020
Project leader	E.ON

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Medicon Village, Sweden

The first ectogrid™ at Medicon Village, Lund will connect 15 commercial and residential buildings with different heating and cooling demands of 1600 persons in more than 120 organizations working in life science.

Figure 1: Medicon Village. Source: http://ectogrid.com/

Medicon Village, Sweden

Project background

The ectogrid™ balances the demand of houses for heat and cooling.

- When heat is needed a heat pump use the heat from hot line
- When cooling is needed heat pump is supplied from cold line
- The current yearly energy demand at Medicon Village is approximately 10 GWh heating and 4 GWh cooling.
- The ectogrid™ at Medicon Village has the potential to balance as much as 11 GWh of energy.
- The system will be built in different phases.
- When completed, the system will use as little as 3 GWh of supplied energy.

Figure 2: Concept of ectogrid. Source: http://ectogrid.com/use-cases/medicon-village/

Medicon Village, Sweden

ectogrid™ Project principles

- Energy balance of all thermal energy flows in a building cluster.
- Built-in flexibility of the system for heat and cooling demand.
- Integrate all energy needs (e.g., eMobility, electricity production from PV) in the building cluster.
- Self-learning and Smart uses algorithms and data about typical demands over time of users, dates, seasons, weather, local energy production and energy trading prices.
- Freedom of choice – ectogrid™ is a grid solution connecting several energy users. Different members of the same system they can have different preferences with respect to how engaged they want to be in their energy system.

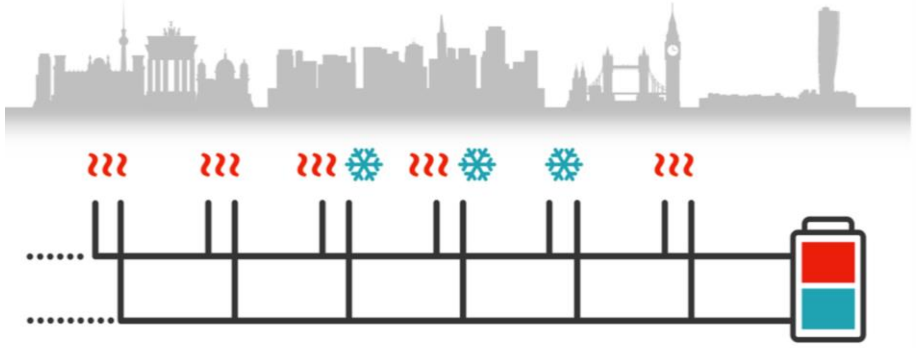

Figure 3: ectogrid principles. Source: http://ectogrid.com/

3. Sonnenhäuser, Cottbus (DE)

Alternative to LTDH: energy self-sufficient buildings, Solar Houses

Project profile

Topic	**Energy self-sufficient buildings through renewable energy**
Year of construction	2018
Project leader	eG Wohnen 1902

Sonnenhäuser, Germany

Project background

- the housing company deliberately resigned from DH solution due to economic reasons
- high cost of district heat in the city
- the aim was to build self-sufficient apartment buildings with a combination of mainly renewable and minimal fossil energy sources

Solution

Large heat storage, as well as lithium-ion batteries to store renewable energy

Figure 1: Sonnenhaus I. Source: Jan Gerbitz, ZEBAU, Germany

Sonnenhäuser, Germany

Project: Approach

- 600 m² of heated living space
- highly insulating brickwork (KfW Efficiency House Standard 55)
- 60-70% of electricity and heat from solar panels
  - 100 m² of solar thermal collectors
  - PV installations, each with 29.58 kW of peak power
  - lithium-ion battery with 54 kWh of storage capacity, each house

Figure 2: The heat storage. Source: Jan Gerbitz, ZEBAU, Germany

Sonnenhäuser, Germany

Project: Approach

- underfloor heating is supplied with heat from solar long-term heat storage
  - heat storage with capacity of 24.6 m^3 in each house
  - excess heat is being distributed to two neighboring buildings via a district heating network
  - reduces heating costs and doubles the yield of the solar thermal system
  - low amount of remaining heating energy required is generated with natural gas-fired boiler with capacity of 40 kW.
- dishwasher hot water is connected to solar energy
- domestic hot water is prepared via freshwater stations
- electricity is stored in accumulators
- if the solar power is insufficient, the housing company buys electricity to compensate

Sonnenhäuser, Germany

Project: Results

- guaranteed overall rent with flat rate for heat and electricity: 10.50 EUR/m^2
- energy costs 60% lower than the costs associated with Passive House buildings for heat and electricity
- up to 80% reduced electricity costs
- costs for the residual energy amount are easy to plan – nearly zero marginal costs

Figure 3: Sonnenhaus II. Source: Mindaugas Kurmis, Klaipedia University Lithuania

4. Brunnshög in Lund (SE)

Innovative low temperature district heating from surplus heat

Project profile

Topic	**largest LTDH network based on fossil fuel free waste energy**
Year of construction	ongoing, start in 2017
Project leader	Kraftringen company

Brunnshög in Lund

Project background

- Lund is a fast-growing city with close to 120 000 inhabitants, the municipality has a political goal to substantially reduce its environmental and climate impact
- existing institutions
  - Lund University
  - research facilities MAX IV (X-ray synchrotron)
  - the European Spallation Source (ESS) – linear proton accelerator, helium-cooled tungsten target wheel as a neutron source, measuring instruments
  - Science Village Scandinavia

Figure 1: Vision image of Brunnshög I. Source: Atkins [4.1]

Brunnshög in Lund

Pilot project

- Aim to construct the largest LTDH network based on waste energy
- Europe`s largest LTDH facility and test field for LTDH solutions
- Total development will cover 100 ha and in 2050 up to 40 000 people will live and work in Brunnshög
  - city can keep growing without increasing the GHG emissions

Figure 2: Vision image of MAX IV Laboratory. Source: Fojab Arkitekter [4.1]

Brunnshög in Lund

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Pilot project: Approach [4.2]

- low-grade surplus heat recovered from the research facilities of ESS and MAX IV will heat the entire district of Brunnshög
- Low-temperature district heating network in Brunnshög:
  - 4.4 km long
  - 65 °C supply line, 35 °C return line
  - construction commenced autumn 2017
  - first delivery 2019

Figure 3: Vision image of Brunnshög II. Source: Atkins [4.1]

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Brunnshög in Lund

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Project: Approach

- between the MAX IV and ESS facilities with 18 hectares of land; the plan is to build 250 000 m² of gross floor area
  - space for innovation, buildings up to eight floors high
- availability of low-temperature heat from ESS and MAX IV to use for heating the Science Village

- Heat comes from
  - Waste/surplus heat from scientific installations i.e., ion cooling/decelerating installation
  - A large-scale biofuel-based CHP facility
  - Large-scale geothermal system
  - Heat pump for recovery of heat from sewage
  - District cooling heat pumps
  - Other renewable energy sources

5. Waste heat utilization in small/medium companies (PL)

Waste heat utilization from soldering furnaces in TERMA Sp. z o.o., Gdansk suburb

Project profile

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Topic	**Waste heat from soldering furnaces used for space heating, ventilation and domestic hot-water preparation**
Year of construction	2020 (waste heat recovery installation launched in June 2020 based on the first soldering furnace)
Project leader	TERMA Sp. z o.o. Czaple, Municipality of Żukowo

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Terma - Czaple, Poland

Project background

- Terma Sp. z o.o. is a dynamic industrial company, operating since 1990 and employing about 500 people;
- It exports products: bathroom and decorative heaters, construction machinery and rehabilitation equipment, to more than 40 countries around the world;
- Until 2018, production took place in hall A (area - 7 405 m²);
- The project implementation was devided in 3 stages:
  - **Stage 1 and 2 – 2019- 2020:**
    construction of hall B (2 996 m²) and a part of hall C (9817 m²)
  - **Stage 3 – in progress**
    completion of hall C and the building MIDO (4 516 m² + 583 m²).

Project goal

Waste heat recovery from the production process for the purposes of space heating, ventilation and preparation of domestic hot water for company needs.

Phased expansion of the Terma plant

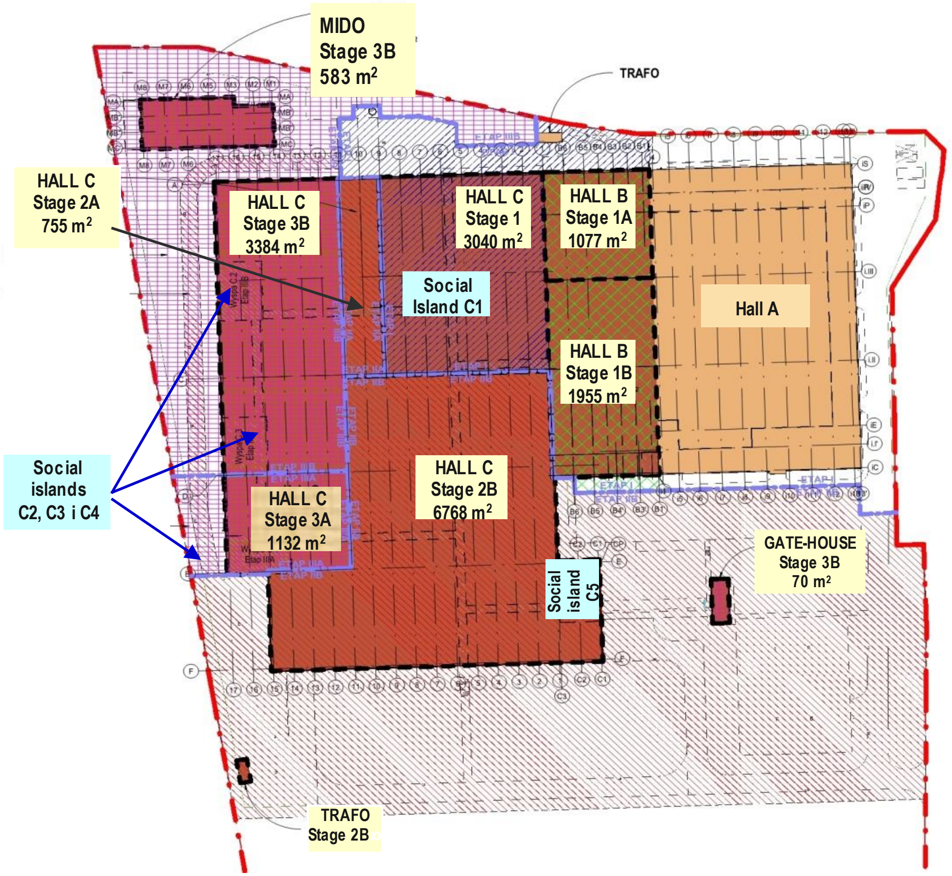


Figure 1: Phased expansion of the Terma plant.
Source: T. Żurek - on the basis of materials of Terma plant

Terma - Czaple, Poland

Basic assumptions of the project

- Use of waste heat from two soldering furnaces (each - 630 kWth) located in hall C;
  energy consumed by the soldering furnace:
  electricity (approx. 65%) + gas fuel (35%);
- The furnaces operate around the clock, practically throughout the year (breaks in operation - max 2 weeks per year).
- When operating at maximum power, the soldering furnaces generate heat at the level of 600 kWth each. Due to the variability of the production process, the average annual use of the equipment power is at the level of 65-70%.

Figure 2: View of the central part of the soldering furnace No. 1
Source: D. Formela – IMP PAN Gdansk

Terma - Czaple, Poland

Basic assumptions of the project

- Waste heat recovery system applies water as medium for:
  - heating of production halls 65/55 °C,
  - heating of social and office rooms 36/28 °C,
  - technological heat for ventilation systems 55/45 °C,
  - preparation of domestic hot water 45-50 °C.
- In summer and in the case of surplus of waste heat, heat gains from soldering furnaces are discharged outside to fan air coolers (dry coolers).

Figure 3: View of the loading and output parts of the soldering furnace No. 1
Source: D. Formela – IMP PAN Gdansk

Terma - Czaple, Poland

Adopted solutions for heat supply systems

1. **Space heating**
   - Radiant heaters:
     production rooms (hall B and C) and MIDO building workshop
   - Floor heating:
     social and office facilities
     (the so-called "islands" located in production halls).

2. **Ventilation systems**

   Ventilation systems with recuperation supporting social islands and working on the basis of water heaters.

3. **System of domestic hot water preparation**

   Domestic hot water tanks located in each social island in hall B and C.

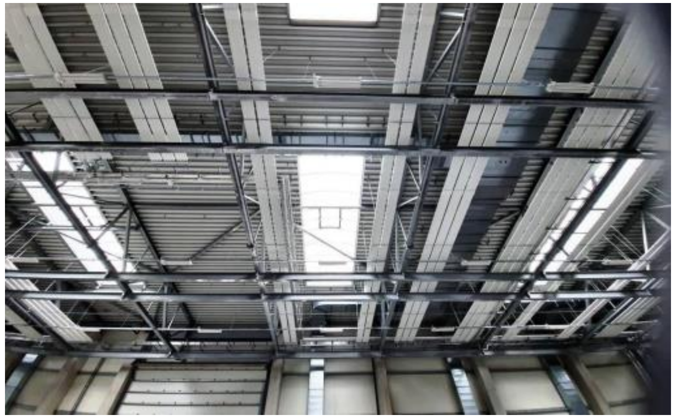


Figure 4: Radiant heaters in production halls of Terma plant.
Source: D. Formela – IMP PAN Gdansk

Figure 5: Domestic hot water heater in one of the social island.
Source: D. Formela – IMP PAN Gdansk

Terma - Czaple, Poland

Heat sources

1. **Basic source**

   Waste heat from soldering furnaces supplied to radiant heaters, floor heating, ventilation and domestic hot water preparation.

2. **Peak heat sources**

   a. **Gas boiler house on C4 island** supplying heaters in the production halls.
   b. **Air to water heat pumps in each social island** for ventilation and floor heating systems and preparation of domestic hot water.

3. **Gas boiler room**

   The main heat source for the MIDO building.

Terma - Czaple, Poland

General scheme of waste heat recovery and utilisation in the Terma plant

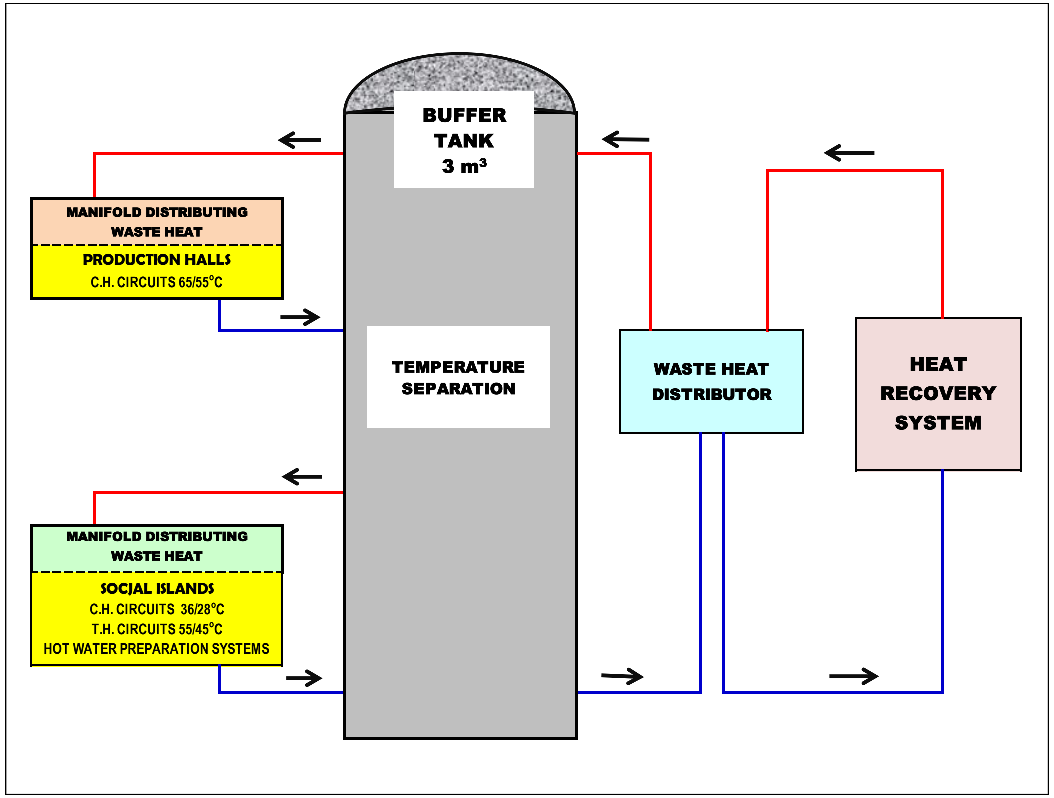


Figure 6: General scheme of waste heat recovery and utilisation.
Source: T. Żurek - on the basis of materials of Terma plant

- The waste heat from the soldering furnaces (at 65 °C) is transferred to waste heat distributor, and then to the buffer tank with a capacity of 3 m³.
- Temperature separation is designed enabling supply of various heating systems with medium at different temperatures: central heating circuits operating at 65/55 °C, technological heat circuits - 55/45 °C, floor heating circuits - 36/28 °C, hot water at 45÷50 °C.
- In the case of excess amount of waste heat, the surplus heat is dissipated by fan air cooler placed at the roof.

Figure 7: Waste heat recovery centre.
Source: D. Formela – IMP PAN Gdansk

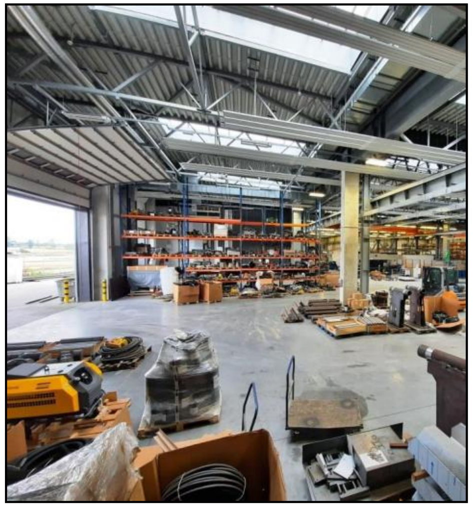
Figure 8: Buffer tank.
Source: D. Formela – IMP PAN Gdansk

Terma - Czaple, Poland

Use of waste heat potential

The amount of waste heat generated in soldering furnaces (on average - with furnaces operating at the level of 70% of nominal power)	**7 076 MWh/year**
The level of waste heat utilization	**39 %**

Table 1: The level of waste heat utilization.
Source: T. Żurek - on the basis of materials of Terma plant



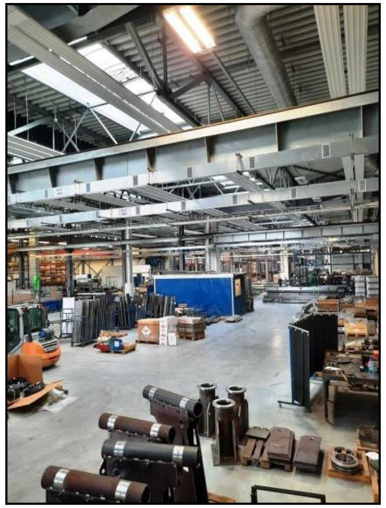


Figure 9: View of one of the production halls of Terma plants.
Source: D. Formela – IMP PAN Gdansk

Energy and economic efficiency of the project and ecological effects

The analysis carried out in relation to the alternative variant including the supply of heat for the production halls and office and social facilities based on a gas boiler room.

No	Name	Value	Units
1	**Avoided amount of additional energy consumption as a result of the project**	**2 362**	**MWh/year**
2	**Avoided amount of additional purchase of an energy carrier (natural gas)**	**246 982**	**m^3/year**
3	**Avoided additional purchase costs of an energy carrier (natural gas)**	**388,12** **88,13**	**thousand PLN** **thousand EUR**
4	**Ecological effects Avoided CO_2 emissions**	**tons of CO_2/year**	**471**
5	**Project cost**	**2 000,00** **454,13**	**thousand PLN** **thousand EUR**
6	**Simple period back time (SPBT)**	**5,15**	**years**

Table 2: Analysis of the project's energy and economic efficiency and environmental effects.
Source: T. Żurek – IMP PAN Gdansk

Terma - Czaple, Poland

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Conclusions

1. The production processes implemented at TERMA Sp. z o.o. require efficient cooling, that generates large amounts (above 7 GWh_{th}) of waste heat per year, which were previously discharged to surrounding through fan air coolers. The implemented project enables utilization of approximately 39% of the waste heat generated in soldering furnaces.
2. The waste heat recovery system applied in the company allows to meet the thermal needs for space heating and ventilation as well as the preparation of domestic hot water in newly built production halls, including social and office facilities.
3. As a result of the project implementation, large energy and economic effects are achieved in the form of additional energy carriers avoided by the company. At the same time, the project will have significant environmental effects in the form of avoided CO_2 emissions at the level of approximately 470 t CO_2/year.
4. The system is an example of the effective use of waste heat in low-temperature installations of the industrial sector.

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6. Waste heat utilization in Kalundborg (DK)

Is low temperature waste heat utilization at large distance (20 km) economically feasible?

Project profile

Topic	**Low temperature waste heat utilization at large distance**
Year of construction	Designed in 2017
Project leader	City of Kalundborg

Waste heat utilization in Kalundborg

Project background

- Kalundborg City: dense industrial sites; thus, a substantial amount of surplus (waste) heat

- Heat transfer – long distance
  20 MWc
  Tc ~ 300 K

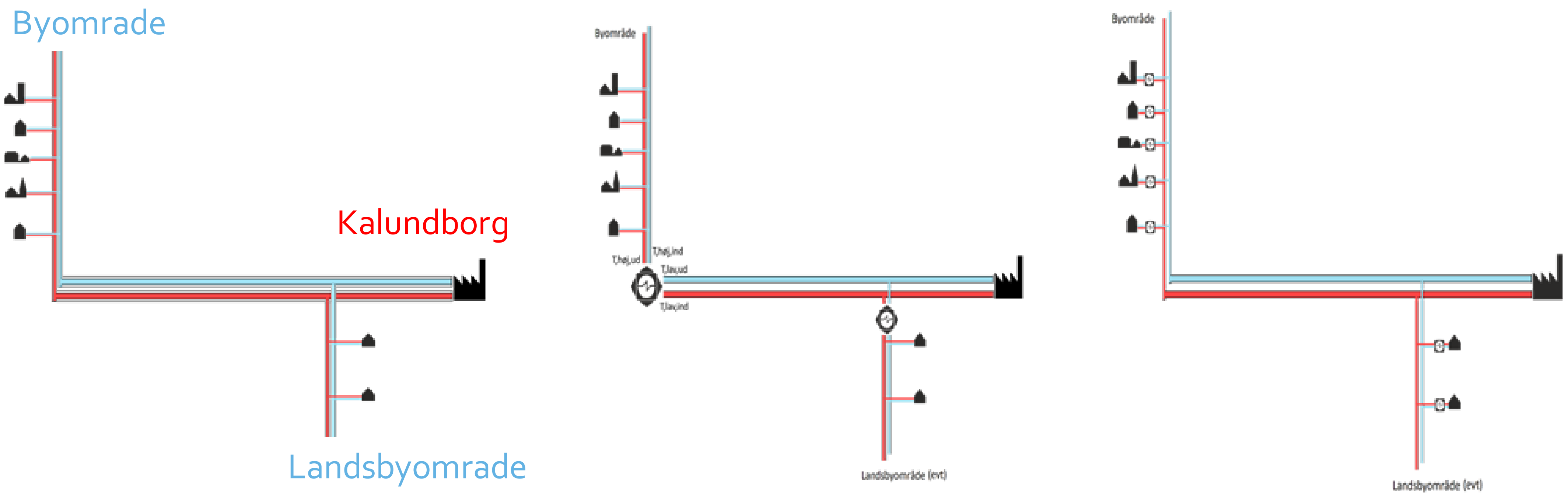
How long can the grid be economically viable?

Figure 1: Location of industrial heat sources. Source: Kalundborg Symbiosis [6.1]

Waste heat utilization in Kalundborg region

Three options

Figure 2: Three options. Source: Kalundborg Symbiosis



(1) Isolated transmission

(2) unisolated transmission + heat pumps

(3) unisolated transmission + individual heat pumps

KALUNDBORG SYMBIOSIS

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Waste heat utilization in Kalundborg region

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Scenario 2: PES + ISO + Central heat pump (low temperature)

Vary the yellow fields

Length of ISO pipes
L,ISO = 1.000 m

Total length of pipes
L,total = 20.000 m

Length of PEX pipes
L,PEX = 19.000 m

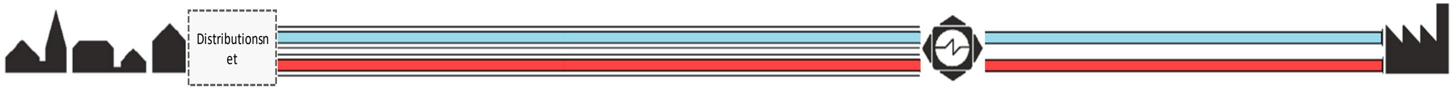
Out of residences
P,ud,bopæle = 8.840.025 W
T,ud,bopæle = 35 °C

Ud af byen
P,ud,by = 8.840.025 W
T,ud,by = 35 °C

Return to heat pump
P,høj,ind = 8.836.713 W
T,høj,ind = 35,0 °C

Return out of heat pump
P,lav,ud= 4.169.010 W
T,lav,ud = 8,1 °C

Return to source (factory)
P,fabrik,ind = 4.164.471 W
T,fabrik,ind = 8,1 °C



T,ind,bopæle = 75,0 °C
P,ind,bopæle = 18.934.692 W
In residences

T,ind,by = 75,0 °C
P,ind,by = 18.934.692 W
Ind i byen

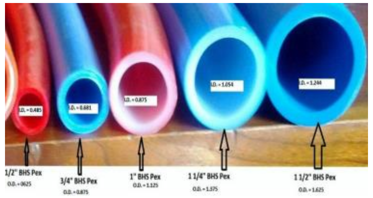
T,høj,ud = 75 °C
P,høj,ud = 18.942.911 W
Flow out of heat pump

T,lav,ind = 23,5 °C
P,lav,ind= 12.095.805 W
Flow into heat pump

T,fabrik,ud = 25 °C
P,fabrik,ud = 12.867.314 W
Out of source (factory)

P,netto by = 10.094.667 W
Allocated residences (Peak)
Peak dimensioning
Energi inkl. distr. t 10.094.667 Wh

P,netto vp = 7.926.796 W
Utilized by heat pump



P,netto by = 30.284.000.000 Wh
Allocated residences
Annual heat demand
Energi inkl. distr. t 30.284.000.000 Wh

= her findes/findes ikke i forvejen et distributionsnet med stikledninger

Figure 3: Scenario 2 of waste heat utilization. Source: Kalundborg Symbiosis

KALUNDBORG SYMBIOSIS

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Waste heat utilization in Kalundborg region

Transmission (Afsætter → Bygrænse)			
Prerequisites			
Efter at røret er blevet dimensioneret, må celle [E5] og [E7] ikke ændres			
Velocity PEX	c	2,000	m/s
Velocity, ISO	c	1,10	m/s
Flow, PEX	Q,pex, pipe	0,12	m3/s
Flow, ISO	Q,iso, pipe	0,06	m3/s
Pipe radius inner PEX	ri	0,1401	m
Pipe radius inner, ISO	ri	0,1324	m
Heat source temperature (to HP)	T,low,in	23,5	°C
Electricity consumption at peak, central heat pump		2.179.402	W
COP factor		4,64	W/W

Table 1: Exemplary results of calculations. Source: Kalundborg Symbiosis

Waste heat utilization in Kalundborg region

Conclusions

1. The obtained results have shown that the low temperature heat could be transferred over a distance of 20 km in an economically and ecologically justified manner (the result is, however, debatable).
2. In the presented case, the long distance (19 km) transmission was postulated to be performed using uninsulated pipe with a small temperature drop from 25 to 23.5 °C; the COP coefficient of the heat pump was calculated as near 5.
3. Kalundborg hasn't yet decided about the project implementation.
4. With the climate agreement, Danish parliament has removed excess heat taxes and heavy reporting requirements. The change in the law came into force on 1st January 2021 and may be decisive for the implementation of the project.

7. Industrial waste heat utilization from Hamburg Aurubis plant – HafenCity Hamburg (DE)

Waste heat utilization in a large city district

Aurubis AG, Hamburg

Topic	Industrial waste heat utilization for heating of the city
Year of construction	2017
Project leaders	Aurubis AG, enercity Contracting Nord GmbH, HafenCity Hamburg GmbH

Aurubis AG, Hamburg

Project background

- German global corporation **Aurubis AG**, headquartered in Hamburg is the world's leading provider of non-ferrous metals, especially the largest copper producer in Europe (the second largest in the world) and the largest copper recycler worldwide.
- The partners (including **enercity Contracting Nord GmbH**) committed to using industrial waste heat from the Hamburg Aurubis plant (located in the **Port of Hamburg**) to provide energy efficient district heating to **HafenCity East** (**7,500** apartments, approx. **15,000** residents in entire **HafenCity**, Hamburg's new urban area along the Elbe).

Goal

Use industrial energy resources – industrial waste heat

Figure 1: HafenCity (East) – currently Europe's largest inner-city development project. Source: Jan Gerbitz, ZEBAU, Germany

Copper smelting process and heat recovery

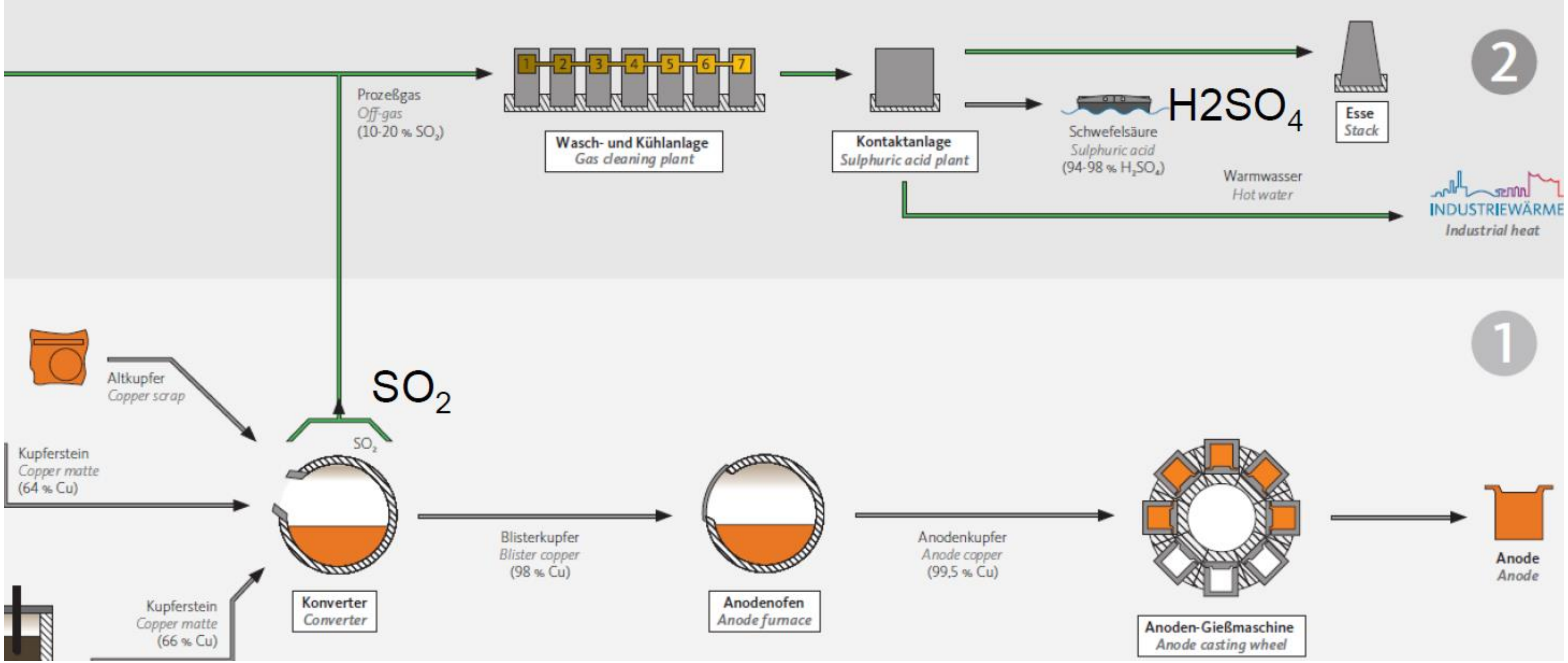

Figure 2: Production process diagram, including waste heat recovery in Hamburg Aurubis copper smelter. Source: Aurubis AG, after J. Beermann [7.1]

Aurubis AG, Hamburg

Heat is extracted during the Contact Process at the sulfuric acid plant (exothermic reactions, three steps). The temperature of the sulfuric acid is generally in the range **70-120 °C**. The sulfuric acid process in Hamburg Aurubis plant is adjusted to run at a temperature of **117 °C** (instead of 65 °C), because of district heating purposes – the supply temperature is **90 °C** and return is **60 °C**.

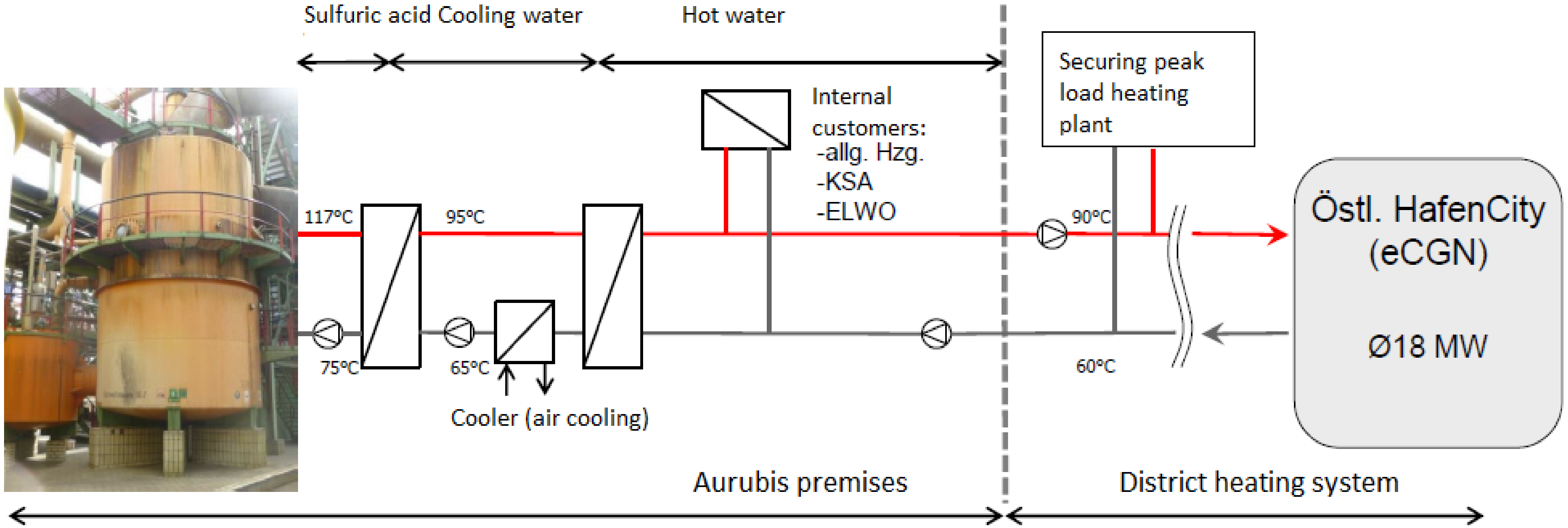

Figure 3: Scheme of sulfuric acid cooling and recovery of waste heat. Source: Ch. Hein [7.2]

Aurubis AG, Hamburg

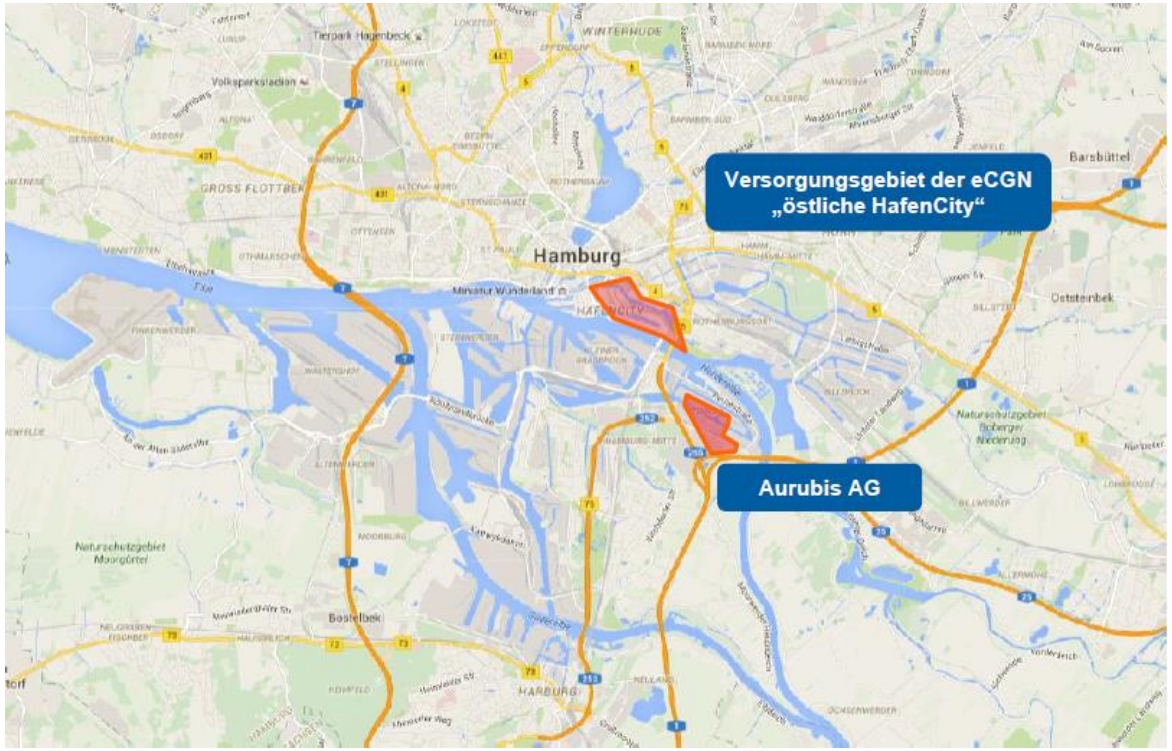

Figure 4: Location of the Aurubis plant and HafenCity. Source: J. Beermann [7.1]

Figure 5: District heating pipeline route from the Aurubis plant to HafenCity East.
Source: Aurubis AG, Hamburg [7.3]

Aurubis AG, Hamburg

Conclusions

- The Hamburg Aurubis plant has three production lines – primary smelting furnace daily capacity of 4000 t (input) and sulfuric acid plant of 3900 t (output), each of which could provide 160 GWh of thermal energy annually and 18 MW of thermal power (one line is sufficient to supply HafenCity East; the other two lines will also be converted in the future, once the technical, financial and contractual foundation has been established).

- Using it will save 20,000 t of CO_2 emissions per year, both through its use at HafenCity East and at the plant, by replacing the natural gas currently used to produce steam. In HafenCity East alone, with district heating system based on the waste heat from Hamburg Aurubis plant about 4,500 t of CO_2 will be saved every year by 2029.

- Annual sales of heat by enercity Contracting Nord GmbH for HafenCity East amounted to 70 GWh, while the thermal power – 28 MW in 2017 (104 GWh and installed thermal power of 100 MW for entire HafenCity).

8. Geothermal heat utilization in Geotermia Podhalańska Poland

Geothermic LTDH system operated by Geotermia Podhalańska

Project profile

Topic	The use of geothermal heat in LTDH system
Year of construction	1993-2020
Project leader	- PEC Geotermia Podhalańska S.A., Zakopane - Mineral and Energy Economy Research Institute of the Polish Academy of Sciences (IGSMiE PAN) in Kraków

Geotermia Podhalańska, Poland

Project background

- PEC Geotermia Podhalańska S.A. is currently **the largest heating company in Poland using the geothermal heat**;
- District heating system of PEC Geotermia Podhalańska operates in 4 municipalities: **Szaflary, Biały Dunajec, Poronin and Zakopane** (in the last it covers 40% of heat demand);
- The total length of the heating network is **over 110 km**;
- Nominal pressure - **16 bar**. The system is divided into 4 pressure zones due to the large difference in ground levels;
- Total installed capacity in the system - **80.8 MWt**;

  including power of the geothermal system - **40.7 MWt** (50%);
- Annual heat production - 450.6 TJ (2017), geothermal heat - **91%**;
- About **1600 buildings** connected to the heating network (75% are residential buildings).

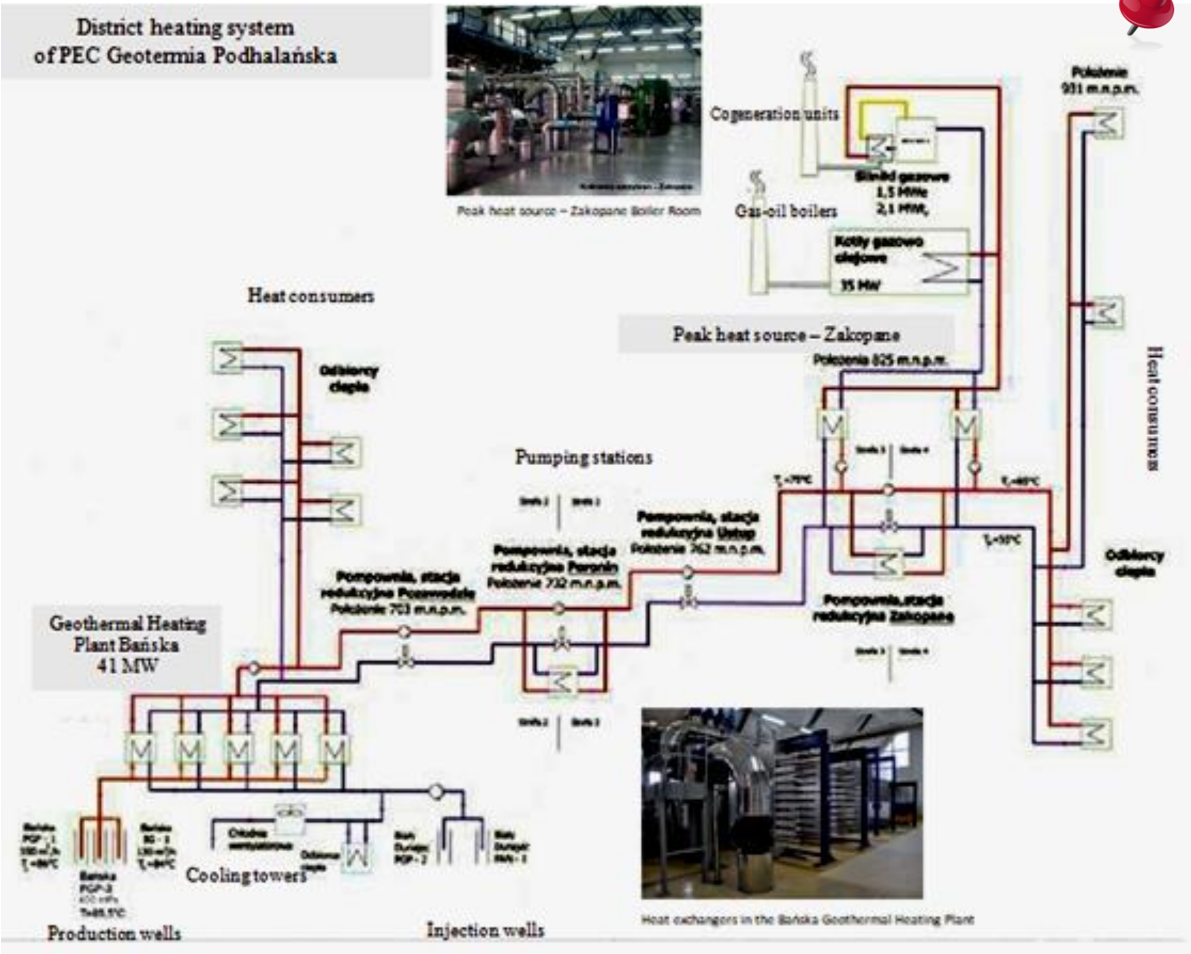

Figure 1: Scheme of DHS of PEC Geotermia Podhalańska. Source: News Press Renata Kluczna [8.1]

Geotermia Podhalańska, Poland

Project background

The current geothermal system includes the following elements:

- **production wells with capacity from 120 to 550 m³ / h** (Bańska IG-1, Bańska PGP-1, Bańska PGP-3)
- **injection wells with a capacity of 375 and 500 m³ / h** (Biały Dunajec PGP-2, Biały Dunajec PAN-1)
- **geothermal pumping station**
- **cooling towers.**

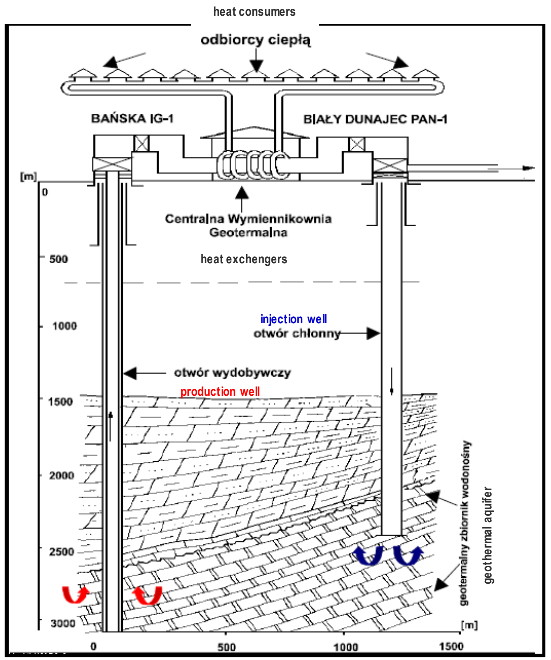

Figure 2: Geothermal installation operating on the basis of a doublet of wells. Sources: W. Bujakowski, [8.3]

Figure 3: Production and injection wells. Source: News Press Renata Kluczna[8.1]

Figure 4: Pumping station and cooling towers in DHS of Geotermia Podhalańska. Source: Multimedia presentation [8.2]

Thermal water at a temperature of 82-86°C is extracted from the deposit through production wells, and then through plate heat exchangers installed in the Geothermal Heating Plant heats the network water used for heating buildings, swimming pools and for the preparation of hot utility water.

After cooling in the heat exchangers, thermal water is forced back into the bed through injection wells, and partly cooled it is also discharged into a surface watercourse.

Geotermia Podhalańska, Poland

Efficiency of using geothermal heat

The heat used for the space heating and domestic hot-water preparation (in residential and public buildings) constitutes only about 22% of the energy extracted from the production wells.

Project goal

Testing the possibility of more efficient use of geothermal heat by using it in low-temperature installations of various industry sectors.

Implementation of the project

Construction of a cascade system for the use of geothermal heat on the premises of the Mineral and Energy Economy Research Institute of the Polish Academy of Sciences

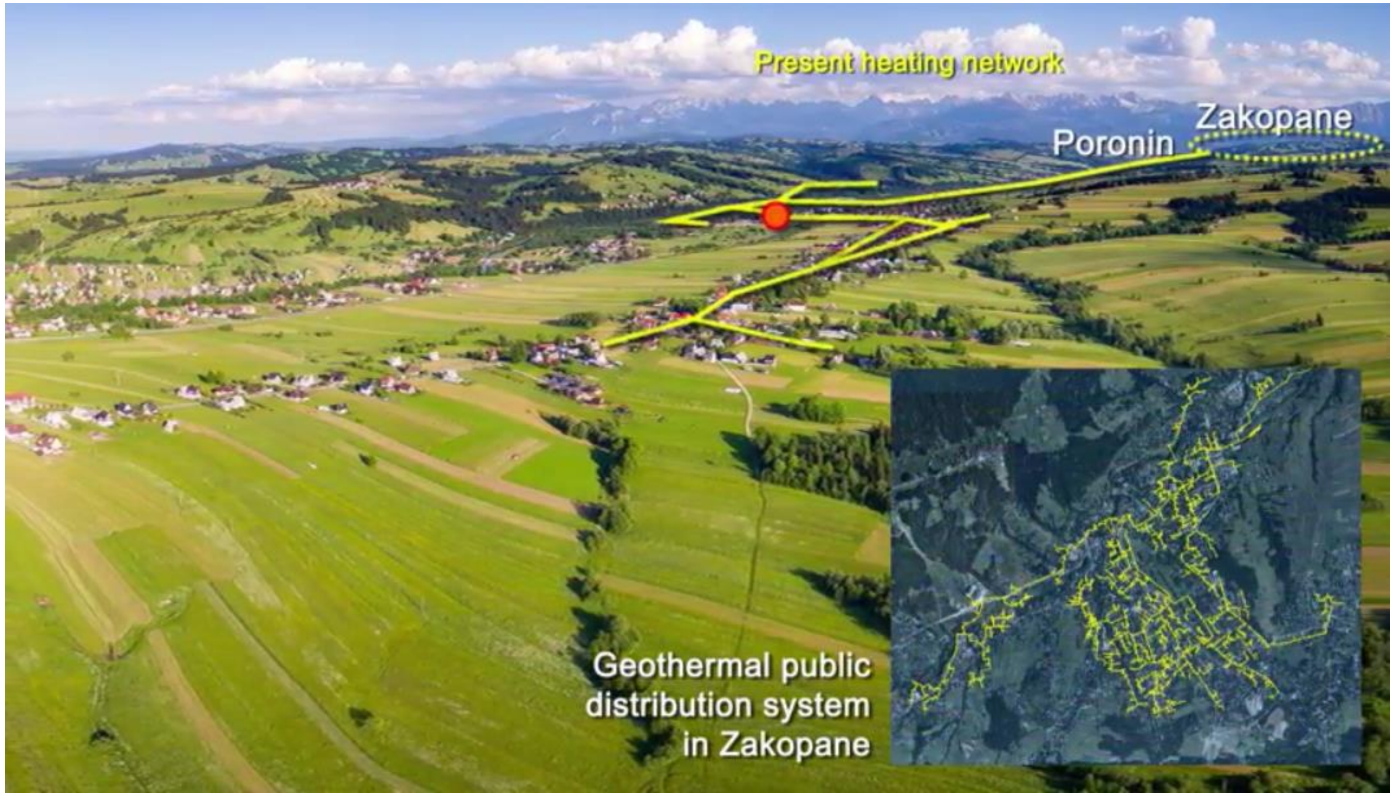

Figure 5: Geothermal DHS in Zakopane. Source: Geotermia Podhalańska [8.4]

Geotermia Podhalańska, Poland

Basic assumptions of the project

Cascade system for the use of geothermal heat

The project enabled demonstration and testing the possibility of multidirectional use of geothermal heat in installations using lower temperature sources.

It was based on the secondary heating water circuit and provided example of 5 steps system for LT heat use.

Step I	-	Geothermal heating network supplying heat for space heating and domestic hot water preparation in residential buildings and public facilities
Step II	-	Wood dryer
Step III	-	Window sill greenhouse for growing vegetables and ornamental plants
Step IV	-	Breeding of thermophilic fish
Step V	-	Foil tunnels for growing vegetables in heated soil

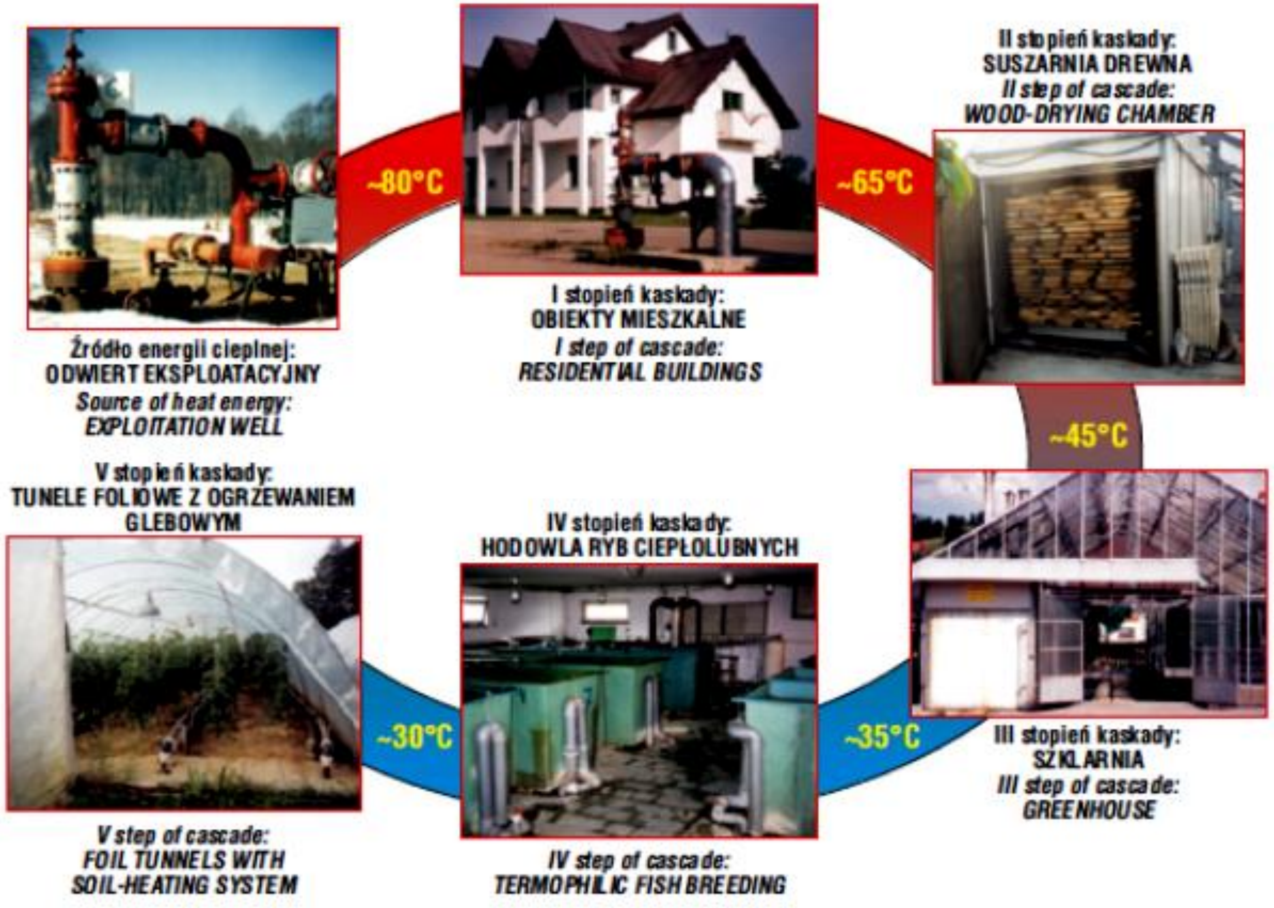

Figure 6: Cascade use of geothermal energy. Source: W. Bujakowski [8.5]

Geotermia Podhalańska, Poland

Pilot project: Conclusions

1. The use of geothermal heat in the Geotermia Podhalańska company has reduced CO_2 emission by about 600,000 tons during 25 years of system operation (a fact of great importance due to the location of 4 national parks in Podhale region).
2. Thermal heat used for the needs of space heating and preparation of domestic hot-water for consumers (residential and public buildings) constitutes only about 22% of energy extracted from the production wells. The surplus heat can be used in other LT systems.
3. The cascade system used in the Mineral and Energy Economy Research Institute of the Polish Academy of Sciences shows the possibilities of more efficient use of geothermal heat in various industry sectors.

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9. Conclusions

Conclusions

- Usage of surplus heat from large facilities, like the research facilities in Brunnshög, are a good opportunity to heat a larger district with fossil-free energy but this is only possible in specific areas where enough heat can be provided.
- In Brunnshög, so much heat is produced, that heating of public grounds like bus stops is considered as well, demonstrating that heat is important in every aspect of private and public life.
- In various companies there are available surplus (waste) heat sources which can be used for local DH network.
- Heat produced by the solar thermal (also private) systems can be fed into the district heating network.
- Equipping buildings with large-scale solar systems and corresponding storage tanks can be an economically viable alternative to connecting them to a centralized district heating network.
- Geothermal heat is an alternative way to supply the LTDH systems.
- Battery systems for photovoltaic panels increase the amount of electricity that is self-consumed.

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Contact

ZEBAU GmbH

Jan Gerbitz
Team Leader GoA 6.3

Große Elbstraße 146
22767
Hamburg

E-mail: jan.gerbitz@zebau.de
Tel: +49 40 380 384 - 0
www.zebau.de
www.lowtemp.eu

IMP PAN

Prof. Adam Cenian
E-mail: cenian@imp.gda.pl
Project Leader

Dr Teresa Żurek
E-mail: tzurek@imp.gda.pl
Dr Mieczysław Dzierzgowski
E-mail: mieczyslaw.dzierzgowski@pw.edu.pl
Jarosław Łosiński
E-mail: jlosinski@imp.gda.pl

14 Fiszera Str.
80-231 Gdańsk
Tel: +48 58 5225 276
www.imp.gda.pl
www.lowtemp.eu