Annex TS1

Low Temperature District Heating
for Future Energy Systems

IEA DHC Annex TS1: Low Temperature District Heating for future Energy Systems

Proceedings of the Industry and R&D Workshop

# "Realization of Innovative Low Temperature District Heating Systems in Communities"

## April 21st, 2016, Frankfurt am Main, Germany

Organized by
German Heat & Power Association – AGFW e.V.
and
Fraunhofer Institute for Building Physics, Germany

# Index

**LOW TEMPERATURE DISTRICT HEATING TECHNOLOGIES FOR FUTURE ENERGY SYSTEMS:**

Contribution of IEA DHC Annex TS1 to the 22nd international trade fair and congress for heating, cooling and CHP, April 19-22, 2016. Messe Frankfurt/Main / Germany

Thursday, April 21, 2016. 10:00 – 12:00. Level 0, Room "Europa 1"

Session title:

Realization of innovative low temperature district heating systems in communities

What kind of session:

**Industry workshop** (120min)

Short description of the technology/application

Low temperature district heating offers a fairly easy and cost effective way to realize a fossil free heating system compared to solutions based on renewable energy production on each building. The utilization of low network temperatures is an economically competitive approach to the heating energy supply of communities because of the easy integration of inexpensive renewable or waste heating energy into the supply systems. The workshop enables the exchange of knowledge and viewpoints form district heating and building technology experts with respect to overcome the technical barriers for a further development of this promising technology by discussing innovative technology options and presenting case studies form a number of countries. This workshop is organized by the joint research group of the international Energy Agency District Heating and Cooling program, the Annex TS1 on "Low Temperature District Heating for Future Energy Systems" www.iea-dhc.org.

Chairperson (name/affiliation)

**Dr. Dietrich Schmidt**
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List of contributions (titles and authors/presenters)

*Successful Implementation of Low Temperature Heating Systems in Communities*
Dr. **Dietrich Schmidt**, Fraunhofer IBP, Germany (Coordinator)

*Technologies for District heating with low Temperatures*
Prof. **Svend Svendsen**, DTU, Denmark (ST leader: Technologies)

*Latest generation of district heating – Technology perspectives*
**Andre Hansen**, DANFOSS, Denmark/Germany

*Technical, ecological and environmental Evaluation of different district heat supply and space heating concepts*
Dr. **Markus Blesl**, University of Stuttgart, Germany (ST leader :Tools)

*District heating interfaces for enabling integration of low temperature and distributed energy sources.*
**Tymofii Tereshchenko**, NTNU, Norway

Related (IEA) project:

IEA DHC Annex TS1:
"Low Temperature District Heating for Future Energy Systems"
www.iea-dhc.org

## DHC Annex TS1: Low Temperature District Heating for Future Energy Systems

**Industry and R&D Workshop on "Realization of Innovative Low Temperature District Heating Systems in Communities"**
**April 21st, 2016**
**Frankfurt Fair and German Heat & Power Association**
Stresemannallee 30
60596 Frankfurt am Main
Germany

Organized by:
**Fraunhofer Institute for Building Physics, Germany & German Heat & Power Association AGFW, Germany**

## Meeting Program (Short Version)

The industry and R&D workshop is targeted on "**Realization of Innovative Low Temperature District Heating Systems in Communities**". In the course of the workshop exchange of information and discussion on the latest developments in the field of research on is aimed.

### At Frankfurt Fair: Level 0. Room Europa 1

⇨ Messegelände-Halle 4.0; Ludwig-Erhard-Anlage 1; 60327 Frankfurt/Main; Germany

### Thursday, April 21st, 2016

**10:00** **Industry and R&D Workshop on " Realization of Innovative Low Temperature District Heating Systems in Communities "**
(Chairman: Dietrich Schmidt, IBP Germany)

- **Successful Implementation of Low Temperature Heating Systems in Communities**
(Dietrich Schmidt, Fraunhofer IBP, Germany)
- **Latest generation of district heating – Technology perspectives**
(Andre Hansen, DANFOSS, Denmark)
- **Technologies for District heating with low Temperatures**
(Svend Svendsen, DTU, Denmark)
- **Technical, ecological and environmental Evaluation of different district heat supply and space heating concepts**
(Markus Blesl, University of Stuttgart, Germany)
- **District heating interfaces for enabling integration of low temperature and distributed energy sources**
(Tymofii Tereshchenko, NTNU Trondheim, Norway)

**11:45** **Discussion and networking**

**12:00** **End of industry and R&D workshop**

# Realization of Innovative Low Temperature District Heating Systems in Communities

An Activity of the IEA DHC Annex TS1:
“Low Temperature District Heating for Future Energy Systems”

22nd International Trade Fair and Congress for Heating, Cooling and CHP
Messe Frankfurt/Main, Germany - April 21st 2016

INTERNATIONAL ENERGY AGENCY IMPLEMENTING AGREEMENT ON
District Heating and Cooling including Combined Heat and Power

# Today’s Program

- Successful Implementation of Low Temperature Heating Systems in Communities
  *Dr. **Dietrich Schmidt**, Fraunhofer IBP, Germany*
- Latest Generation of District Heating – Technology Perspectives
  ***André Hansen**, Danfoss, Denmark/Germany*
- Technologies for District Heating with Low Temperatures
  *Prof. **Svend Svendsen**, Technical University of Denmark DTU, Denmark*
- Technical, Ecological and Environmental Evaluation of Different District Heating Supply and Space Heating Concepts
  *Dr. **Markus Blesl**, IER Stuttgart University, Germany*
- District Heating Interfaces for Enabling integration of Low Temperature and Distributed Energy Sources
  ***Tymofii Tereshchenko**, Norwegian University of Science and Technology, Norway*

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# Successful Implementation of Low Temperature Heating Systems in Communities

22nd International Trade Fair and Congress for Heating, Cooling and CHP
Messe Frankfurt/Main, Germany - April 21st 2016

**Tekn. Dr. Dietrich Schmidt**
**Fraunhofer Institute for Building Physics**, Germany

Fraunhofer IBP

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# Future developments in our cities?


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## Challenges in the energy sector

- Buildings/cities are main users of energy
- New buildings shall be developed as small power stations!
- Retrofit rates need to be increased!
- Developments are focusing more and more on a community level.


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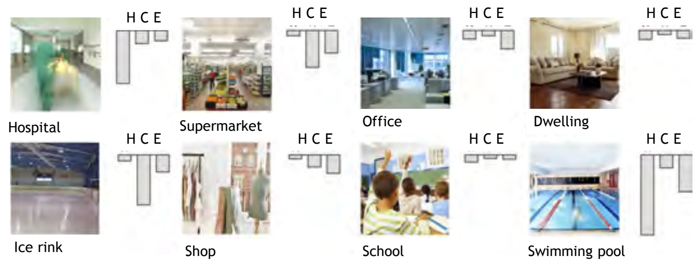
## Different energy profiles at a community level




Source: REAP Projekt, TU Delft

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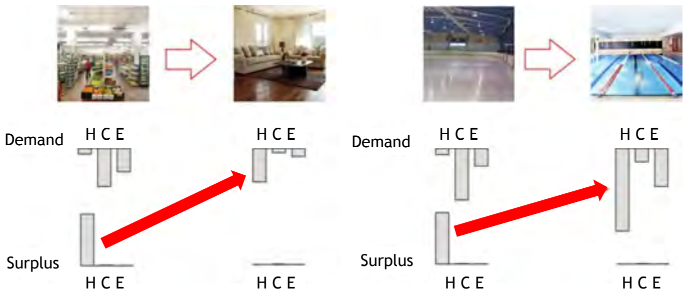
## Synergies via waste heat utilization and cascading




Source: REAP Projekt, TU Delft

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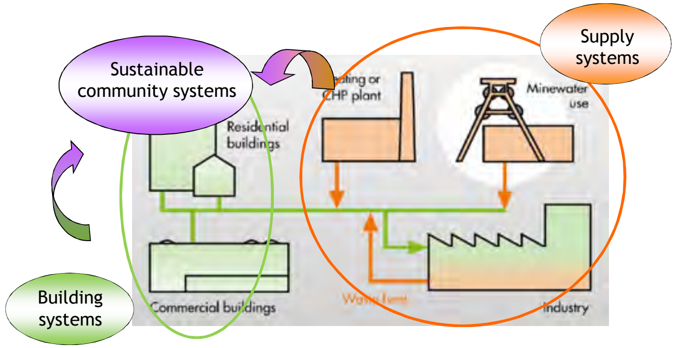
## Communities as energy systems

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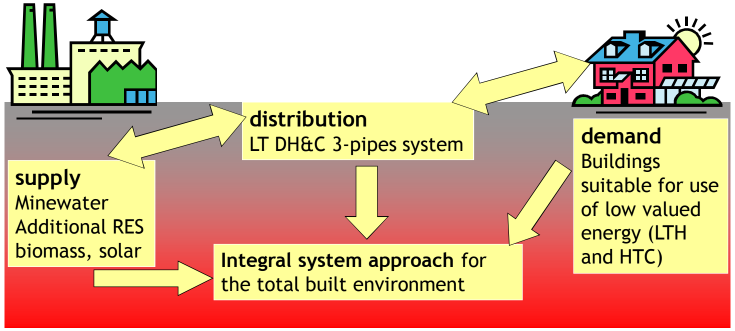
## Example: The Minewater project in Heerlen / NL





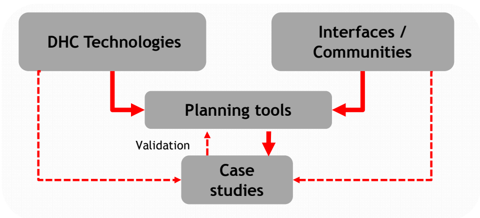

## Objectives of IEA DHC Annex TS1

The objective is to **demonstrate** and **validate** the potential of low temperature district heating as one of the most cost efficient technology solution to achieve 100% renewable and GHG emission-free energy systems on a community level.

⇒ **DHC is an enabling technology** to increase the integration of renewable and waste energy for heating and cooling (Solar thermal, Biomass CHP, HP to use excess wind power)



## The IEA DHC Annex TS1




IEA DHC|CHP

Outcome:
**Future Low Temperature District Heating Design Guidebook**
for key people in communities *(will be published in September 2016)*

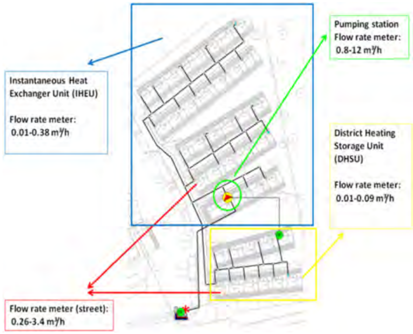


## Example: Hyvinkää (FI)

- Improving the competitiveness of district heating in small houses (LCC)
- Design criteria for new small houses according to 2012- and 2021 regulations
- Solutions for new 2012- and 2021 small house districts
- New business and pricing models

Source: VTT/Espoo

## Example: Lystrup (DK)




- Lowering of the grid temperatures for existing buildings Hydraulic and thermal simulations
- Realisation and monitoring
- Low energy houses with low temperature radiators

Source: DTU Lyngby / COWI

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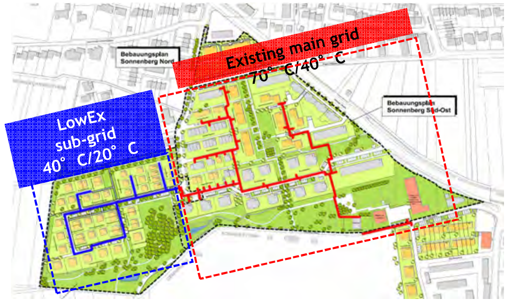
## Example: Ludwigsburg (GER)




- Grid extention as low temperature DH
- Decentralised heat storages inside the buildings
- New buidlings in Passive House standard

Source: HfT Stuttgart

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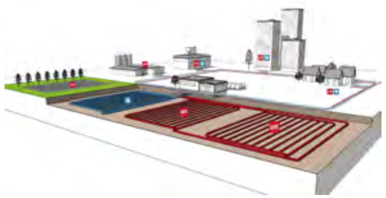
## Example: Wüstenrot (GER)



- Heat demand supplied via heat pumps combined with agrothermal collectors
- Integration of different users
- Decentral DHW-preparation

Source: HfT Stuttgart

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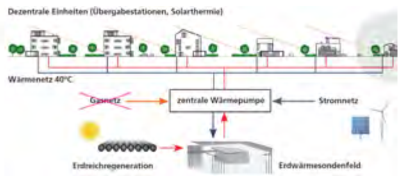
## Example: Kassel (GER)

- Low temperature DH with ground coupled HP and solar collectors
- Decentral DHW-preparation
- Solution for new housung areas
- New business and pricing models




Source: IBP, UniK, SWKs & City of Kassel

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Presentation 1:
D. Schmidt, Fraunhofer IBP, Germany
Successful Implementation of Low Temperature Heating Systems in Communities

## Brochure of Case Studies


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District Heating and Cooling including Combined Heat and Power

## The DHC Annex TS1 participants


IEA DHC|CHP

**IEA DHC Annex TS1:**

**Low Temperature District Heating for Future Energy Systems**

**www.iea-dhc.org**

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District Heating and Cooling including Combined Heat and Power


## Content

- What are the district heating generations?
- How does the 4GDH benefit the energy infrastructure?
- How does 4GDH help with utilization of local low grade renewable heat sources?
- What impact has the 4GDH on currently applied technologies?
- Why does 4GDH fit with future low energy buildings?
- 4GDH and multifamily buildings?
- 4GDH projects in Denmark
  - LTDH in Lystrup, Microbooster in Aarhus and Electric booster in Odder

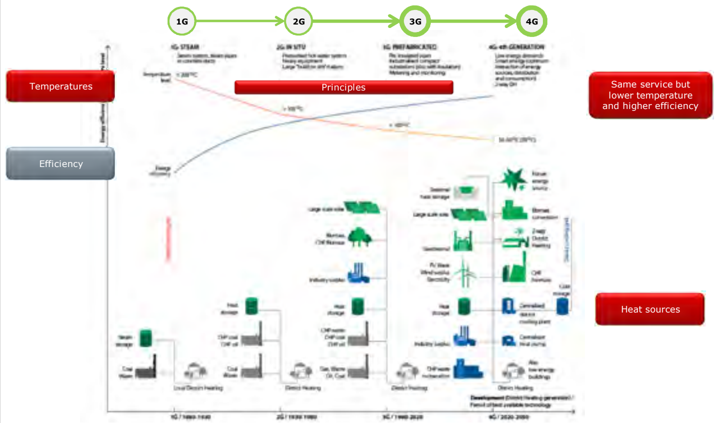


## What is 4GDH?

- From the start of district heating in the 1880s until today the technology has been developing
- The development can be categorized in 4 generations
- 1st generation: Steam based systems (1880-1930)
- 2nd generation: Pressurized super-heated water at temperatures above 100°C
  - stations built on site and pipe insulated on site (1930-1980)
- 3rd generation: Pressurized water at temperatures typically below 100°C
  - Industrialized stations and pre-insulated pipes (1980-2010)
- 4th generation: Pressurized water at temperatures of 50°C (peak 70°C)
  - Low energy demand and smart systems (2010+)



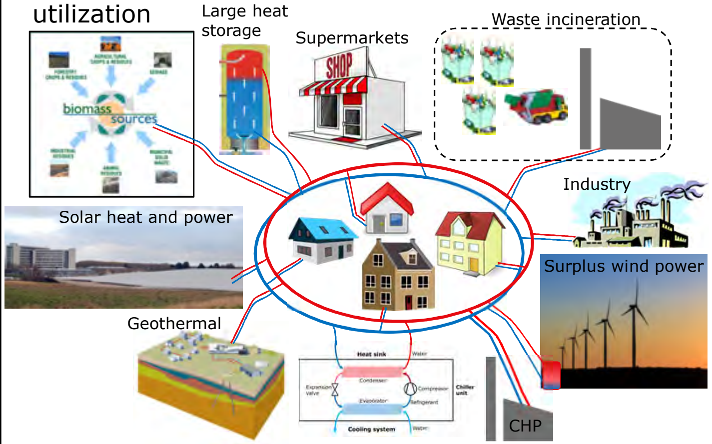
## What are the district heating generations?






Presentation 2:
A. Hansen, DANFOSS, Denmark
Latest generation of district heating – Technology perspectives

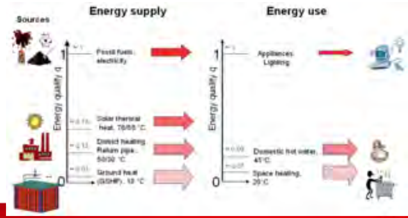
## Increased possibilities of renewable and surplus heat utilization




5 | Danfoss Heating Segment - Application Centre   Andre Hansen & Dr. Oddgeir Gudmundsson - 2016   ENGINEERING TOMORROW

## Other benefits of 4GDH systems to the energy infrastructure

- Increased CHP efficiency
  - Lower supply temperatures increase power generation efficiency
  - Lower return temperatures increase flue gas condensation
- Reduced distribution losses
  - Heat losses are linear dependent on the temperature
    - The lower the network temperatures the less heat loss is experienced
- Better match of supplied energy quality and demanded energy quality

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## What impact has the 4GDH on currently applied technologies?

**4GDH impacts the existing technologies due to the low supply temperature**

**1) Distribution network**

- Minimum pipe dimensions
- Optimization in regards to pump power consumption and heat losses
- The low supply temperature opens up for increased application of flexible pre-insulated plastic pipes
- Fast installation
- Cost efficient

*Pictures from Thermaflex pipe manufacturer*

**2) Space heating**

- Heat emitters:
  - *Radiators:* need to be dimensioned for 55°C supply, 25°C return for 20°C indoor air temperature (55/25/20°C)
  - *Floor heating:* No impact as floor heating is designed for 45/25/20°C
- Control equipment:
  - High focus on smart controllers

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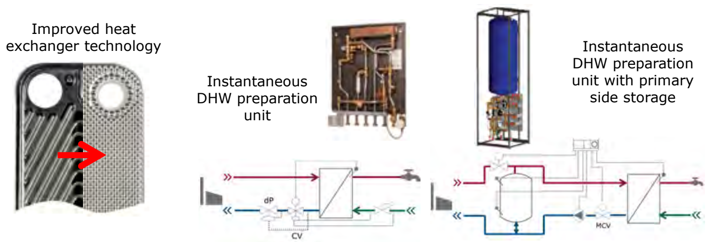
## What impact has the 4GDH on currently applied technologies?

**3) Domestic hot water (DHW) preparation**

- Due to the low supply temperature instantaneous DHW preparation using high efficiency heat exchangers is required to prevent Legionella growth
- DHW piping volume should be less than 3 liters
- Special focus is needed during idling periods to limit the DHW waiting time

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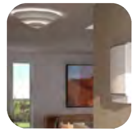
## Why does 4GDH fit with future low energy buildings?

- **Low energy buildings:**
  - Are generally designed with low temperature heating installation
    - Floor heating
    - Low temperature radiators
  - **D**omestic **H**ot **W**ater installation is designed to minimize energy consumption
    - Instantaneous DHW preparation
    - Minimum DHW pipe distances
    - No DHW circulation
- Those points fit exactly with 4GDH!



## 4GDH and multifamily buildings?

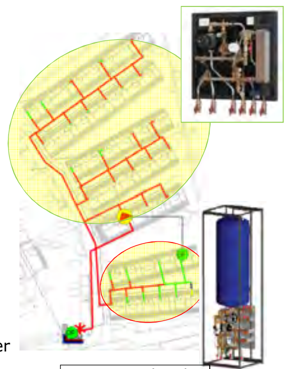
- **Flat stations**
  - Suitable for low-temperature DH
  - Flat station in each flat
  - Overall DHW system volume <3 L
  - Individual control over space heating
  - Simple energy metering
    - ☺ One heat meter for all heat consumption
  - No DHW circulation
    - ☺ Reduced heat loss
  - No vertical risers in flats
    - ☺ Reduced noise
    - ☺ Reduced heat loss






## 4GDH projects
## - LTDH in Lystrup

- Project supported by the Danish government
- 40 low-energy single-family houses
- Higher DH water speed, higher press. drop
- Testing of developed low-temp. substations
- Only 14% heat loss from DHN vs. 41% for traditional designed 80/40°C
- Additional pumping energy is only 4% of primary energy saved from the heat loss



- Good cost-efficiency
- No complaints
- Instantaneous substation lower total heat loss & cheaper

Inner diameter 14 mm!

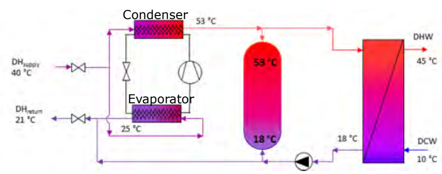
$\Delta p_{max}$ = 8 kPa/m
$w_{max}$ = 2 m/s
$Ød_{min}$ = 14 mm



## 4GDH projects
## - Ultra-LTDH in Gedding

**DH designed for 40/25°C**

- 40°C is enough for floor heating
- DH water heated by small heat pump up to 53°C
  - Heat source is DH network
  - DHW temperature up to 50°C
  - Substation has DH side storage



## 4GDH projects
## - Ultra-LTDH in Odder

- **DH designed for 40/25°C**
  - Electric heater added on outlet of DHW
    - DHW instantaneously heated to 37°C by DH
    - Electrical heater boosts the temperature up to 60°C by electric heater
  - Expected heat loss reduction is:
    - 17% compared to 50/25°C
    - 40-55% compared to 80/40°C
  - Prototypes installed in 5 houses
    - First results are promising



Thank you for your attention

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- Transforming the energy system towards a sustainable system, based on high share of fluctuating renewable sources for heating and cooling, and at the same time reduced specific building energy consumption as well as supply and return temperatures, calls for further development of the DH and cooling concept. This development path is characterized as the 4th generation DH.

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DTU Technical University of Denmark

## Technologies for district heating with low temperatures in existing buildings

Svend Svendsen
Technical University of Denmark
ss@byg.dtu.dk

Low temperature district heating technologies for existing buildings

## Step by step implementation of low temperature technologies in buildings

**Step 1: Low return temperature**

- Benefit in heat production:
  - Condensation of flue gas from wet biomass
- Benefit in district heating net:
  - Reduced heat loss and increased capacity

**Step 2: Low supply and return temperature**

- Benefit in heat production:
  - Waste heat, heat pumps, solar and geo thermal
- Benefit in district heating net: reduced heat loss

## Benefits of lower return temperatures

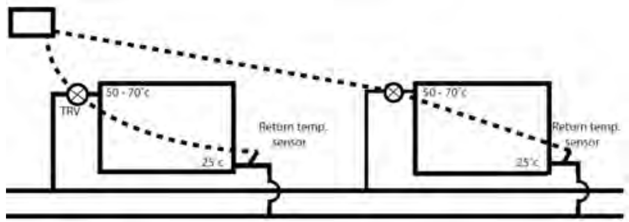
Typical example from Denmark:

- Price reduction in heat from biomass due to lower return temperature: 1% per 1°C
- Return temperature reduction: 45-25= 20 °C
- Heat price reduction: 20%
- Heat price: 0.1 € /kWh
- Heat price reduction: 0.02 € /kWh

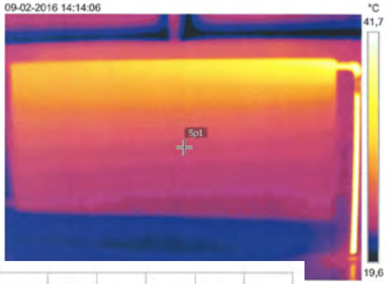
## Space heating system with improved control Digital thermostatic radiator valve with wireless return temperature sensor

The flow in the radiator is controlled to

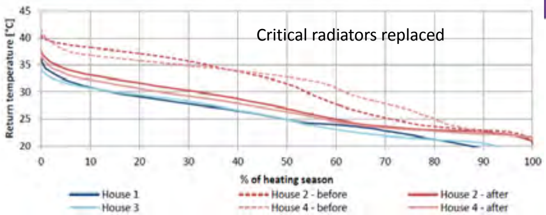
- heat the room to the set point and
- cool the return temperature to 25 °C or slightly higher in cold days



## Space heating system with improved control




Old houses designed for 90/70°C
Supply temperature : 50 - 65°C




## TRV with return sensor – example of economy

- Space heating use: 10 MWh/year
- Return temperature reduction: 20°C
- Savings: 10.000 kWh/y x 0.02 €/kWh = 200 €/y
- Savings in 10 years: 2000 €

- Compare to investment in 3-5 new digital thermostatic radiator valves with return sensor and 1 or 2 ‘missing’ / critical radiator

## Technologies for low temperature operation of domestic hot water system

**Comfort requirements** (according to DS 439)

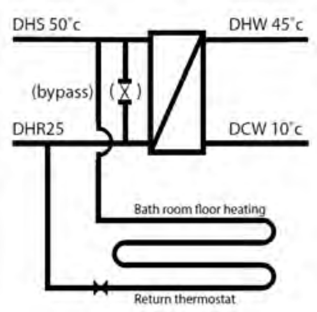
- Temperatures: 40-45C
- Waiting time: 10s
- Flow : shower + kitchen: 0.24 l/s or 32kW

**Health requirements**

- Legionella bacteria limitation: avoid temperatures of 25-45°C and large volumes

## Technologies for low temperature operation of domestic hot water system in small buildings

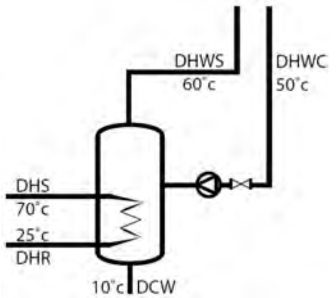
- Heat exchanger for DHW heating
- Bath room floor heating all year for comfort
- No need for bypass flow at high return temperatures (45°C)



**Technologies for low temperature supply of DHW use and heat loss of circulation system in large existing buildings – low return**

1. **Heat loss reduction and storage based supply**

- **Reduced heat loss by insulation and in-line return pipe**
- **Supplied by DHW tank cooling 60°C → 50°C**
- **District heating flow only when cold water is heated**




## DHW circulation heat loss reduction – example of economy

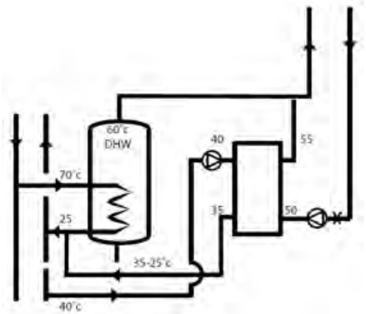
- Reduce DHW Circulation pipe heat loss in existing apartment buildings : 20 → 5 W/m
- Annual heat loss reduction:
  - 15 W/m x 8760 h/year = 130 kWh/m year
- Savings due to reduced heat loss and lower return temperature:
  - 130kWh/m y x 0.10 €/kWh = 13 €/m year
  - 5W/m x 8760h/y x 0.02 €/kWh = 0.9 €/m year

  Savings in 10 years : 140 €/m

**Technologies for low temperature supply of DHW use and heat loss of circulation system in large existing buildings – low return**

**2. Heat pump on district heating return water**

- Circulation of return water from street to building in extra pipe or in-line pipe
- Heat pump heating of DHW circulation
- DH return pipe for distributing ultra low temp. heat



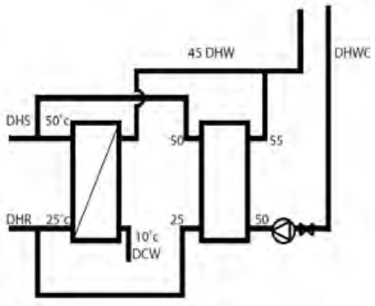

## Heat pump on district heating return – example of economy

- Example: price of heat from return line
- due to free low temp. waste heat or geo-heat
- Heat price: 0 €/kWh
- Electricity price: 0.25 €/kWh
- Heat pump COP: 4
- Price of heat from heat pump:
- 0.25 / 4 = 0.06 €/kWh
- Standard price of heat from supply 0.1 €/kWh

**Technologies for low temperature supply of DHW use and heat loss of circulation system in large existing buildings – low supply and return**

**3. Heat pump on DH supply for heating DHW circulation**

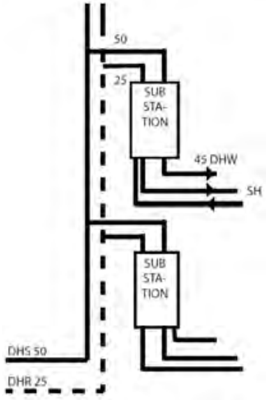
- Low temperature district heating 50/25°C
- Heat exchanger for heating DHW to 45°C
- Heat pump for heating DHW circulation to 55°C
- Benefits due to central production at low temp.




**Technologies for low temperature supply of DHW use and heat loss of circulation system in large existing renovated buildings – low supply and return**

**4. Decentral substation in each flat**

- District heating twin pipes as risers in building
- Minimized heat loss of distribution of heat in building
- Comfort bath room floor heating all year – no by pass needed




## Conclusion

- Step by step implementation of
- Technologies for low temperature operation of
- Space heating systems and
- DHW heating systems
- In small and large existing buildings is:
- Possible and economical for:
- Users and district heating companies and
- Energy system and society

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Institut für Energiewirtschaft und
Rationelle Energieanwendung (IER)




## Motivation

- For climate protection at local level **energy efficient supply** structures are essential, since a major part of energy consumption is spent on heat supply
- A transition to efficient **low temperature** heating systems is thus required **(LowEx)**
- **LowEx-heating** systems through the coordination of
  - heat generation,
  - technical building services and
  - energy standard of the building.
- Possible energy systems of the future:
  - Integration of **renewable energy** (e.g. solar thermal energy, waste heat)
  - **Reduction of distribution losses**
  - **Higher efficiency** in heat generation

➡ **For the evaluation of the different systems a Tool is helpful and necessary**



## Requirements for such a Simplified Tool

By evaluating the selected planning tools for DH, requirements can be derived for the development of a Simplified Tool.

Such a tool should include:

i. district energy supply: evaluation and comparison
ii. low temperature DH (<= 50°C)
iii. integration of renewable energy sources
iv. development of urban districts

Characterisation of the tool:

i. Time horizon — 1 year
ii. Time resolution — minimum representative days / hourly
iii. Spatial resolution — due to the aggregation and pre calculation point model



## Motivation for the Easy District Analysis (EDA) Tool

- For climate protection at local level **energy efficient supply** structures for cities and municipalities are required
- **LowEx-heating** systems through the coordination of
  - heat generation,
  - technical building services and
  - energy standard of the buildung.
- Integration of **renewable energy**
- **Reduction of distribution losses**
- **Higher efficiency** in heat generation



Presentation 4:
M. Blesl, University of Stuttgart, Germany
Technical, ecological and environmental Evaluation of different district heat supply and space heating concepts

### Easy District Analysis (EDA)

- **Demand side**
  - Distinction between different kind and number of consumers
  - Generation of a load curve for space heating and domestic hot water (hourly resolution)
- **Supply side**
  - Technologies
    - CHP
    - Boiler
    - Solar thermal system
    - Thermal storage (buffer)
- **Distribution**
  - Heat grid

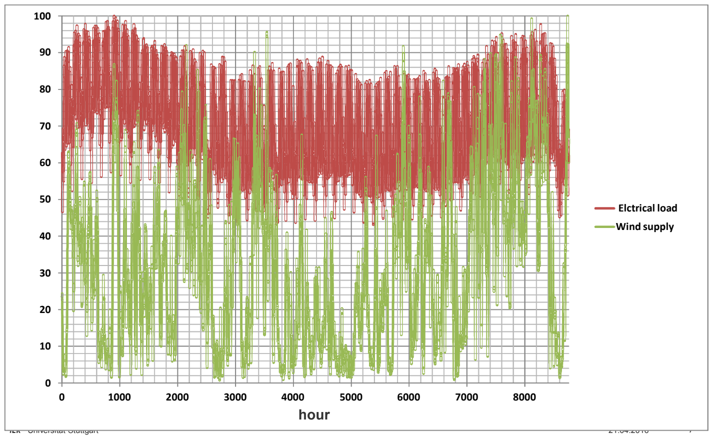



### Results of the Tool Easy District Analysis (EDA)

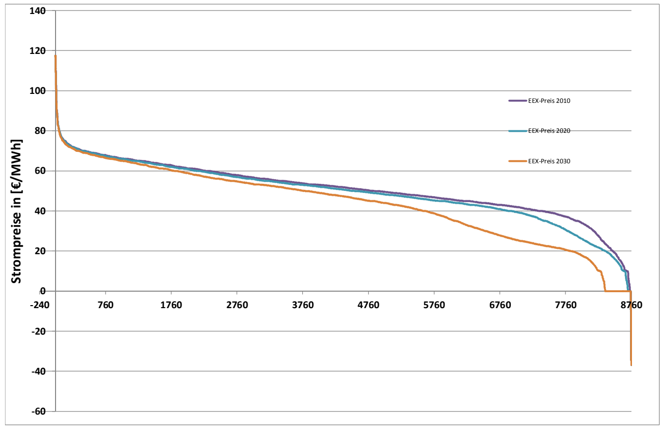
- Technical and economically optimized results
- Primary energy consumption (differentiated by different evaluation methods)
- Final energy use
- $CO_2$ emissions (differentiated by different evaluation methods)
- Costs by cost categories



### Motivation for including the economical optimization - changes in the energy system of the future




### Electricity Price at EEX






Presentation 4:
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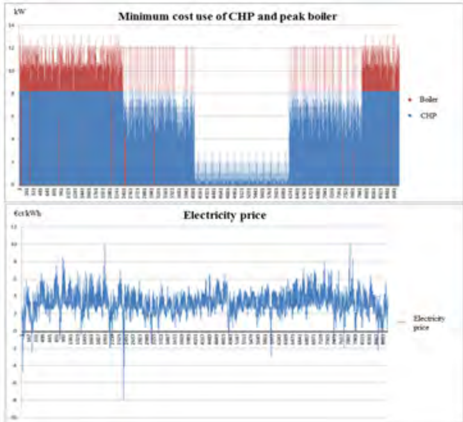
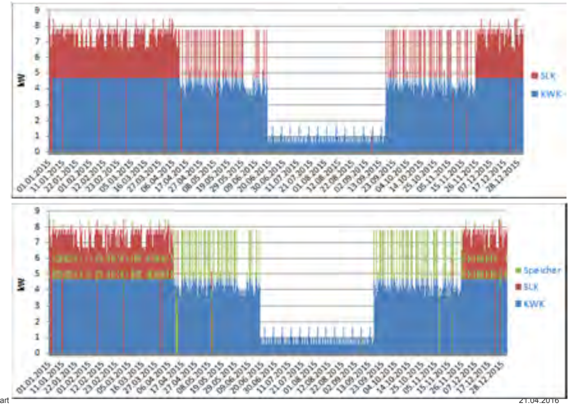
Technical, ecological and environmental Evaluation of different district heat supply and space heating concepts

## Minimum cost use of technology to cover the heat demand depending on the assumed electricity prices for Germany 2015






## Cost optimal usage of technologies (CHP unit, peak boiler, thermal storage)






## Case Study background

- **High temperature** levels are **not required for** the supply of **space heating and domestic hot water**, as depending on the design…
  - radiators only need temperatures between 55°C and 90°C
  - panel heating between 35°C and 45°C and
  - floor heating systems between 25°C and 35°C
- A **reduction of temperature** is **reasonable** because of…
  - a **higher efficiency** of heat…
    - generators (e.g. reduced exhaust gas losses)
    - distribution (e.g. decreased temperature gradient between hot water and ambient temperature)
    - consumption (e.g. reduced losses at the house transfer station, distribution losses in the consumer pipeline network)
  - a **facilitated integration of renewable energies**

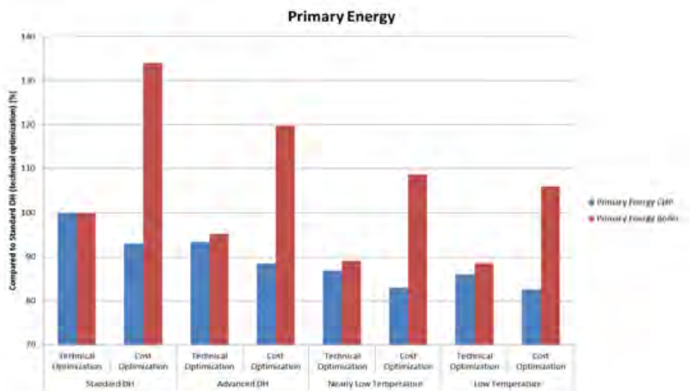


## Comparison of the energy efficiency of different DH systems

- A reduction from 90°C/60°C to 70°C/55°C …
  - has the greatest impact on heat distribution resulting in 2.3% reduced distribution losses
  - leads to an 2% increased efficiency of a CHP unit and a peak boiler
  - reduces the losses in the consumer heating grids by 2%

| DH characterisation | | Standard DH 90°C 60°C | Advanced DH 70°C 55°C | nearly low temperature DH 60°C 45°C | low temperature DH 50°C 35°C |
|---|---|---|---|---|---|
| CHP | $\eta_{th}$ | 47 | 49 | 51 | 51,5 |
| | $\eta_{el}$ | 40 | 40 | 40 | 40 |
| | $\eta$ | 87 | 89 | 91 | 91,5 |
| Boiler | $\eta_{th}$ | 87 | 89 | 92 | 92,5 |
| DH Grid | distribution losses | 13,3 | 11 | 8 | 8 |
| Consumer | $\eta_{th}$ | 96 | 97 | 98 | 98 |
| | distribution losses | 10 | 8 | 6 | 6 |

**Technical vs. cost optimization for different DH systems with regard to primary energy consumption**

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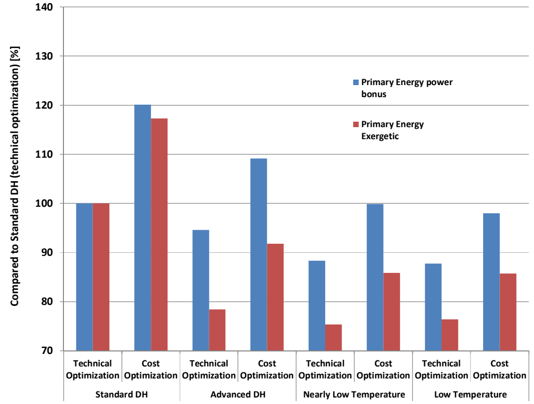
**Technical vs. cost optimization for different DH systems with regard to evaluated primary energy consumption**

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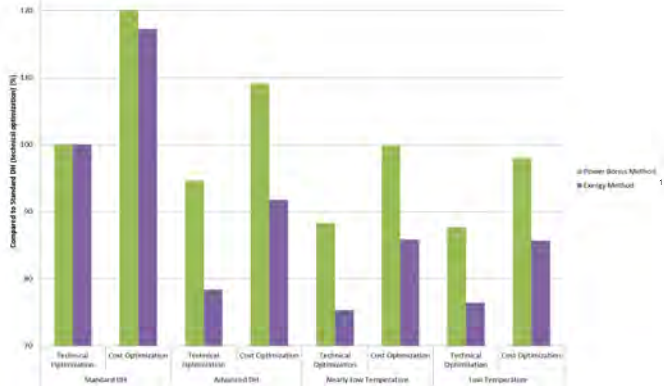
**Technical vs. cost optimization for different DH systems with regard to $CO_2$ emissions**

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[1]Power Bonus: Reference Power Plant η = 42.4 %, Emission Factor Natural Gas: 0.247 kg $CO_2$/kWh

**$CO_2$ Abatement Costs: Technical vs. Cost Optimization (CHP unit + Boiler)**

| | Unit | Standard DH | Advanced DH | Nearly Low Temperatue DH | Low Temperature DH |
|---|---|---|---|---|---|
| $CO_2$ Abatement Costs | €/t $CO_2$ | 76 | 90 | 104 | 114 |

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## Conlusion

- Low LowEX systems reduce the primary energy consumption and the $CO_2$ emissions by around 22 %.
- But the efforts of the technology improvement might be negated by the economical conditions.
- Taking into account the environmental impact cost might correct the development.

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## Thank you for your attention!

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## Backup

## Work items

- Procedures, models and software tools for design and performance analysis.
  - Development of **simplified and easy to understand assessment tools** for local energy systems based on low temperature district heating technologies.
  - Development of **advanced and dynamic assessment tools** for local energy systems based on low temperature district heating technologies.
- System optimisation strategies based on *energy*, *exergy*, *emission* and *cost* indicators.
- Based on the developments, promising and innovative research areas may be identified, e.g. within low temperature production of domestic hot water

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# District Heating Interfaces for Enabling Integration of Low Temperature and Distributed Heat Sources

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Department of Energy and Process Engineering
Norwegian University of Science and Technology

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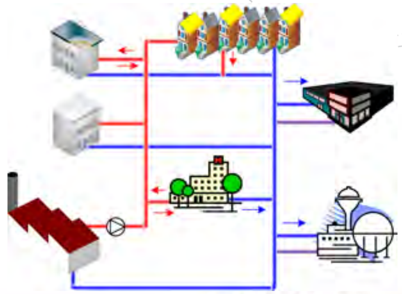
## Integration of distributed energy sources

- Buildings and building complexes may export heat to the district heating grid
- Future district heating system will compound of a large share of waste heat and low temperature heat from distributed energy sources



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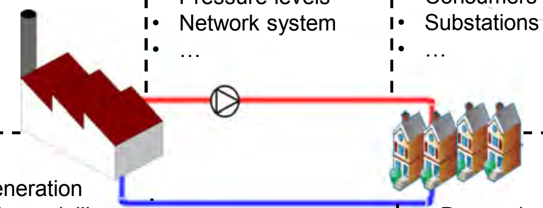
## Scope of Subtask C

Hard issues

- Temperature levels
- Pressure levels
- Network system
- …

- Heating demand
- Consumers
- Substations
- …



Soft issues

- Generation side modelling
- Distribution system
- Development
- Demand side modelling

- Optimization between generation and demand
- Pricing models, allocation factors, and energy measurement
- Policies, ….

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## Technical obstacles for the integration

- Reducing the temperature in the existing network
  - Reduce as much as possible the return temperature
  - Use high efficient heat exchanger
- Transition of the existing buildings to the low temperature district heating system
- Network extension with the low temperature system
  - Connection to the return line of the district heating network
  - Secondary grid using the heat exchanger in the supply or return of primary network
- Technology for two-ways communication
- Measurement technology requirements

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Presentation 5:
T. Tereshchenko, NTNU Trondheim, Norway
District heating interfaces for enabling integration of low temperature and distributed energy sources

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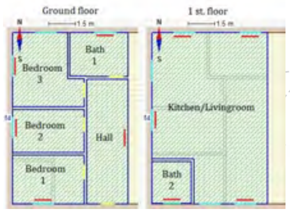
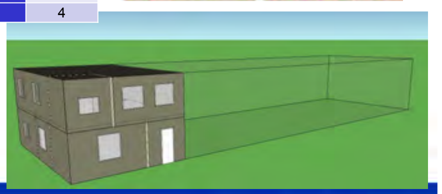
# Transition to low temperature district heating




Building description

| Properties | Values |
|---|---|
| Ratio opening/available area (%) | 15 |
| U-value walls (W/m²K) | 0.5 |
| U-value roof (W/m²K) | 0.4 |
| U-value toward ground (W/m²K) | 0.4 |
| U-value windows (W/m²K) | 2.8 |
| U-value outer door (W/m²K) | 2.0 |
| Infiltration (at 50 Pa pressure diff.) ($h^{-1}$) | 4 |

Building area: 122 m²
DHW use: 29.8 kWh/m²
Average installed light: 2.65 W/m²
Users: 2.6





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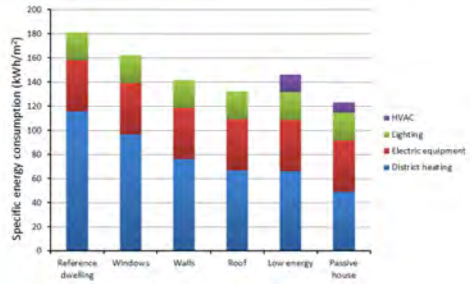
# Transition to low temperature district heating

- Simulation was performed for the Oslo weather conditions
- Each energy efficiency measure is successively added to the previous



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# Transition to low temperature district heating

Hours when slightly higher district heating temperatures have to be used

Radiator size as dimensioned

| | Supply temperature | | | |
|---|---|---|---|---|
| | 80 °C | 60 °C | 55 °C | 50 °C |
| Reference building | 0 | 329 (Bath 2) | 767 (Bath 2) | 1750 (Bath 2) |
| Windows | 0 | 122 (Bath 2) | 368 (Living room) | 921 (Bath 2) |
| Walls | 0 | 0 | 12 (Living room) | 109 (Living room) |
| Roof | 0 | 0 | 0 | 8 (Hall) |
| Low energy | 0 | 89 (Bedroom 1) | 136 (Bedroom 3) | 516 (Bedroom 1) |
| Passive house | 0 | 0 | 0 | 0 |

Radiator are 50 % oversized

| | Supply temperature | | | |
|---|---|---|---|---|
| | 80 °C | 60 °C | 55 °C | 50 °C |
| Reference building | 0 | 4 (Gang) | 88 (Bath 2) | 358 (Bath 2) |
| Windows | 0 | 0 | 7 (Bath 2) | 153 (Bath 2) |
| Walls | 0 | 0 | 0 | 0 |
| Roof | 0 | 0 | 0 | 0 |
| Low energy | 0 | 0 | 0 | 16 (Bath 1) |
| Passive house | 0 | 0 | 0 | 0 |




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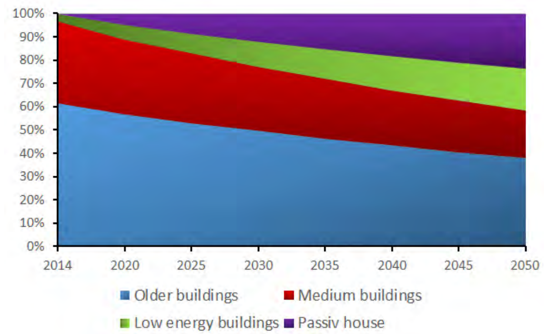
# Future heat demand




61.7% of older buildings
3.1% of low energy buildings
35.1% of intermediate buildings
0.1% of passive houses

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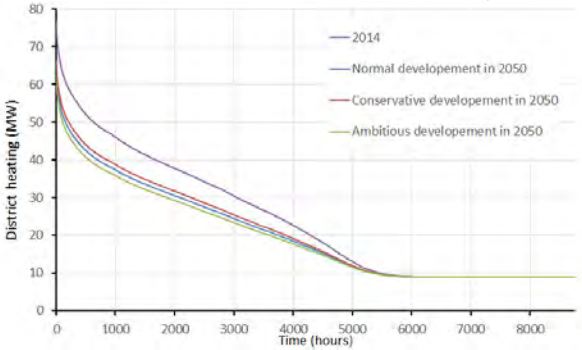
## Future heat demand




- Decrease of heat demand about 18% in 2050 compared to current heat demand

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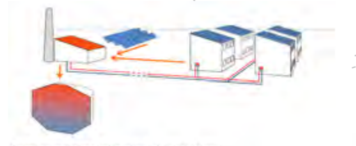
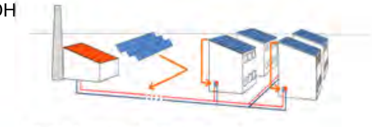
## Integration of other heat sources

- Centralized
  - Collectors mounted on buildings transfer heat via a collecting grid
  - Long term storage
  - Lower investment cost



*Central solar district heating system. (Source: Solites)*

- Decentralized
  - Collectors supply heat directly in DH network
  - Buildings importers/exporters
  - Flexibility
  - Management difficult



*Distributed solar district heating system. (Source: Solites)*

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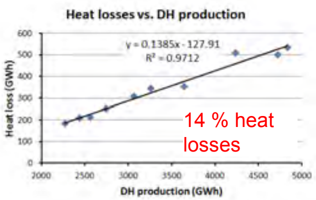
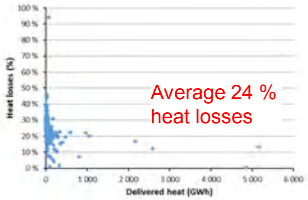
## Distribution and development issues

- Difficulties to get reliable data on distribution losses in the district heating network
- Who will take responsibility for these unavoidable distribution losses in the network?
- How they will influence the heat cost and price models?




Example from Norway, national level




Example from Denmark, for separate plants

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## Integration of renewable heat sources via prosumers

- Prosumer can produce and consume heat from DH
- Prosumer may deliver heat into the supply or return line
- Introduction of prosumers will require lower DH temperature, because of:
  1. Lower temperature requirement for utilization of renewable and waste heat
  2. Renewables produce heat with higher efficiency at lower temperature level

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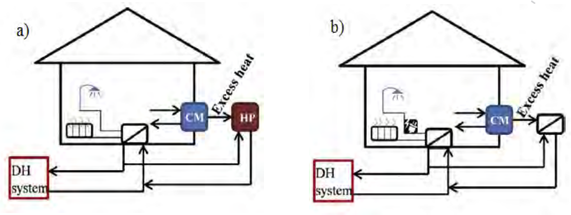
## Integration of renewable heat sources via prosumers




Examples of waste heat integration into DH:
a) with heat pump for higher temperature level and
b) low temperature DH network

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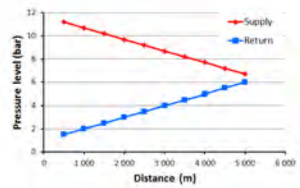
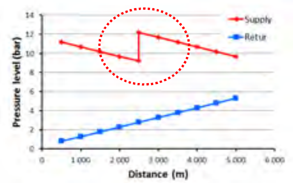
## Fails with current solutions

- Delivered heat amount and operation parameters are at lower level than expected
- Pressure distribution is changed, influencing other customers
- Pressure control strategies are highly important for proper operation of the whole DH system with the prosumers




Current situation




New situation with prosumers

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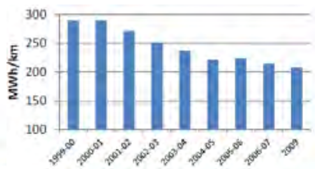
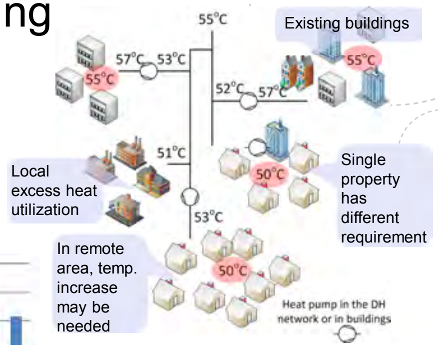
## Example of waste heat based district heating

- Viborg district heating in Denmark uses excess heat from the Apple computer center
- Viborg DH plan for decreasing the DH temperature and distribution losses




**References**
- Strategies for temperature levels in Viborg District heating network 2011-2025, report
- The local potentials – Apple and other excess heat sources, presentation from Tom Diget

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## Example of waste heat integration

- Heat recovery at NTNU campus, Trondheim, Norway
- NTNU campus made its own DH ring
- Connect the condenser heat in the return line


- Hanne Risnes, Analyse av høytemperatur ammoniakk kjøle- og varmepumpeanlegg ved NTNU
- Jørn Stene, Combined Liquid Chiller and Heat Pump Inst. for Computer Cooling and High-Temperature Heat Recovery at NTNU Gløshaugen, Trondheim, presentation

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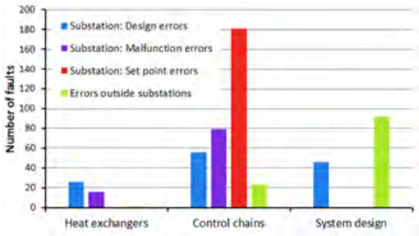
## Necessity for better substation control

- Development of more standardized customer substations
- Development of smarter heat grids with a higher intelligence control, especially in substation interfaces
- Elaborating market rules for customer acceptance of high market shares for excess and renewable heat




Frederiksen, S. and S. Werner, District heating and cooling, 2013, Lund: Studentlitteratur

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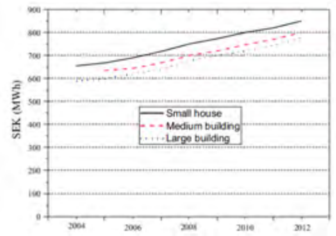
## District heating prices

In Norway, without tax


In Sweden, without tax, after market deregulation




Currency ratio:
1 EUR = 9.2 NOK
1 EUR = 9.2 SEK

A review of the pricing mechanisms for district heating systems, Hailong Li, Qie Sun, Qi Zhang, Fredrik Wallin

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## Business and pricing models

- **Extend service on operation and maintenance and fault detection** - to decrease the return temperature and consequently the supply temperature
- Extend service so that DH company takes over the responsibility for the entire HVAC
- DH companies may take **responsibility** for the **heat export from waste and solar heat**
- Sonderborg, Denmark, enlarged the service on leasing the substation
  – http://www.sonderborg-fjernvarme.dk/#

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## Examples of business models for integration of renewables

- In Denmark, DH operators are mostly organized in cooperatives
  – DH is taking responsibility for the operation and maintenance of the entire system
  – As a result, they have achieved the best results
- In Gothenburg, Sweden, building associations own solar collectors and export heat to the DH
  – Delivered heat amount and operation parameters may be in some cases at lower level than expected
- In Austria, Energy Service Companies (ESCO) own and operate the solar heating system

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## Conclusions

- There is enough available heat from renewables and waste heat sources at the low temperature level, so the low temperature DH will be highly needed in the future
- Good knowledge on the heat losses and how operation and temperature levels may contribute to the distribution losses is highly necessary
- Increasing number of the prosumers will require a transformation of today’s DH network into smart grid
- Better data utilization may create new business models for both DH companies and IT sector

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## Thank you for your attention!

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