Intro Energy Supply Systems and LTDH

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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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1. Energy Supply Systems

Energy sources

Developments and trends

Energy Supply Systems

Energy sources (Fossil and renewable):

- Oil
- Gas
- Coal
- Nuclear energy
- Solar energy
- Wind energy
- Geothermal energy
- Hydro energy
- Biomass
- Waste heat
- Heat recovery
- …

Figure 2: Solar energy. Source: RoyBuri [2]

Figure 1: Wind energy. Source: Al3xanderD [1]

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Energy Supply Systems

Facts and numbers:

- Heating accounts for **more than half** of total energy consumption in households
- DH networks can have high heat losses:
  - Advanced networks 5-15%.
  - Old networks up to **30%** or beyond.

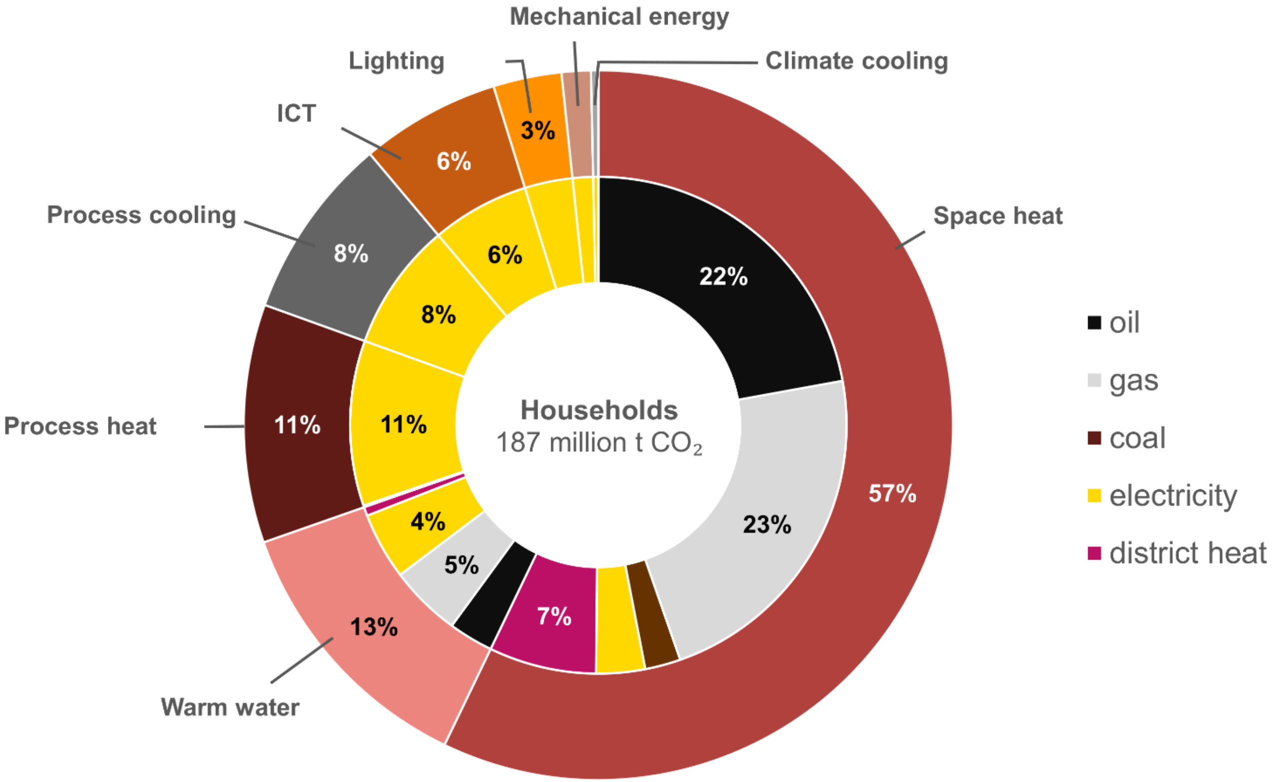

Figure 3: Emmissions cased by domestic sector in Germany in 2014. Source: J. Conrad, S. Greif [3]

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Total primary energy supply (TPES) by source, European Union 1990 -2017

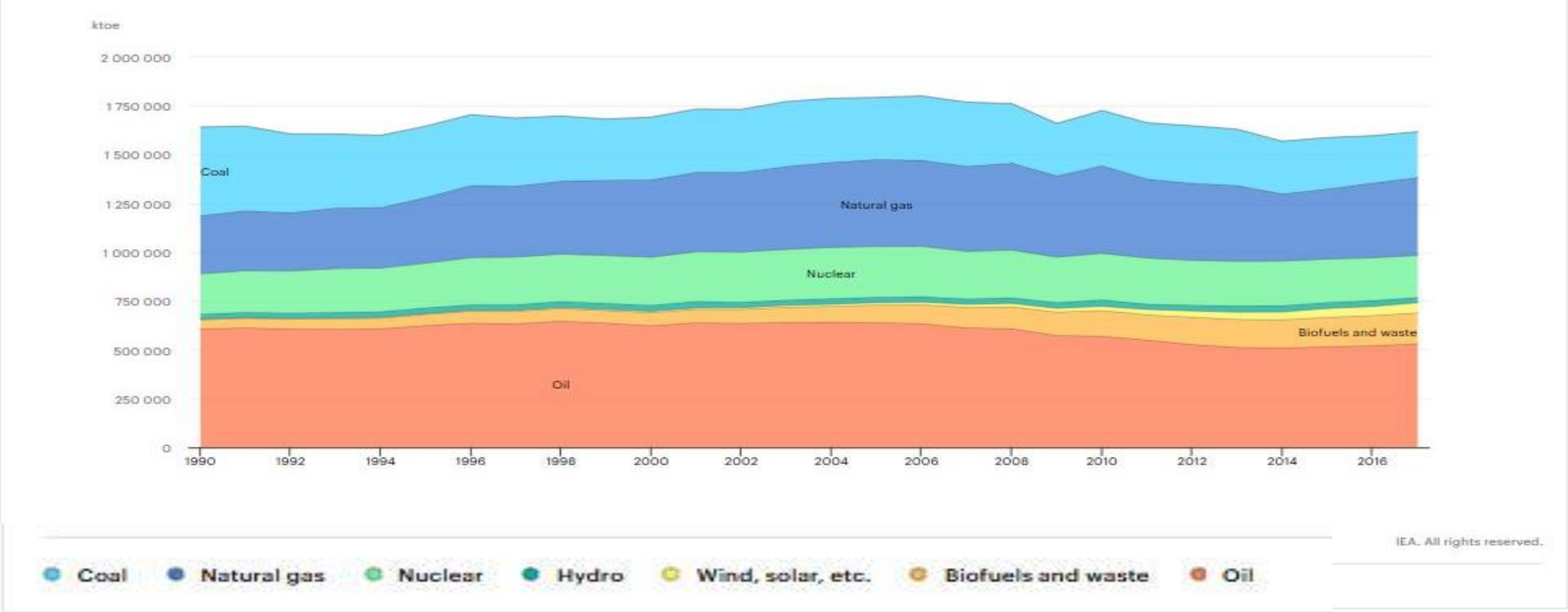

Figure 4: Total primary energy production by source, European Union. Source: IEA [4]

Energy Supply Systems

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Facts and numbers:

- In 2019 still more than half of the sales for heating equipment were fossil fuel based!

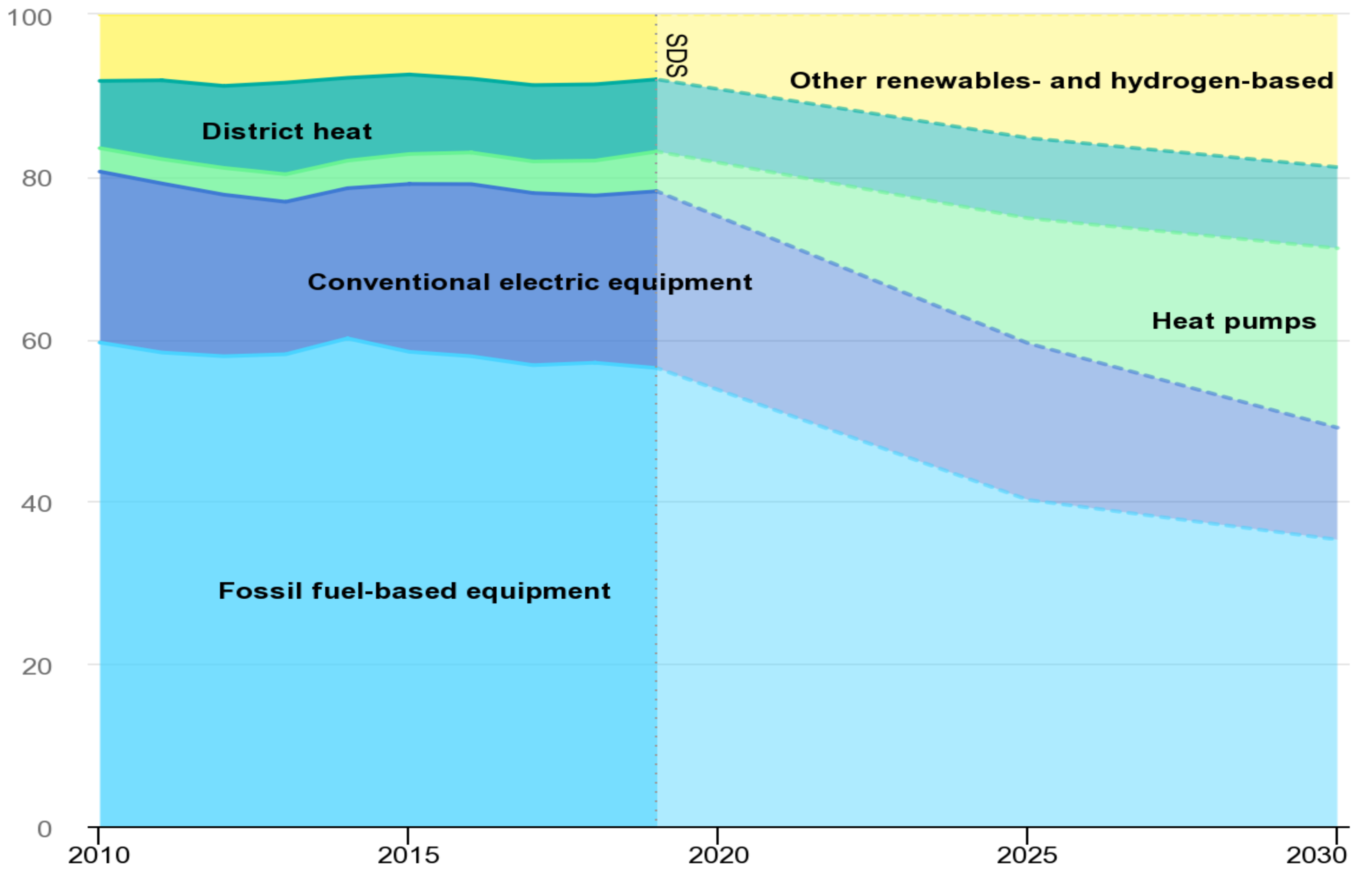

Figure 5: Technology sales in heating equipment 2020 to 2030 projection. Source: IEA [5]

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Energy Supply Systems

Developments and trends

- The energy supply systems have changed significantly over the last 100 years
- Trend towards sustainable and more efficient systems
- District heating makes up 25% in new homes in germany, compared to 14% in all german homes

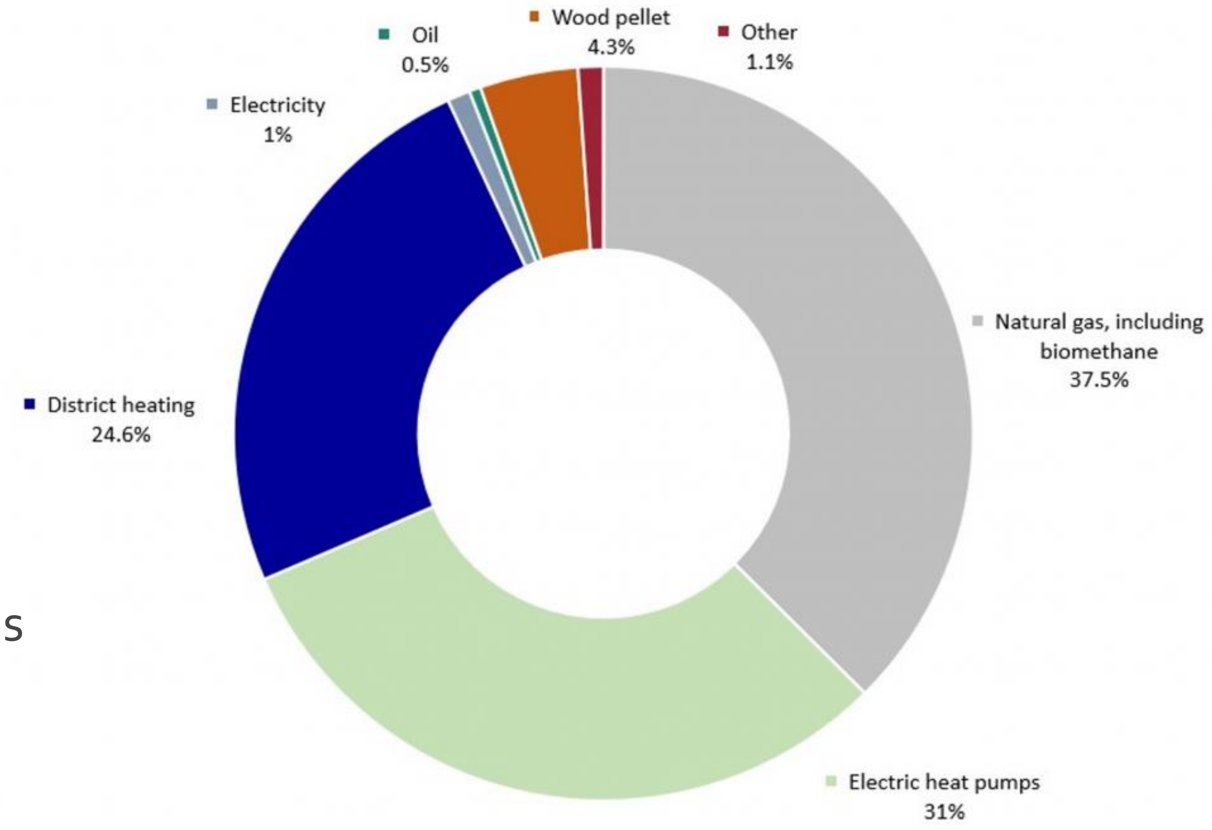


Figure 6: Heating sources in new german homes 2019. Source: BDEW [6]

Energy Supply Systems

Fuel	Mechanism	System efficiency	Fuel carbon factor gCO_2/kWh in 2020	Emissions vs natural gas
Coal	combustion	75%	321	+98%
Biomass	combustion	75%	305	+88%
Oil	combustion	85%	247	+34%
LPG	combustion	85%	215	+17%
Natural gas	combustion	85%	184	-
Direct electric	resistance	100%	136	-37%
Electricity / ASHP	heat transfer	240%	136	-74%
Electricity / GSHP	heat transfer	340%	136	-82%
Electricity / GSHC	heat transfer	540%	136	-88%
Green Electricity / GSHC	heat transfer	540%	-	-100%

Figure 7: Relative Carbon Emissions of heating systems. Source: BEIS [7]

2. Low Temperature District Heating (LTDH)

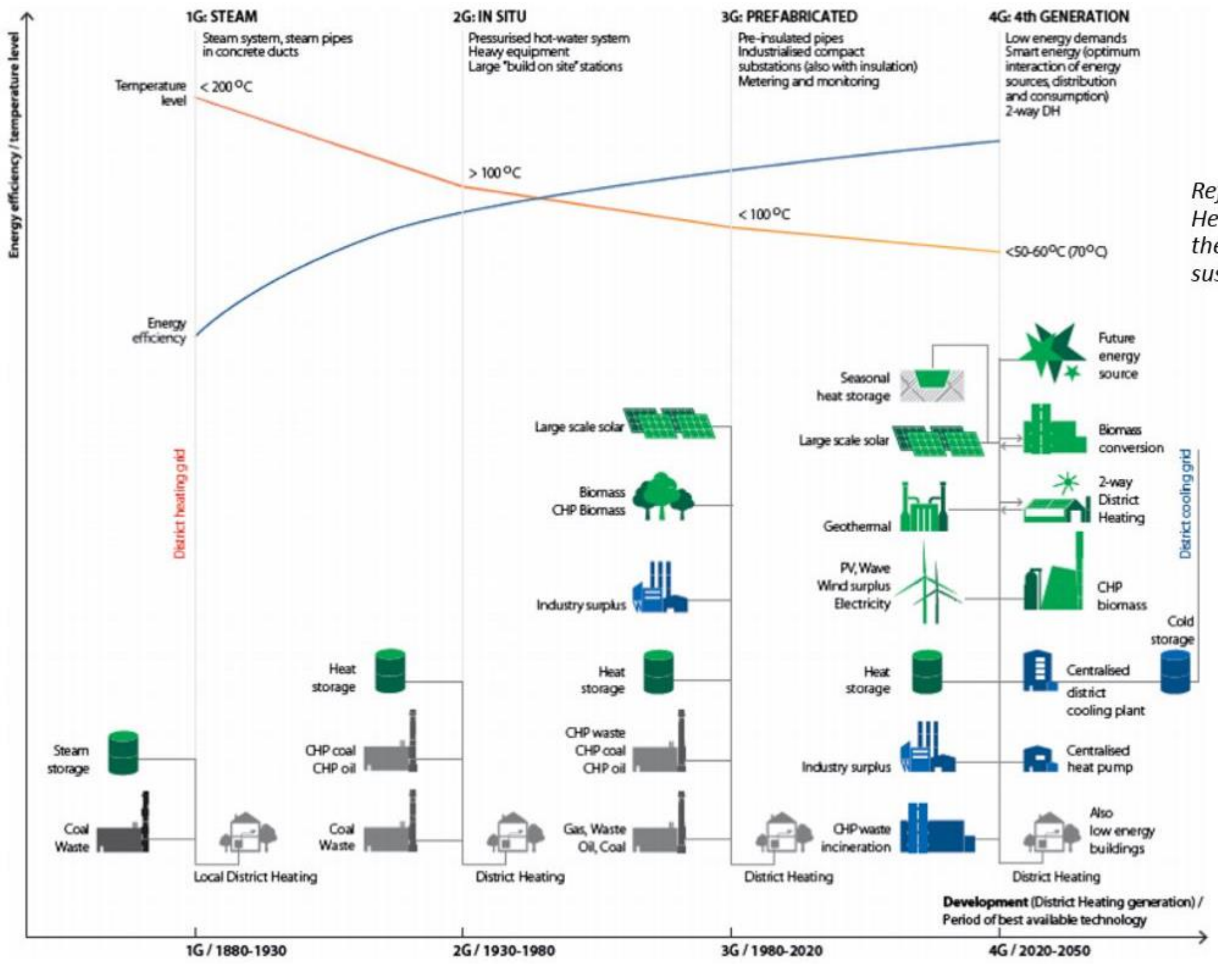
The history of disctrict heating

Current systems and applications

District Heating History

Generation	Temperatures	Sources	„Consequences"
1st Generation 1880-1930	steam < 200°C	Coal steam boilers and some CHP plants	
2nd Generation 1930-1980	> 100°C	Coal and oil based CHP and some heat-only boilers	
3rd Generation 1980-	< 100°C	Large-scale CHP, distributed CHP, biomass and waste incineration	Lower pressure, integration of several sources possible
4th Generation	below 50 - 70°C	More renewable sources and surplus heat	Well insulated buildings, low temp heating installations, new ways of hot water production

District Heating History



Ref. Article: 4th Generation District Heating (4GDH) Integrating smart thermal grids into future sustainable energy systems

Figure 8: District heating generations timeline. Source: H. Lund et al. [8]

EMD International A/S
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Disadvantages of existing District Heating Systems

- Current "3rd Generation" of district heating systems, characterized by:
  - still predominantly use of fossil fuels
  - long transport routes of high temperatures leads to heat loss = lower efficiency than locally generated heat
  - Possible monopoly position of suppliers (lack of competition, long-term contractual obligations, ...)
  - Not adapted to higher energy efficiency standards in buildings

Figure 9: Coal. Source: OnzeCreativitijd [9]

Figure 10: Air pollution. Source: SD-Pictures [10]

Advantages of the „4th Generation“ systems

- LT heat supply network with reduced feed (55 ° C to 70 ° C) and return temperatures (25 ° C to 40 ° C)
  - Low-temperature district heating networks can make a significant contribution to the sustainable and efficient use of energy resources
  - Adaptation to the requirements of lower heating temperatures in the areas of energy-efficient buildings, which means a considerable reduction of heat demand
  - Optimized integration of renewable energy sources (geothermal and solar energy) and industrial waste heat
  - Reduced heat loss in pipes through improved insulation and lower network temperatures

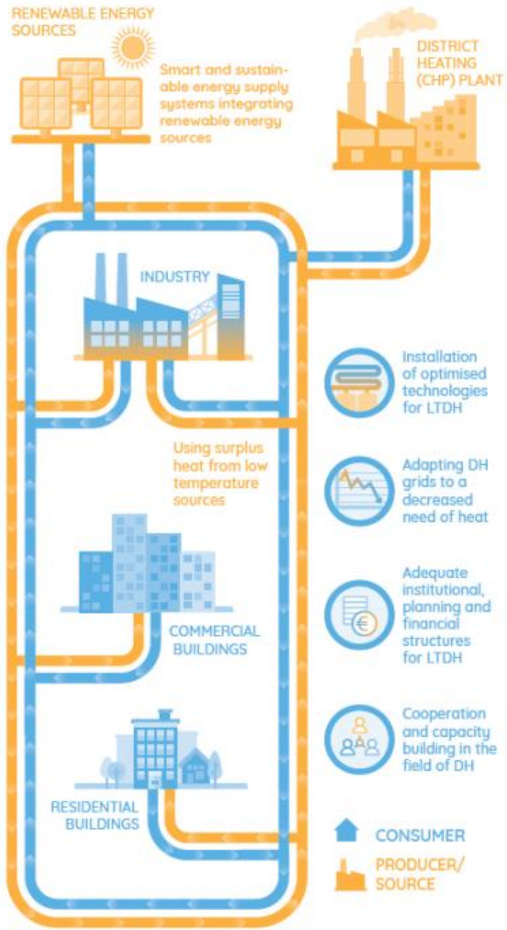

Figure 11: LowTEMP project scheme
Source: LowTEMP project [11]

District Heating – indirect or direct systems

- Direct or indirect district heating supply possible
- Direct district heating supply: the heat transfer medium of the supplier also flows through the house system. Requires less space in the house connection room than an indirect system.
- Indirect district heating supply: heat exchanger separates the house network from the supplier's network. Hot drinking water is always produced indirectly, whereby both, the district heating water and the heating water from the house system, can be used for heating.
- The decision for a direct or indirect connection to the district heating network is usually made in the guidelines of the district heating supply company

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District Heating – indirect or direct systems

- Differences between direct and indirect systems:

Direct System	**Indirect System**
Supply-side flow temperature = maximum consumer-side flow temperature	Maximum flow temperature can be manually set by the consumer
Central heating water replenishment of the heating system	Decentral heating water replenishment of the heating system is necessary
There is no hydraulic and heating system separation upstream	There is a hydraulic and heating system separation upstream
Base station is functional without electrical components	Electrical supply line is required

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Direct systems

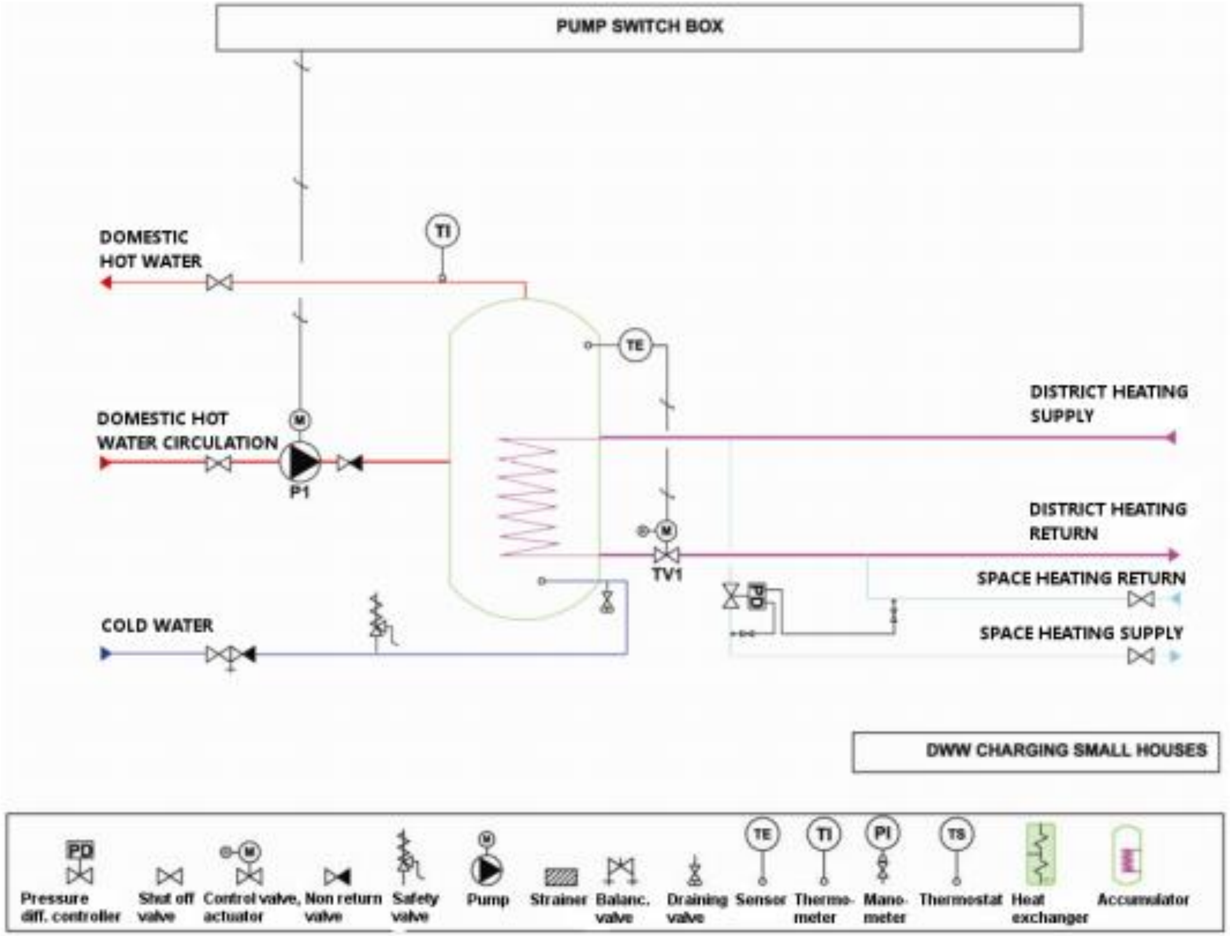

Figure 12: Direct heating systems. Source: Euroheat & Power [12]

Indirect systems

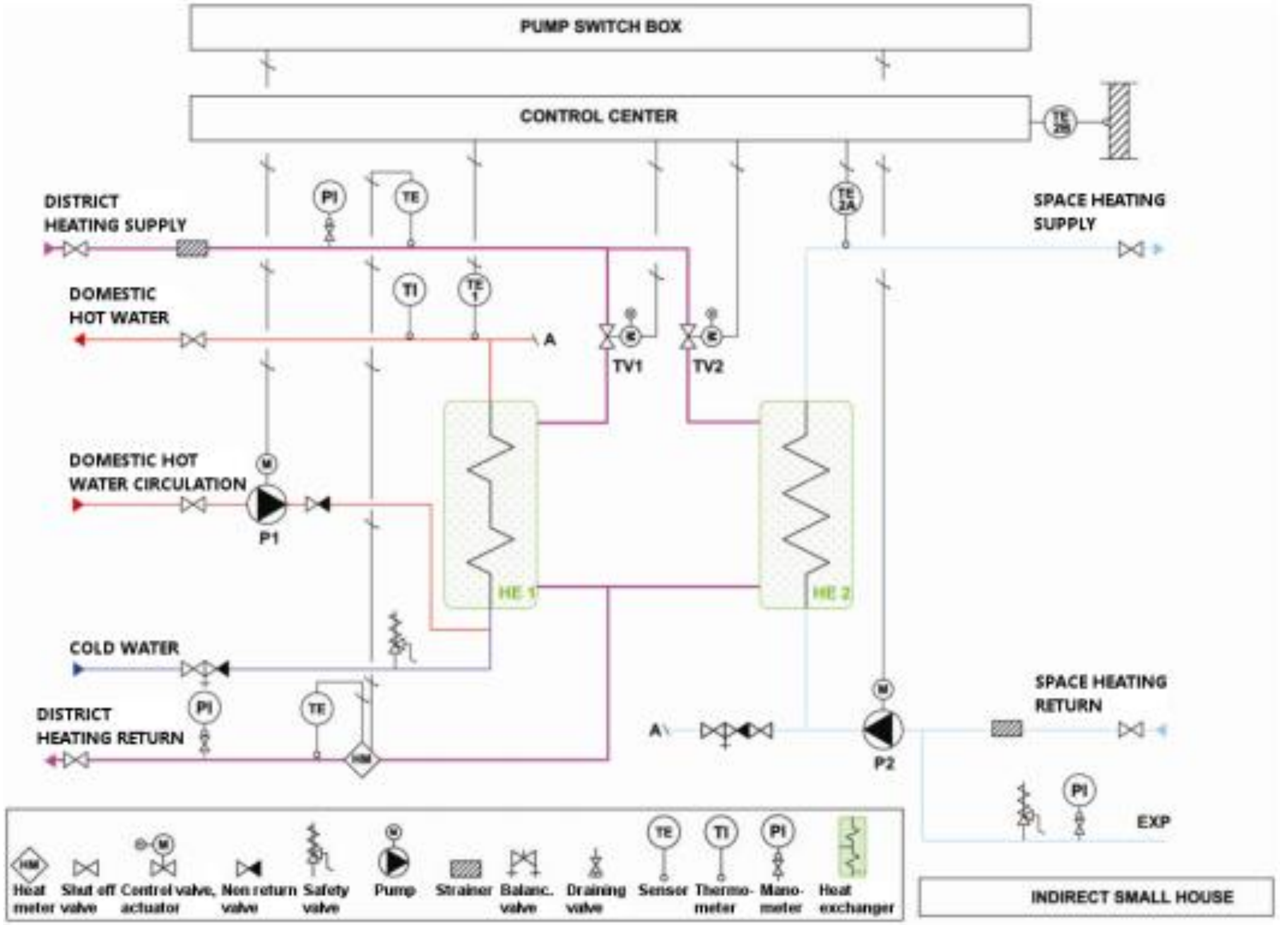

Figure 13: Indirect heating systems. Source: Euroheat & Power [12]

iGRID temperature zones solution

Goal

In the direct DH system, it is possible to lower temperature locally for a chosen customer or a city district by application of a mixing shunts techniques. One example is the Grundfos iGRID temperature zones solution equipped with the Grundfos Temperature Optimisation (GTO) units

Grid Schemes

Schemes of DH grids before and after iGRID system implementation are presented in Fig. 9.

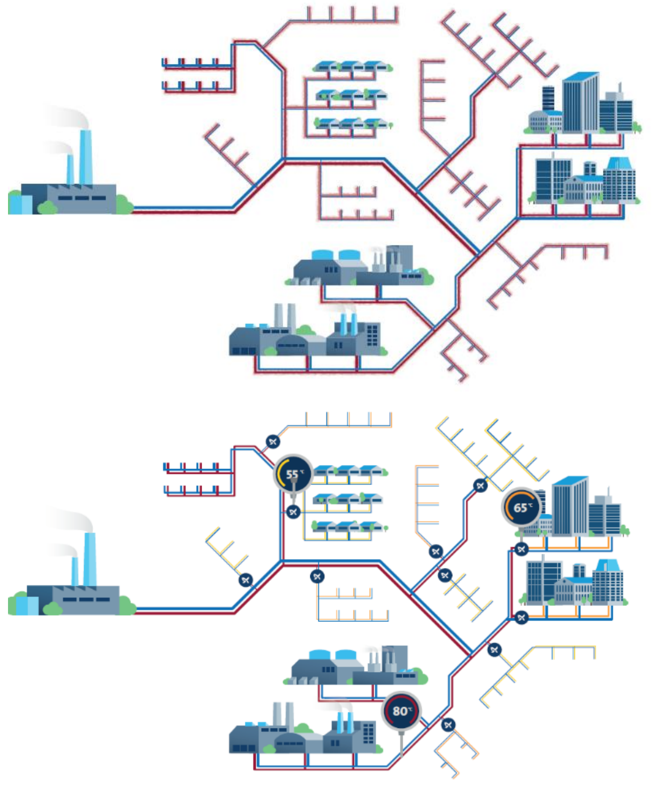

Figure 14: Scheme of DH grids before and after Implementation of **iGRID** system. Source: Grundfos [13]

iGRID temperature zones solution

The units

a mixing loop that takes water from the return line and shunts it into the supply, to lower the temperature to the required level in any given network zones. They are produced in various configurations,

Free flow solution uses two pumps. The pump in supply line adjust required pressure in flow line. The pump in the string between the flow and return pipes adjusts secondary flow temperature to the required level. This configuration eliminate pressure losses and assures high reliability.
Shunt pump solution utilize the pressure from the main grid pumps. Efficiency grows through the decrease of supply temperature by mixing supply and return flows. Here it is not possible to lower pressure locally by the solution is easy to implement, reliable and reduce losses on valves.

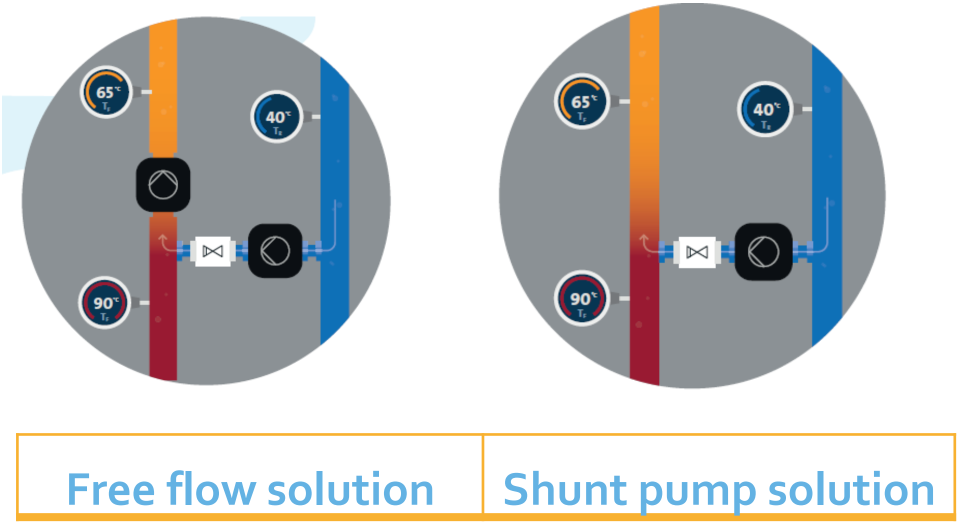

Figure 15: The Grundfos Temperature Optimisation (GTO) units in various configurations. Source: Grundfos [13]

iGRID temperature zones solution

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Pilot implementation of lowtemperature zone in Copenhagen

The temperature zones solution was applied to decrease average supply temperature (for a district of single and multifamily houses) from **79°C** do **60°C** – see Fig. 11**.** Before the implementation, the nominal supply temperature in the whole grid was **110°C.**

Annual customer heat demand: 9 000 MWh	Before implementation	After implementation
Average temperature (supply/return) [°C]	79/ 48	60/ 38
Distribution losses [MWh]	2 570	1 950
Additional energy use by grid pumps [MWh/rok]	0	14,0

Effects: distribution losses decrease by 24%,
CO_2 reduction: 47 tonnes,
simple payback time: 3 years

Figure 16: Low temperature grid-zone implementation in Copenhagen area. Source: Grundfos [13]

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3. Research and Projects

Heating Roadmap Europe

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Aarlborg Studies

Heat Roadmap Europe

- Consortium of 24 partners from research, education, industry and legislation
- A series of studies since 2012 focused on low carbon heat systems
- First pan-European Thermal Atlas (Peta) of heating and cooling demand in Europe
- Roadmaps for decarbonization of the heating sector for 14 EU countries that cover 80% of emissions together.
- More heat is wasted by electricity production in Europe than needed for the total heating demand!
- Research is openly availabe – enabling other studies to use the tools and models for new studies
- Funded by Horizon 2020 – EU Budget for Climate Action

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Aarlborg University Studies

- Largest research center of its kind with over 400 researchers involved
- Studies concerning district heating and low carbon solutions
- Collaborations with public and private companies for application oriented solutions
- Leading Partner for 4^{th} Generation district heating
- Flow Laboratory and Thermal Systems Components Laboratory
- #1 in Europe and #8 globally in engineering research (US News & World Report 2018)

LowTEMP Project

- EU funded research project in the Baltic Sea Region (BSR)
- 24 project partners from 8 countries
- Sharing Information with neighboring countries development of a modelling tool, which helps municipals in decision making concerning district heating
- Seminar materials for expert training
- Knowledge Platform with best practice examples

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4. Potential and Outlook

2050 Roadmap

2050 Roadmap

- EU goal for 2050 is to be carbon neutral
- Reducing emissions, increasing energy efficiency and introducing renewables
- LTDH has great potential to integrate renewable and low carbon energy sources
- It is very efficient – little heat loss and waste heat
- Distribution covered with a mix of centralised and decentralised sources – reliable

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