IEA DHC | CHP

Annex TS1

Low Temperature District Heating
for Future Energy Systems

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

**Proceedings of the special session on**

# Low Temperature District Heating for Future Energy Systems

September 6th, 2016, Seoul, Korea

Hosted by

The 15th International Symposium on DHC2016

**Organised by:**

**German Heat & Power Association – AGFW e.V. & Fraunhofer-Institute for Building Physics**

AGFW

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

## Special Session on "Low Temperature District Heating for Future Energy Systems"
## September 6th, 2016

**The-K Hotel Seoul**
70, Baumoe-ro 12-gil,
Seocho, Seoul / Korea

## At the 15th International Symposium on District Heating and Cooling at The-K Hotel Seoul

## Tuesday, September 6th, 2016

**9:00** **IEA DHC Annex TS1 session on**
**"Low Temperature District Heating for Future Energy Systems"**
*(Chairman: Dietrich Schmidt, IBP Germany)*

- THE FEASIBILITY ANALYSIS FOR THE CONCEPT OF LOW TEMPERATURE DISTRICT HEATING NETWORK WITH CASCADE UTILIZATION OF HEAT BETWEEN THE NETWORKS
  *(Yong Hoon Im, KIER, Korea)*
- TECHNOLOGICAL ISSUES TO SUPPLY LOW TEMPERATURE DISTRICT HEATING
  *(Hongwei Li, DTU, Denmark)*
- EXERGY-BASED ANALYSIS OF RENEWABLE MULTI-GENERATION UNITS FOR SMALL SCALE LOW TEMPERATURE DISTRICT HEATING SUPPLY
  *(Anna Kallert, Fraunhofer IBP, Germany)*
- LOW TEMPERATURE DISTRICT HEATING FOR FUTURE ENERGY SYSTEMS
  *(Dietrich Schmidt, Fraunhofer IBP, Germany)*
- DEVELOPMENT OF AN INNOVATIVE LOW TEMPERATURE HEAT SUPPLY CONCEPT FOR A NEW HOUSING AREA
  *(Dietrich Schmidt, Fraunhofer IBP, Germany)*
- NECESSARY MEASURES TO INCLUDE MORE DISTRIBUTED RENWABLE ENERGY SOURCES INTO DISTRICT HEATING SYSTEM
  *(Natasa Nord, NTNU Trondheim, Norway)*
- TRANSITION TO LOW TEMPERATURE DISTRIBUTION IN EXISTING SYSTEMS
  *(Miika Rämä, VTT Espoo, Finland)*
- EVALUATION OF DIFFERENT DISTRICT HEAT SUPPLY CONCEPTS FOR SETTLEMENT AREAS
  *(Markus Blesl, University of Stuttgart, Germany)*
- FLEXYNETS - A NEW GENERATION OF INTELLIGENT LOW EXERGY DISTRICT HEATING AND COOLING NETWORKS
  *(Ben Ilyes Hassine, HfT Stuttgart, Germany)*

**12:20** **End our session at the DHC 2016 Symposioum**

# The Feasibility Analysis for The Concept of Low Temperature DH Network with Cascade Utilization of Heat Between the Networks

6. Sept. 2016

Yong Hoon Im*, M. Imran, M. Usman, B.S. Park
Korea Institute of Energy Research

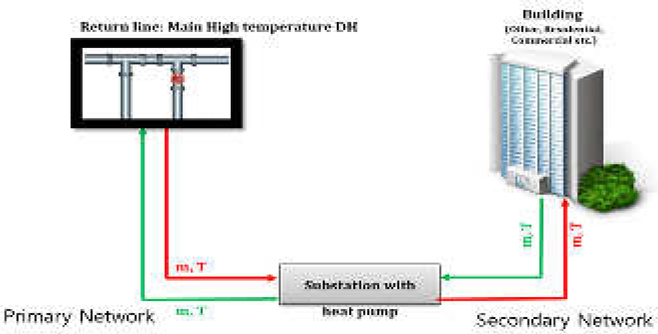


## Research Aims & Objectives

- Present Status of DH Network in South Korea
- Possibility of Low Temperature District Heating Sources
- Assessment of Technical and Economical Feasibility
- Suggestion of Business Model for Low Temperature DH



## Low Temperature District Heating Network






## Return of High Temp. DH Network

| Parameters | Ambient Temperature (C) | Supply T (C) | Return T (C) | Supply P (kg/cm²) | Return P (kg/cm²) | Flow Rate (m³/hr) |
|---|---|---|---|---|---|---|
| Average Value | 13.6 | 104.6 | 55.3 | 10.0 | 8.2 | 2.113 |
| Maximum Value | 32.7 | 118.2 | 76.8 | 14.1 | 10.6 | 4.069 |
| Minimum Value | -15.9 | 41.2 | 29.1 | 7.4 | 5.5 | 0.067 |

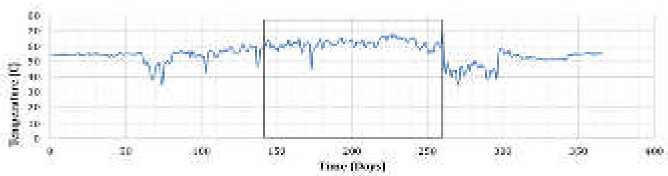



Fig. Variation of temperature of main DH return line



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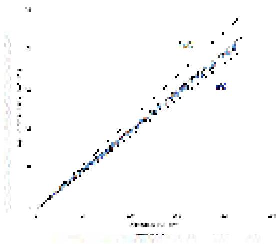
## Building Load Model



- If the building material and construction style is assumed similar, the building load can be estimated by time of day and ambient temperature.

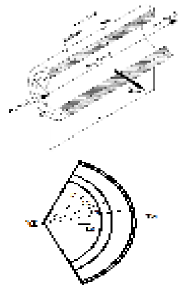
| Month | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| $R^2$ | 99.2 | 99.6 | 98.4 | 98.3 | 94.2 | 92.6 |
| Month | 7 | 8 | 9 | 10 | 11 | 12 |
| $R^2$ | 91.6 | 93.4 | 95.2 | 98.2 | 98.7 | 99.6 |

[illegible]

[illegible]



## Heat Loss Estimation



$$Pipe\ Heat\ Loss = Q_{loss} = UA_{p,s}(T_f - T_a) = UA_{p,s}\Delta T$$

$$Pipe\ Surface\ Area = A_{p,s} = 2\pi D_4 L$$

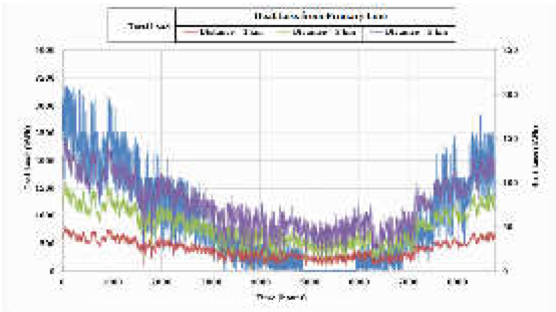
$$U = \frac{1}{R}\ ;\ \ R = \frac{1}{h_i} + \frac{r_4 \ln\frac{r_2}{r_1}}{k_p} + \frac{r_4 \ln\frac{r_2}{r_1}}{k_p} + \frac{r_4 \ln\frac{r_3}{r_2}}{k_i} + \frac{r_4 \ln\frac{r_4}{r_3}}{k_c} + \frac{1}{h_o}$$

$$h_i = \frac{k_p}{D_1} \times 0.023 Re^{0.8} Pr^{0.4}$$

$$h_o = 13.79 + 0.03232\Delta T - 40.86 D_4 + 0.000117\Delta T^2 + 97.3 {D_4}^2 - 0.01388\Delta T D_4$$



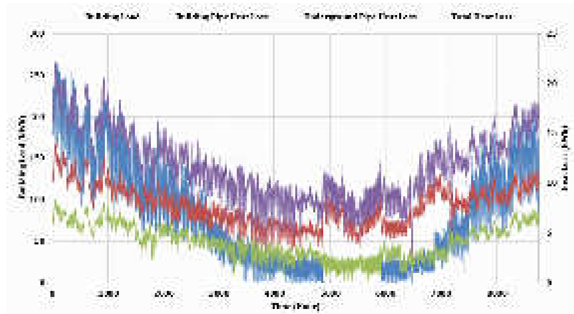
## Heat Loss: Primary Network



Primary Network Heat Loss Variation over the year



## Heat Loss: Secondary Network



Secondary Network Heat Loss Variation over the year



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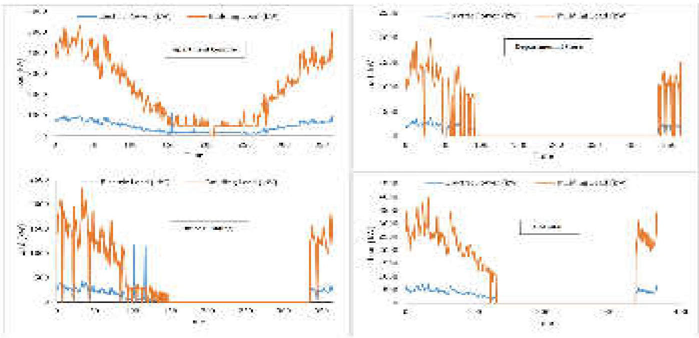
## Steady State Heat Pump Model





## Economic Analysis: Different Scenarios

Operating Cost: Different scenarios based on heat loss

| Cases | Primary Network | | Secondary Network | | Heat Pump |
|---|---|---|---|---|---|
| | Heat Loss | Pumping Power | Heat Loss | Pumping Power | Electric Power |
| 1 | Included | Included | Included | Included | Included |
| 2 | Not Included | Included | Included | Included | Included |
| 3 | Included | Included | Not Included | Included | Included |
| 4 | Not Included | Included | Not Included | Included | Included |

Assumptions:

Project life is 30 years and Inflation rate is considered as 5%

The distance of sub station is set as 3km.

Two pipe system has been selected for secondary network.

The price of pipes, electricity, heat and labor is based on local market of Korea.



## Economic Analysis: Capital Cost(Primary side pipe network)

| Type | Pipe Standard | Price | Carrier Pipe | | Insulation | Casing Pipe | |
|---|---|---|---|---|---|---|---|
| | | | Inner | Outer | Thickness | Thickness | Outer Dia. |
| | | ₩/m | mm | mm | mm | mm | mm |
| PEX | 150A | 253,300 | 154.2 | 165.2 | 38.4 | 4 | 250 |
| | 125A | 163,800 | 129.6 | 139.6 | 39.1 | 3.5 | 225 |
| | 100A | 124,000 | 104.5 | 114.3 | 39.4 | 3.5 | 200 |
| | 80A | 103,200 | 80.1 | 89.1 | 32.2 | 3.2 | 160 |
| | 65A | 84,300 | 67.3 | 76.3 | 28.7 | 3.2 | 140 |
| | 50A | 67,600 | 52.7 | 60.5 | 29.1 | 3.2 | 125 |
| | 40A | 49,200 | 41.2 | 48.6 | 27.7 | 3 | 110 |
| | 32A | 38,300 | 35.5 | 42.7 | 30.7 | 3 | 110 |
| | 25A | 32,990 | 27.2 | 34 | 25.5 | 2.5 | 90 |
| | 20A | 29,600 | 21.4 | 27.2 | 28.9 | 2.5 | 90 |



## Economic Analysis: Capital Cost(Secondary side pipe network)

| Type | Pipe Standard | Price | Carrier Pipe | | Insulation | Casing Pipe | |
|---|---|---|---|---|---|---|---|
| | | | Inner | Outer | Thickness | Thickness | Outer Dia. |
| | | ₩/m | mm | mm | mm | mm | mm |
| STS (SCH 10) | 100A | 83,780 | 114.3 | 108.2 | 50 | 0 | 158.2 |
| | 80A | 67,730 | 89.1 | 83 | 50 | 0 | 133 |
| | 65A | 51,550 | 76.3 | 70.2 | 50 | 0 | 120.2 |
| | 50A | 46,040 | 60.5 | 54.9 | 50 | 0 | 104.9 |
| | 40A | 41,220 | 46.8 | 41.2 | 50 | 0 | 91.2 |
| | 32A | 36,400 | 42.7 | 37.1 | 50 | 0 | 87.1 |
| | 25A | 32,250 | 34 | 28.4 | 50 | 0 | 78.4 |
| | 20A | 29,600 | 27.2 | 23 | 50 | 0 | 73 |



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THE FEASIBILITY ANALYSIS FOR THE CONCEPT OF LOW TEMPERATURE DISTRICT HEATING NETWORK WITH CASCADE UTILIZATION OF HEAT BETWEEN THE NETWORKS

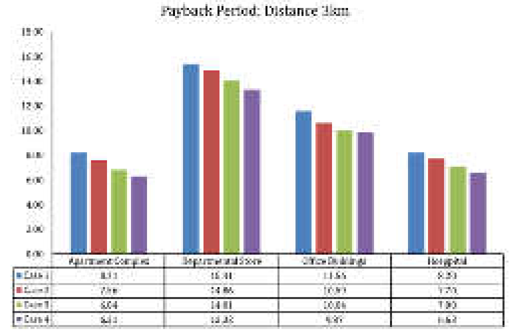
## Economic Analysis: Capital Cost & Elec. Price

| Energy charge (₩/kW) | | | |
|---|---|---|---|
| Time Period | Summer | Spring/Fall | Winter |
| Off-Peak | 55.2 | 55.2 | 62.5 |
| Mid-Peak | 108.4 | 77.3 | 108.6 |
| On-Peak | 178.7 | 101.0 | 155.5 |

Cost of Heat Pump = 450 USD/kW (Average values for 30kW ~ 300kW valid price quotations)



## Economic Analysis: Payback Period

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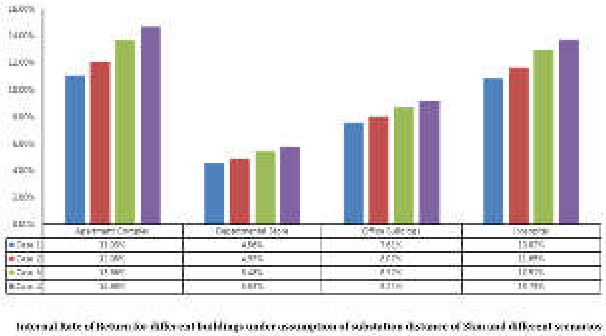
## Economic Analysis: IRR



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## Conclusion (1/2)

- In this study, the concept of cascade utilization of surplus energy in district heating network is newly suggested by utilizing the return water of HTDH as a heat source for LTDH.
- The economic analysis for different types of buildings shows that the rate of return of residential building varies from 5~6 years, for office 9~10 years, for hospital 5~7 years, and for departmental store 12~ 14 years depending on various cases considered in economic analysis
- Decrease of return temperature from 45C~30C results in double saving of electric power per kW of heat production. Similarly 37% reduction in heat loss, supply T reduced 90 to 60C.

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## Conclusion (2/2)

- In this work, the applicability and feasibility of the model is carried out from the view point of expanding the existing DH network to a neighboring building.
- In forthcoming study, the feasibility analysis between the thermal networks, i.e. to build complex connected by the low supplying temperature network, will be carried out and its result will be presented.



## Thank you for your attention!

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# TECHNOLOGICAL ISSUES TO SUPPLY LOW TEMPERATURE DISTRICT HEATING

**IEA DHC Annex TS1, Subtask B: District heating and cooling technologies**

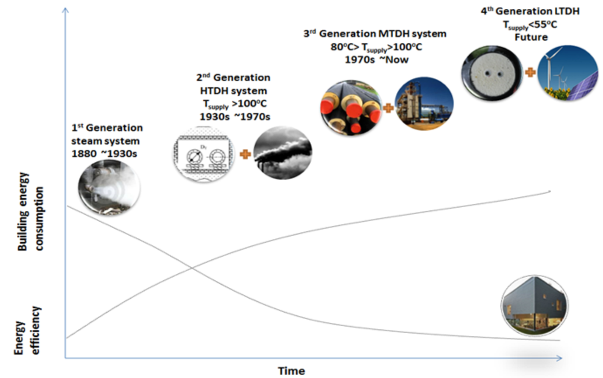
**06.09.2016**

**Hongwei Li**

**Technical University of Denmark**



## Development of low temperature district heating (LTDH)






## Technical Issues in LTDH- Reduction of supply temperature for space heating

**Advantages**

- Higher utilization of renewable and waste heat
- Higher power to heat ratio
- Lower network heat loss
- Better quality match between supply and demand

**Issues**

- Heat density of the area: high vs. low
- Building type: low energy vs. existing
- Heating devices: type, size
- Set-point temperature
- Hydraulic issues :single pipe vs. double pipe, hydraulic balance
- Flexible operation



## Technical Issues in LTDH- Reduction of return temperature from space heating

**Advantages**

- Higher delta T
- Lower network heat loss
- Better waste heat recovery: flue gas condensation
- Incentives

**Issues**

- Malfunction of device or man-made control error
- Return flow limter
- Trade off between flow rate and temperature



Presentation 2:
Hongwei Li, DTU, Denmark
TECHNOLOGICAL ISSUES TO SUPPLY LOW TEMPERATURE DISTRICT HEATING

## Technical Issues in LTDH- Supply domestic hot water

**Issues**

- Hygiene issue - solutions for Legionella treatment (thermal, chemical, physical, alternative solution)
- Comfortable issue – temperature and waiting time
- Type of DHW substations (storage tank vs. instantaneous heat exchanger)
- Type of buildings (single family vs. multi-story building)



## Technical Issues in LTDH- Energy efficient network

**Issues**

- Factors influence network heat loss: temperature, type of pipe, insulation
- Solutions to remove street pipe bypass
- Solutions to remove service pipe bypass

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## - Technical Issues in LTDH- Decentralized heat sources

**Issues**

- Type of decentralized heat sources
- Primary connections
- Decentralized solar thermal plant

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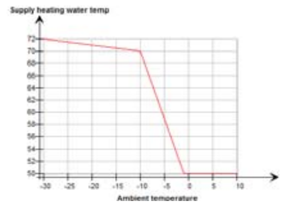
## Flexible operation

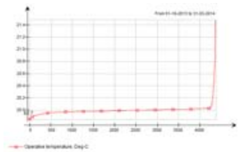
**Simulation**

-1970s building
-Floor area 142m2
-Heating demand: 110kWh/m2, 9.2kW peak load




**Conclusion**

-Annual room temperature below 19.9ºC is around 2%
-Supply 50ºC when Ta>-1oC
-Accounts 80% of total heating season



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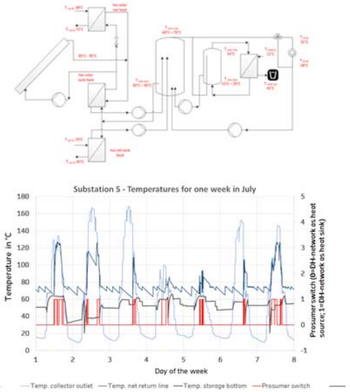
## Distributed renewable heat supply

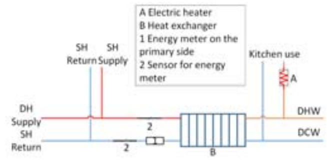
- Ludwigsburg, Germany
- Buffer storage tank for DHW and heat exchanger to exchange heat with solar collector and DH
- Results: in summer period, the amount of solar supplied heat to grid exceed significantly for the removal heat from the network






## Ultra-low temperature DH

- Jutland, Denmark
- Waste heat recovered from pumping station.
- 40ºC at the consumer side
- 11 kW in-line heat for kitchen only






## Thank you for your attention!

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**Email: hong@byg.dtu.dk**

# EXERGY-BASED ANALYSIS
## OF RENEWABLE MULTI-GENERATION UNITS FOR SMALL SCALE LOW TEMPERATURE DISTRICT HEATING SUPPLY

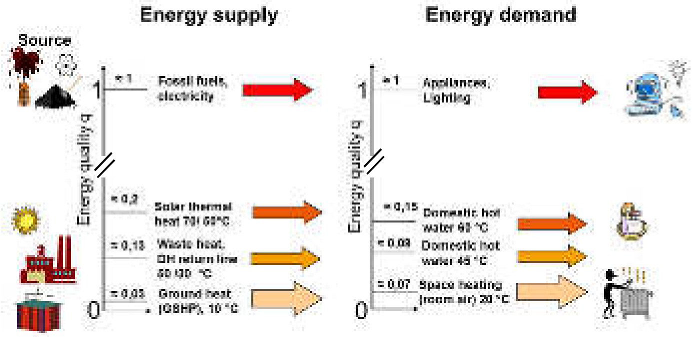
**September 4th - 7th, 2016**

*A. Kallert, D. Schmidt, T. Blaese*

Fraunhofer Institute for Building Physics
Gottschalkstrasse 28a
DE-34127 Kassel
Germany



## Exergy-based analysis of LTDH supply



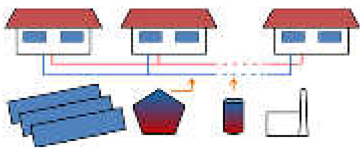



## Modelling of a small energy system

**LTDH Network**
- Radial network
- Design supply temperature 45 °C
- Equipped with pre-insulated twin-pipes

**Suppliers**
- GSHP, CHP, solar thermal collectors
- Implementation of storage facilities (seasonal storage / buffer storage)

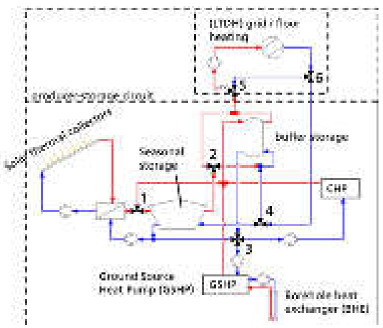
**Group of 10 buildings**
- Equipped with floor heating systems
- Specific heating demand of 45 kWh/m²a
- Equipped with a substation
- User profiles for heating and DHW



| | user type „average" | user type „saver" | user type "waster" |
|---|---|---|---|
| Room temperature | 21 °C | 19 °C | 22 °C |
| Night setback | Yes | Yes | No |
| Air exchange rate | 0,6 1/h | 0,3 1/h | 1,0 1/h |



## Investigation of different supply scenarios




| | Scenario | Solar thermal (ST) | Heat pump (HP) | CHP |
|---|---|---|---|---|
| 0 | NG boiler | | | |
| 1.1 | ST | 800 m² (100%) | | |
| 1.2 | HP | | 60 kW | |
| 1.3 | CHP | | | 60 kW |
| 2.1 | ST + HP | 350 m² (40%) | 60kW | |
| 2.2 | ST + CHP | 350 m² (40%) | | 60 kW |
| 2.3 | HP + CHP | | 60 kW | 5kW |
| 3 | ST + HP +CHP | 350 m² (40 %) | 45 kW | 20kW |

## Exergy and energy assessment

Exergetic analysis

- Better match of supplied and demanded energy quality
- Identification of optimization potential, beyond energy analysis and offers prospects for an optimized community supply
- Other objectives such as maximizing the use of renewables or minimizing emissions are not inherently included

…for that reason the assessment of $CO_2$ emissions and investment costs are added to this method…

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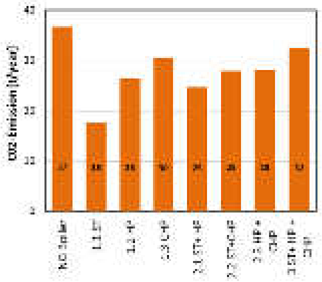
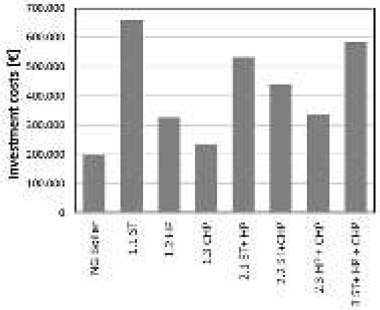
## Assessment of further aspects

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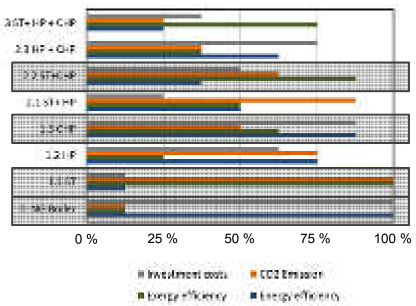
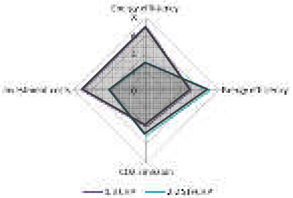
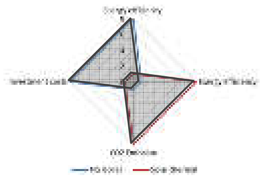
## Comparison of supply variants

$$f_{Performance} = \frac{x_{min,j} - x_{j,n}}{x_{max,j}}$$





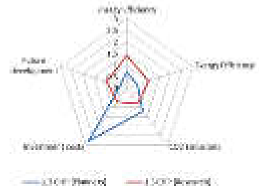
## Conclusion and next steps

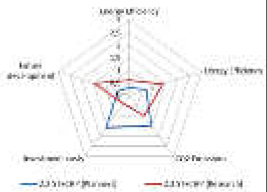
Conclusion

- Combination of innovative supply strategies and exergetic assessment leads to a "holistic understanding" of the energy conversion chain
- Exergetic analysis shows optimization potential, beyond energy analysis and offers prospects for an optimized community supply
- Simultaneous consideration of energy and exergy efficiency as well as $CO_2$ emissions and economic aspects provides great opportunities for a precise analysis of LTDH

Next steps

- Economic analysis has to be extended by consumption costs and operational related costs (full-cost analysis)
- Identification of further influencing parameters
- Implementation of weighting factors





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Presentation 3:
Anna Kallert, Fraunhofer IBP, Germany
TECHNOLOGICAL ISSUES TO SUPPLY LOW TEMPERATURE DISTRICT HEATING


Thank you for your attention!
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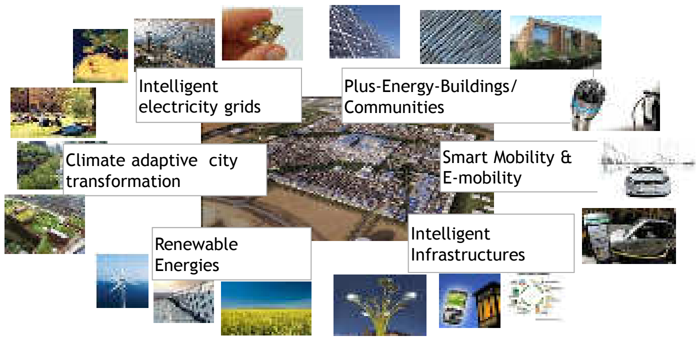
# LOW TEMPERATURE DISTRICT HEATING FOR FUTURE ENERGY SYSTEMS

September 4th - 7th , 2016

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



## Future developments in our cities?

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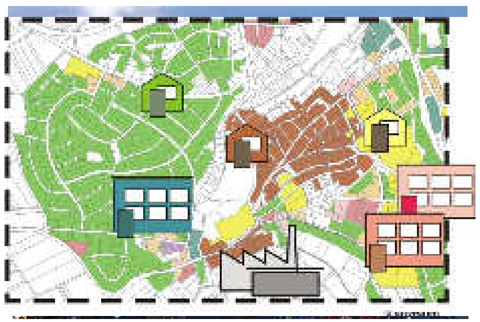
## Challenges in the energy sector

- 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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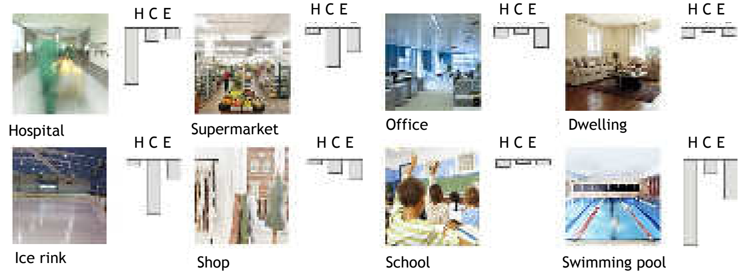
## Different energy profiles at a community level




Source: REAP Projekt, TU Delft

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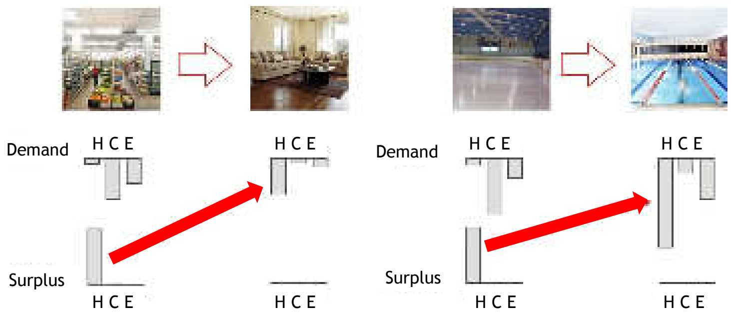
Presentation 4:
Dietrich Schmidt, Fraunhofer IBP, Germany
LOW TEMPERATURE DISTRICT HEATING FOR FUTURE ENERGY SYSTEMS

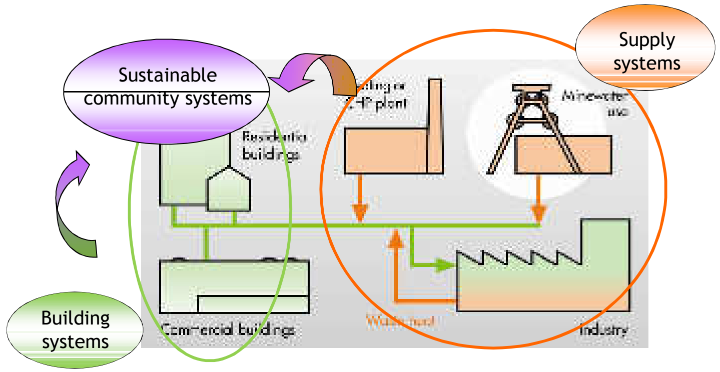
## Synergies via waste heat utilization and cascading




Source: REAP Projekt, TU Delft

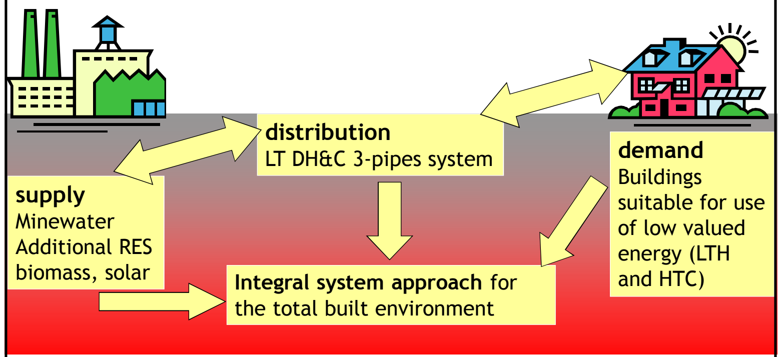


## Communities as energy systems






## 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)



Presentation 4:
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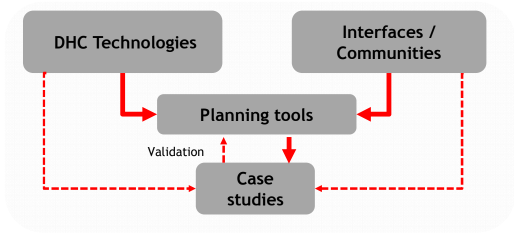
LOW TEMPERATURE DISTRICT HEATING FOR FUTURE ENERGY SYSTEMS

## The IEA DHC Annex TS1




IEA DHC|CHP

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



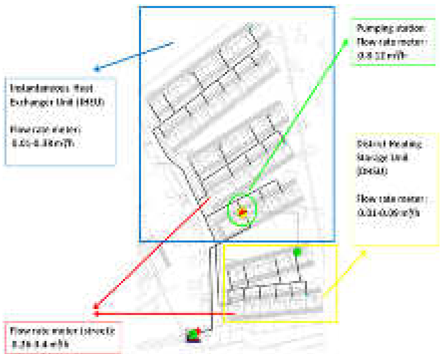
## Example: Hyvinkää (FI)

- 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)

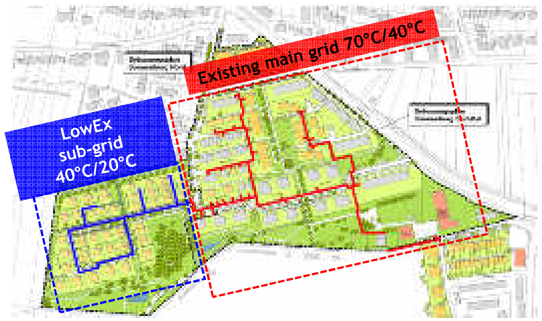


- Lowering of the grid temperatures for existing buildings Hydraulic and thermal simulations
- Realisation and monitoring
- Low energy houses with low temperature radiators

Source: DTU Lyngby / COWI



## 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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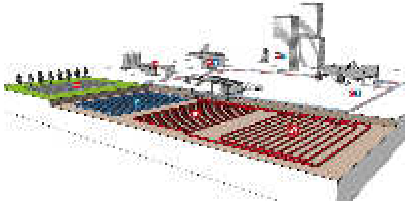
LOW TEMPERATURE DISTRICT HEATING FOR FUTURE ENERGY SYSTEMS

## 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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## The DHC Annex TS1 participants


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IEA DHC|CHP

**IEA DHC Annex TS1:**

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

www.iea-dhc.org

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Thank you for your attention!
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DHC2016
THE 15th INTERNATIONAL SYMPOSIUM ON
District Heating and Cooling
on behalf of

# DEVELOPMENT OF AN INNOVATIVE LOW TEMPERATURE HEAT SUPPLY CONCEPT FOR A NEW HOUSING AREA

September 4th - 7th , 2016

Dr. Dietrich Schmidt
Fraunhofer Institute for Building Physics (IBP), Kassel
Germany

Schmidt, D; Kallert, A; Reul, O.; Orozaliev, J.; Vajen, K; Best, I.; Bennewitz, J; Gerhold, P.

Fraunhofer IBP · Universität Kassel · Städtische Werke Kassel · AGFW





## The Project

**Development of an innovative heat supply concept for the housing area „Zum Feldlager“ in Kassel/Germany**





## The Project

**Development of an innovative heat supply concept for the housing area „Zum Feldlager“ in Kassel/Germany**

Boundaries for the project:

- “**Future save**” and innovative development, affordable prices
- Minimized primary energy use, reduction of $CO_2$ & no fine dust emissions, efficient energy use, integration of renewable energy sources.
- 130 buildings in future German building Standard (approx. 45 kWh/m²a)
- ➢ **Pre-study for the selection of technology sets**





## Analyzed Supply Variants

Building focused:

- De-central air/water-heat pumps, domestic hot water preparation (DHW) supported by solar thermal systems
- De-central gas-condensing boiler with solar thermal systems for domestic hot water preparation (DHW) ***(Reference)***

Community focused:

- De-central water/water heat pumps connected to cold DH system (**20°C**) in combination with solar thermal systems and heating rod for DHW
- Central heat supply via heat pump and low temperature DH (**40°C**) in combination with de-central solar thermal systems and heating rod for DHW
- Gas-CHP-heat pump system with CHP unit and electric heat pump in combination with large heat storage. Operated with natural-gas or bio-gas



Presentation 5:
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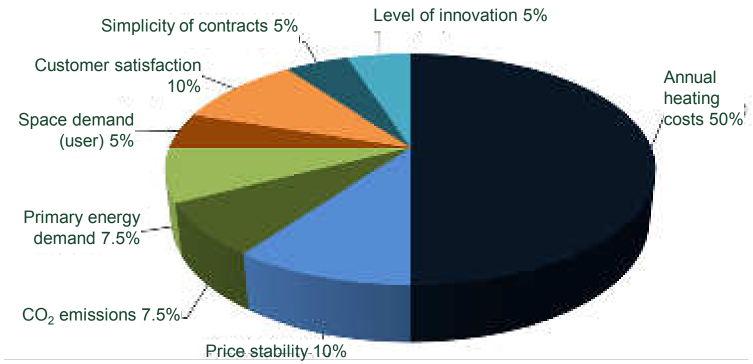
DEVELOPMENT OF AN INNOVATIVE LOW TEMPERATURE HEAT SUPPLY CONCEPT FOR A NEW HOUSING AREA

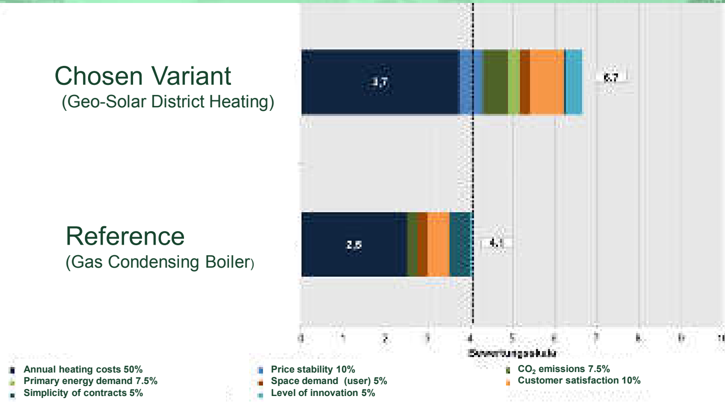
## Assessment of the Variants - Parameters and Weighting Factors







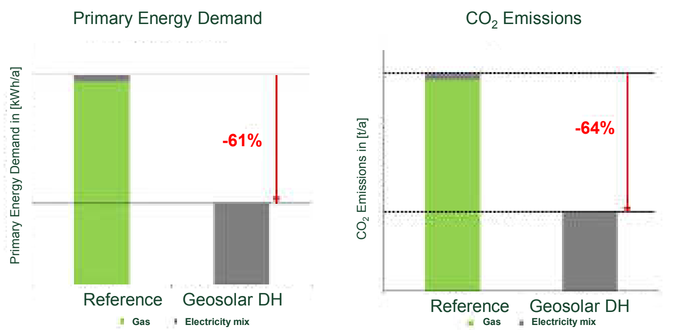

## Results from the Pre-Study








## Results - Ecological Assessment

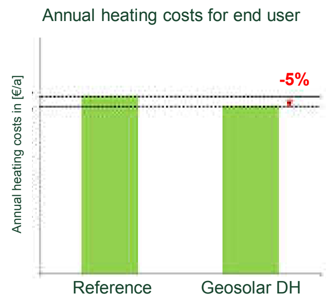



* Acc EnEV16 for electricity mix with primary energy factor 1,8 and $CO_2$-Emissions 0,347 kg/kWh





## Results - Economical Assessment



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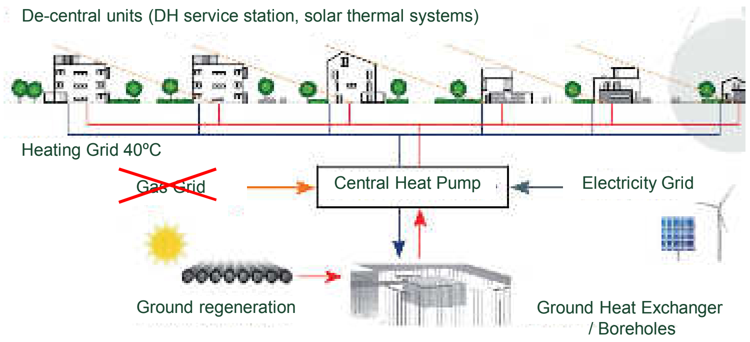
DEVELOPMENT OF AN INNOVATIVE LOW TEMPERATURE HEAT SUPPLY CONCEPT FOR A NEW HOUSING AREA

## Geo-Solar District Heating - Chosen Supply Variant

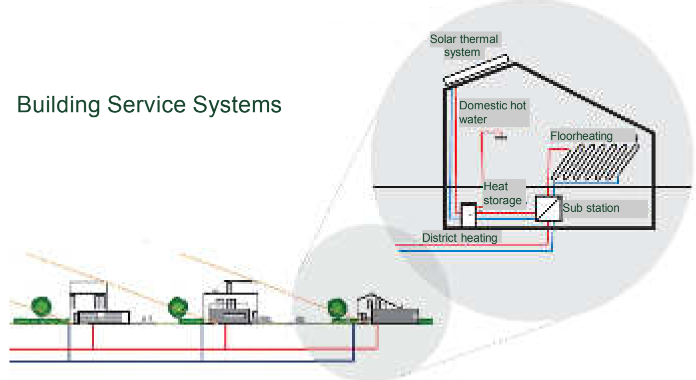







## Geosolar District Heating - Chosen Supply Variant

Building Service Systems








## Summary

- **Renewable heating energy supply**
  Solar heat, geothermal heat, heat pump, low temperature district heating for the first time connected in a large city neighborhood
- **More cost efficient than conventional supply**
  Today already 5% cheaper compared to common technology and independent from rising oil and gas prices; incl. higher energy security
- **Transferable to most new housing area developments**
- **Intelligent combination of proven technologies**
  Integration of innovative **DH & HVAC** technologies

Thanks for the financial support given by the
**German Ministry for Economic Affairs and Energy**





## Thank you for your attention!

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**& Prof. Klaus Vajen**
**University of Kassel, Department of Solar and System Engineering**
**Email: vajen@uni-kassel.de**



Presentation 5:
Dietrich Schmidt, Fraunhofer IBP, Germany
DEVELOPMENT OF AN INNOVATIVE LOW TEMPERATURE HEAT SUPPLY CONCEPT FOR A NEW HOUSING AREA

# NECESSARY MEASURES TO INCLUDE MORE DISTRIBUTED RENEWABLE ENERGY SOURCES INTO DISTRICT HEATING SYSTEM

IEA DHC Annex TS1

**2nd September 2016**

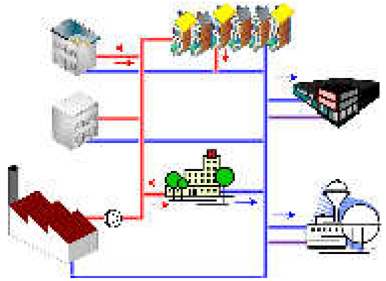
**Natasa Nord**

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



## 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

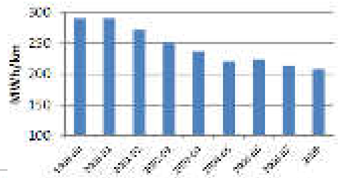


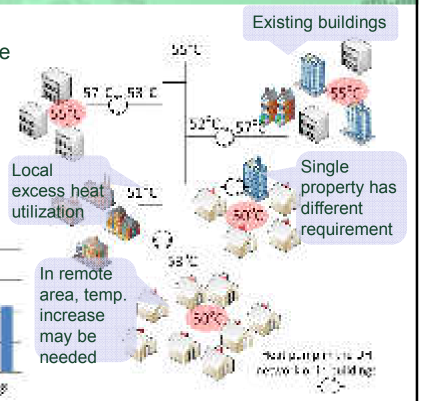


## Example of waste heat based district heating

- Viborg DH in Denmark will use excess heat from the Apple computer center
- The surplus heat from the servers is rejected to the DH

Viborg DH plan for decreasing distribution losses

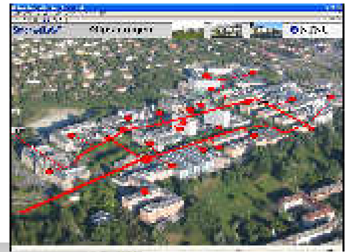





## Example of waste heat integration

- Heat recovery at the university campus, Trondheim, Norway
- NTNU campus made its own DH ring
- Connect the condenser heat in the return line
- The supply and return temperature are controlled in the optimal way to harvest most of the waste heat from the IT center





Presentation 6:
Natasa Nord, NTNU Trondheim, Norway
NECESSARY MEASURES TO INCLUDE MORE DISTRIBUTED RENEWABLE ENERGY SOURCES INTO DISTRICT HEATING SYSTEMS

## Methodology

- **Aim**: evaluate possibilities to utilize distributed heat sources at building complexes and their interaction to the DH system
- Total annual heat demand for an imaginary building area

$$Q_{Tot,h} = \sum_i p_i \cdot q_i \cdot A$$

- Heat delivered from the central DH system can be expressed as:

$$Q_{dh,cen} = Q_{Tot,h} - \underbrace{Q_{HP} - Q_{WH} - Q_{sol}}_{\text{Delivered from distributed energy sources}}$$



## Methodology

- The total specific cost

$$c_{tot} = C_{tot}/Q_{Tot,h}$$

- The optimization problem was defined as a multiobjective problem

$$min\ (Q_{dh,cen}, c_{tot})$$

- The optimization parameters were: $\dot{W}_C$, compressor power, $n_{HP}$, number of the heat pumps, $Q_{WH}$, available waste heat, and $A_{sol}$ area of the solar collectors



## Input data

### Building heat demand and area structure

| Building type | Specific heat demand (kWh/m²) | Building area structure |
|---|---|---|
| Residential | 119 | 66 % |
| Multipurpose | 154 | 20 % |
| Offices | 140 | 12 % |
| High energy use | 280 | 2 % |

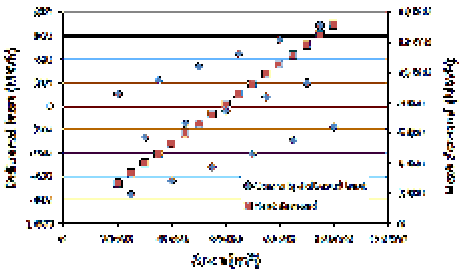
### Technical and economic input

| Parameter name and unit | Value |
|---|---|
| COP of the heat pumps | 3 |
| Specific annual solar irradiation | 400 $kWh/m^2$ |
| Average efficiency of the solar collectors | 0.75 |
| Investment cost for the heat pump | 500 $EUR/kW$ |
| Investment for the solar collectors | 300 $EUR/m^2$ |
| District heating price | 0.08 $EUR/kWh$ |
| Electricity price | 0.1 $EUR/kWh$ |
| Waste heat price | 0.3$\cdot c_{dh}$ |



## Possibility of building complex to deliver heat to the DH system

- The possible amount of heat that might be delivered to the central DH system vary a lot depending on the area size and structure
- The total specific cost might achieve values lower than 0.05 EUR/kWh

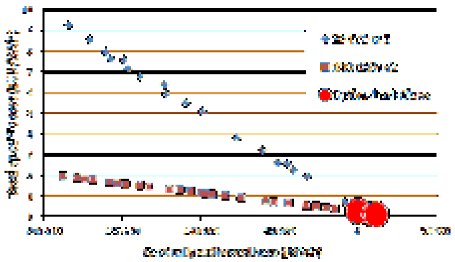




Presentation 6:
Natasa Nord, NTNU Trondheim, Norway
NECESSARY MEASURES TO INCLUDE MORE DISTRIBUTED RENEWABLE ENERGY SOURCES INTO DISTRICT HEATING SYSTEMS

## Optimization results

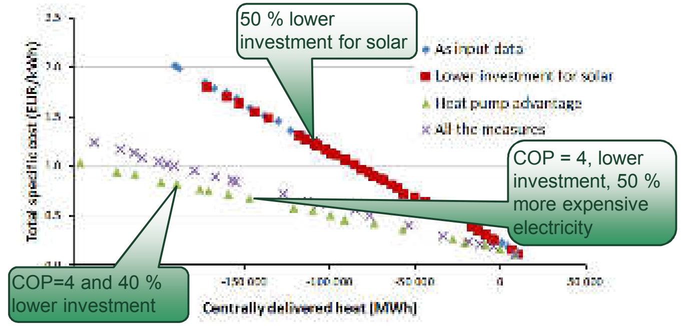
- For the current economic condition, the big area may become a heat prosumer
- The optimal solution for the 100 000 m² area was still using about 10 GWh of the DH heat centrally delivered





## Necessary measures to enable more distributed sources

**The measures implementation in the 100 000 m² area**






## Conclusions

- The bigger the building area, the more heat might delivered
- The bigger area was less sensitive in the change of the parameters
- For the **current economic conditions**, it was still favorable to use a big part of the heat from the central DH plant
- Lower investment and better performance of the heat pump gave the best results and the fastest decrease of the total specific cost
- Future work should consider development of heat prices and operation issues to enable reliable heat delivery



## Thank you for your attention!

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Presentation 6:
Natasa Nord, NTNU Trondheim, Norway
NECESSARY MEASURES TO INCLUDE MORE DISTRIBUTED RENEWABLE ENERGY SOURCES INTO DISTRICT HEATING SYSTEMS

# Transition to low temperature distribution in existing systems

A summary of the conference paper

6th September 2016

Mr. Miika Rämä

VTT Technical Research Centre of Finland



## Presentation contents

1) Background and motivation
2) Benefits and challenges of a transition to low temperature distribution
3) Evaluation of transition
   - Overall evaluation process
   - System specific evaluation
4) Next steps



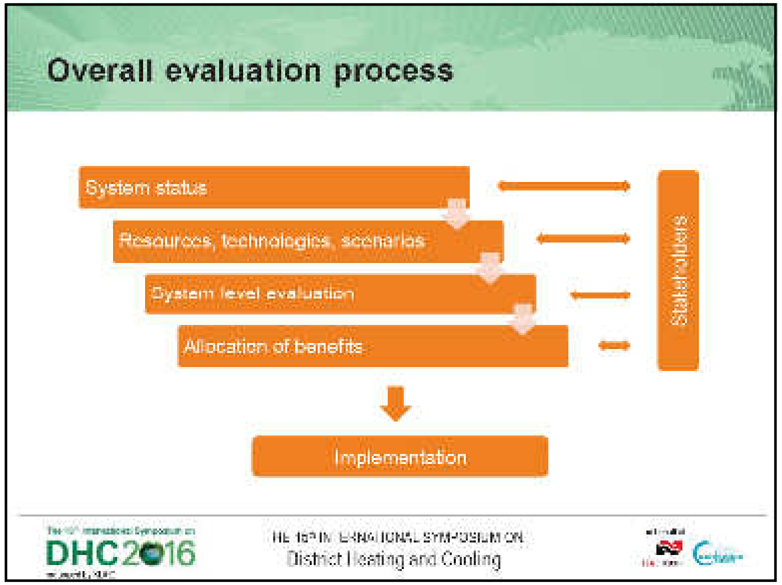
## Background and motivation

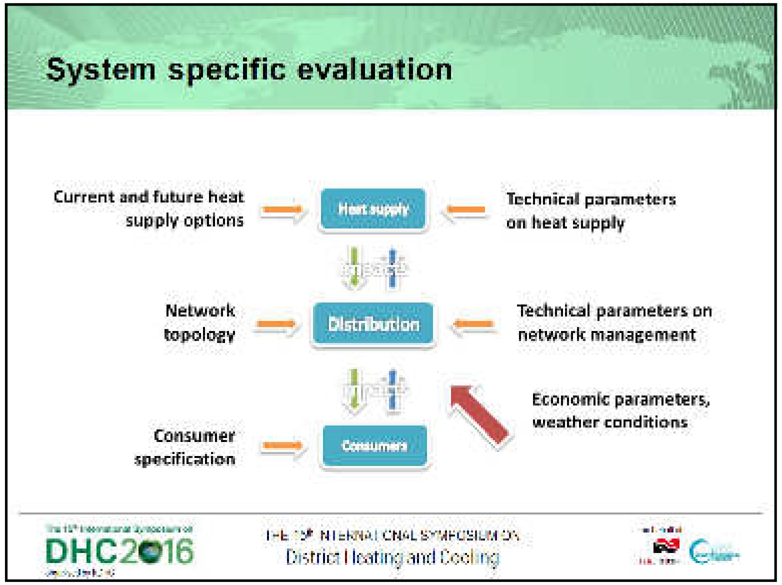
- District heating and cooling globally an untapped potential on energy efficiency
- On an European level, a recently announced EU Strategy on Heating and Cooling sets a framework for promoting the technology
  - Replacing building specific system with district energy systems can reduce primary energy consumption, fossil fuel usage and CO2 emissions by 7%, 9% and 13%, respectively (Heat Roadmap Europe 2050)
- Low temperature distribution is a key element in realising the full potential of district heating as part of future energy systems
- More diversified and distributed heat supply requires new solutions

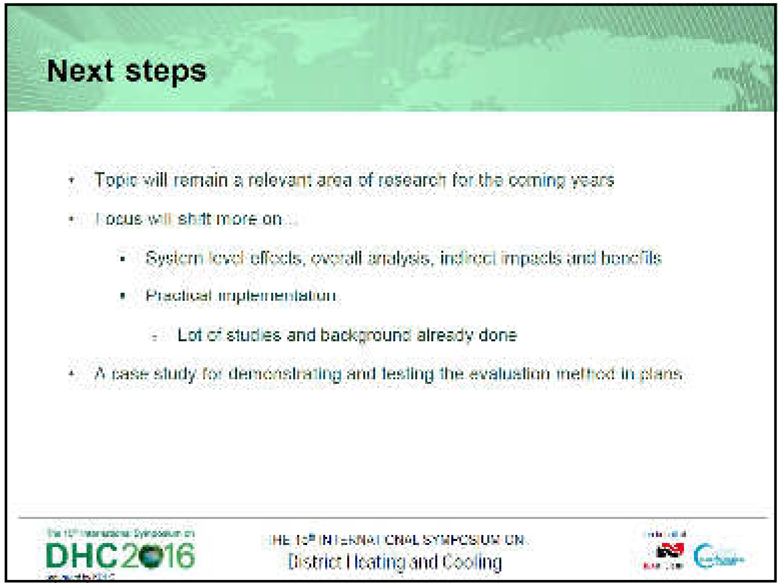


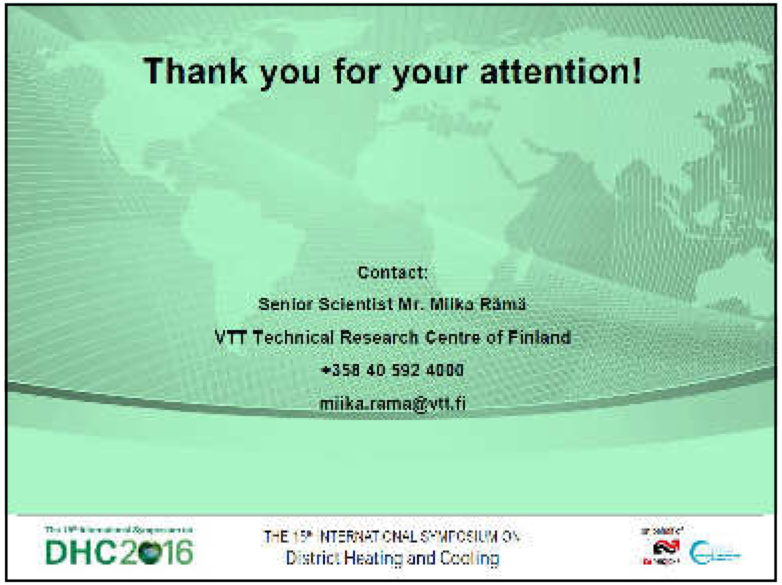
## Benefits and challenges

- Low temperature distribution has several benefits
  - Accelerated integration of renewable energy sources, enabled use of currently underutilised sources of excess heat
  - More efficient operation on conventional heat supply technologies
  - Lower heat losses in distribution
- Challenges for existing systems remain as well
  - Lower temperature difference can represent capacity issues in the network
  - Consumer equipment can require modifications and investment
  - The mind set and business models within the industry needs developing




Presentation 7:
Miika Rämä, VTT Espoo, Finland
TRANSITION TO LOW TEMPERATURE DISTRIBUTION IN EXISTING SYSTEMS

# EVALUATION OF DIFFERENT DISTRICT HEAT SUPPLY CONCEPTS FOR SETTLEMENT AREAS

September 6, 2016

Markus Blesl; Markus Stehle
Institute of Energy Economics and the Rational Use of Energy (IER); University of Stuttgart



## Agenda

- Motivation
- A Simplified Tool for District Heating: Easy District Analysis (EDA)
- Application of EDA: Case Study
- Conclusion



## Motivation

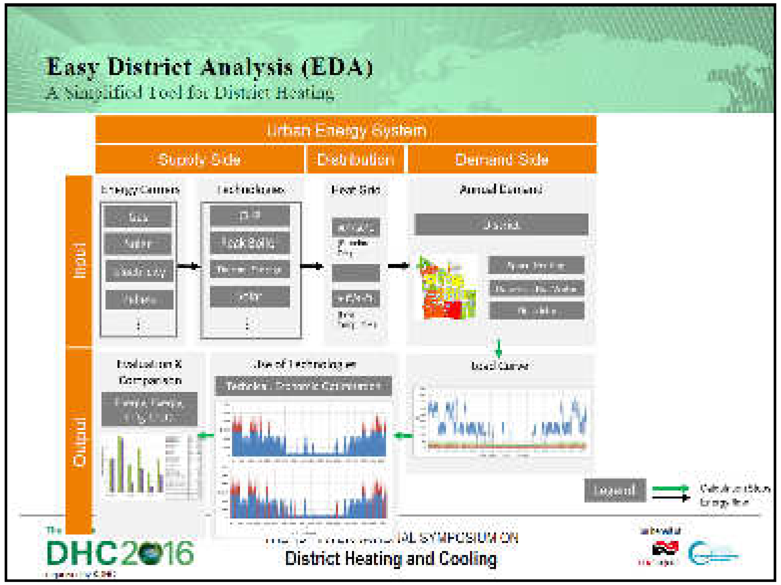
- For climate protection at local level **energy efficient supply** structures are essential
- Efficient **LowEx** –heating systems require the coordination of heat generation, technical building services and energy standard of the building.
- Possible energy systems of the future:
  - Integration of **renewable energy**
  - **Reduction of distribution losses**
  - **Higher efficiency** in heat generation

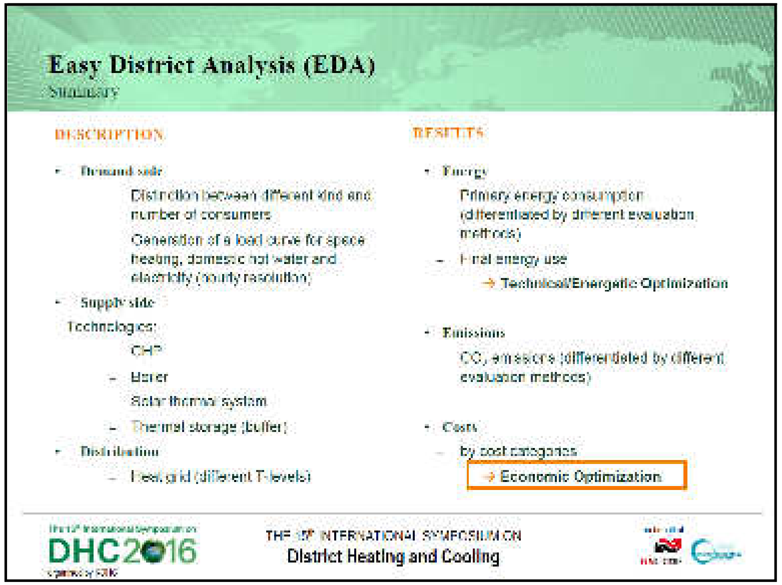
➡ For the evaluation of the different systems a **tool** is helpful and necessary

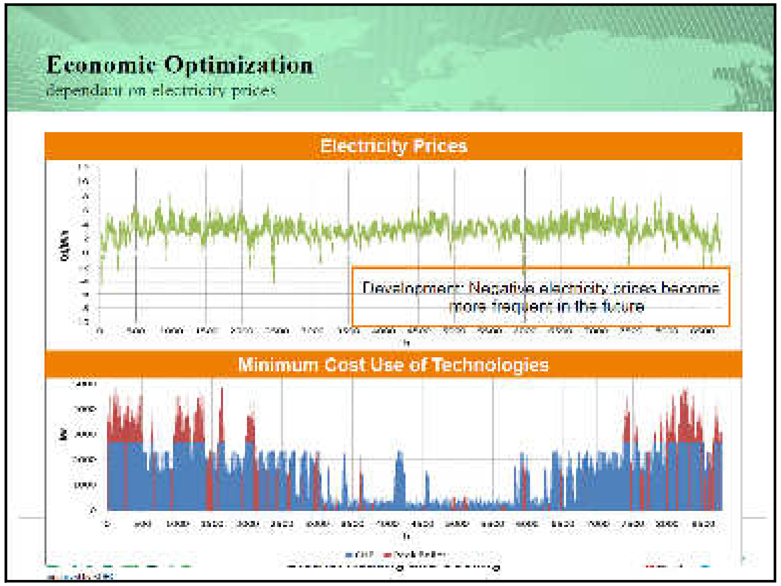


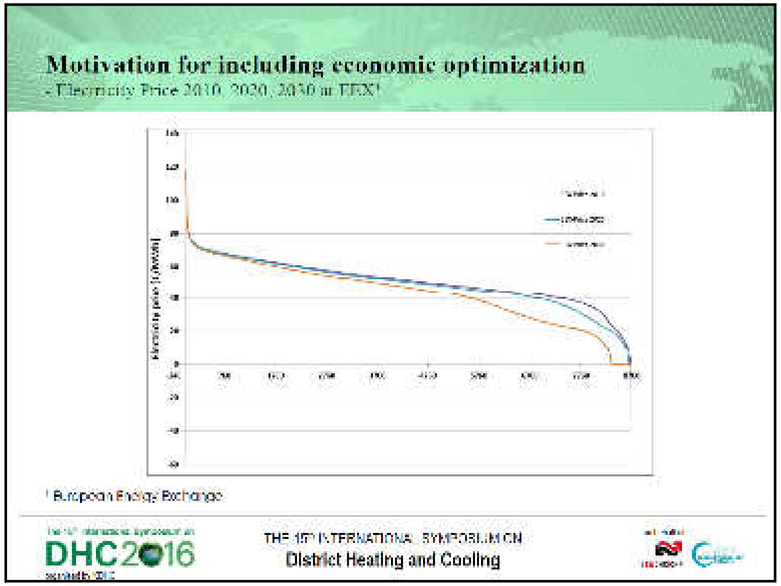
## Agenda

- Motivation
- **A Simplified Tool for District Heating: Easy District Analysis (EDA)**
- Application of EDA: Case Study
- Conclusion


Easy District Analysis (EDA)
A Simplified Tool for District Heating
Urban Energy System
Supply Side
Distribution
Demand Side
Input
Output
Annual Demand
Load Curve
Legend
THE 15TH INTERNATIONAL SYMPOSIUM ON
District Heating and Cooling
DHC2016


Easy District Analysis (EDA)
Summary
DESCRIPTION
Demand side
Distinction between different kind and number of consumers
Generation of a load curve for space heating, domestic hot water and electricity (hourly resolution)
Supply side
Technologies:
CHP
Boiler
Solar thermal system
Thermal storage (buffer)
Distribution
Heat grid (different T-levels)
RESULTS
Energy
Primary energy consumption (differentiated by different evaluation methods)
Final energy use
→ Technical/Energetic Optimization
Emissions
CO2 emissions (differentiated by different evaluation methods)
Costs
by cost categories
→ Economic Optimization
THE 15TH INTERNATIONAL SYMPOSIUM ON
District Heating and Cooling
DHC2016


Economic Optimization
dependant on electricity prices
Electricity Prices
Development: Negative electricity prices become more frequent in the future
Minimum Cost Use of Technologies
CHP
Peak Boiler


Motivation for including economic optimization
- Electricity Price 2010, 2020, 2030 at EEX[1]
[1] European Energy Exchange
THE 15TH INTERNATIONAL SYMPOSIUM ON
District Heating and Cooling
DHC2016

## Agenda

- Motivation
- A Simplified Tool for District Heating: Easy District Analysis (EDA)
- Application of EDA: Case Study
- Conclusion



## Case Study
Easy District Analysis (EDA)

- District
  - annual heat demand 12.5 GWh/a
  - 140 Multi-Family Houses
- District Heating (DH) system:
  - CHP
  - Peak Boiler
- Comparison of different DH variants:

| Standard DH | Low Temperature DH |
|---|---|
| 90°C / 60°C | 50°C / 35°C |
| Technical vs. Economic Optimization | |

- A reduction of temperature level is reasonable, as high temperatures (≥ 90°C) are often not required to supply low temperature demand (space heat, DHW).
- A benefit of low temperature DH is the higher efficiency along the heat supply chain compared to standard DH.

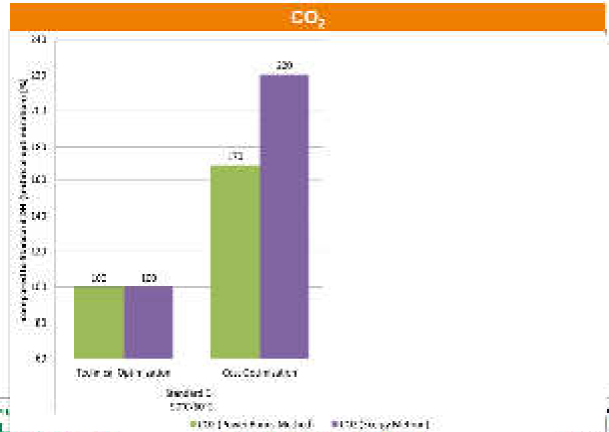


## Comparison of the energy efficiency of different DH systems
From standard DH to low temperature DH

| DH characterization | | 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 | 93 | 93.5 |
| DH Grid | distribution losses | 13.3 | 11 | 8 | 8 |
| Consumer | $\eta_{th}$ | 96 | 97 | 99 | 99 |
| | distribution losses | 10 | 8 | 6 | 6 |



## Technical vs. Cost Optimization for Standard DH
Case Study District (140 MFH)

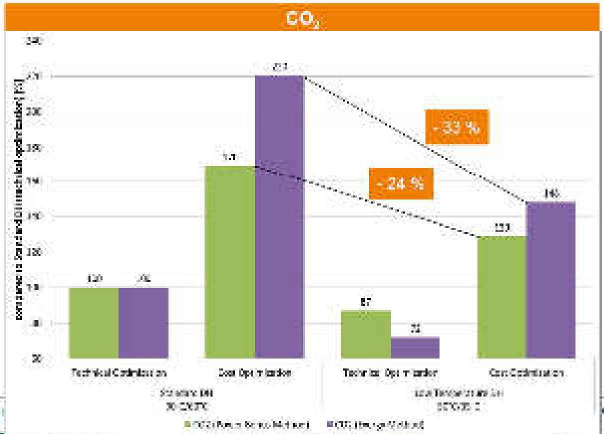





Presentation 8:
Markus Blesl, University of Stuttgart, Germany
EVALUATION OF DIFFERENT DISTRICT HEAT SUPPLY CONCEPTS FOR SETTLEMENT AREAS

## Technical vs. Cost Optimization for different DH systems

Case Study District (140 MFH)






## $CO_2$ Abatement Costs: Technical vs. Cost Optimization

Case Study District (140 MFH)

| | Unit | Standard DH | Low Temperature DH |
|---|---|---|---|
| $CO_2$ Abatement Costs (compared to Cost Optimization) | €/t $CO_2$ | 44 | 47 |



## Agenda

- Motivation
- A Simplified Tool for District Heating: Easy District Analysis (EDA)
- Application of EDA: Case Study
- Conclusion



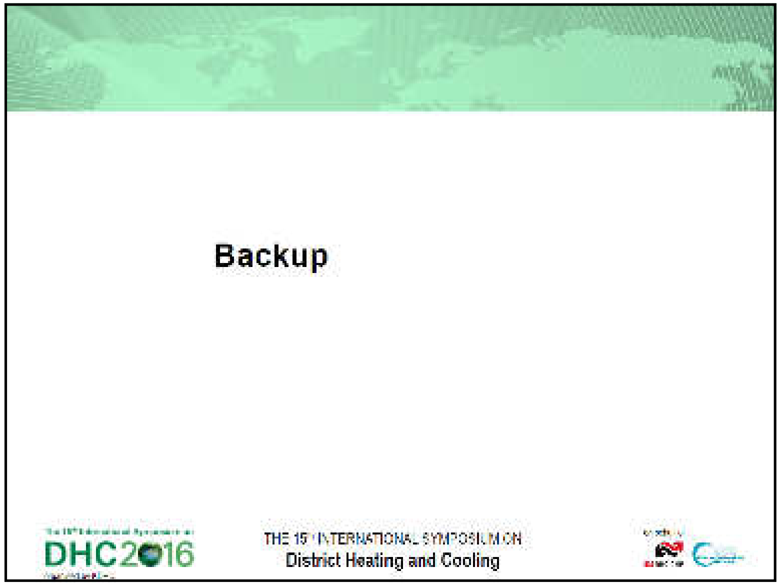
## Conclusion

- The simplified tool EDA for urban planners has been developed to enable analyses of districts to compare different DH supply options in terms of energy, ecology and costs.
- The integration of intermittent renewable energy such as solar thermal into the district energy system is also part of EDA.
- Aside the design of heat supply technologies the operation of a DH energy system can be optimized economically.
- A case study of a district of 140 multi-family houses has shown that low temperature DH can save up to 28 % of carbon emissions compared to standard DH.
- However, this improvement might be negated by the economic conditions (e.g. a more frequent occurrence of negative electricity prices).
- Taking into account the environmental impact cost might correct the development.



Presentation 8:
Markus Blesl, University of Stuttgart, Germany
EVALUATION OF DIFFERENT DISTRICT HEAT SUPPLY CONCEPTS FOR SETTLEMENT AREAS


Thank you for your attention!
Contact:
PD Dr. Markus Blesl,
Markus.Blesl@ier.uni-Stuttgart.de
DHC2016
District Heating and Cooling


Backup
DHC2016
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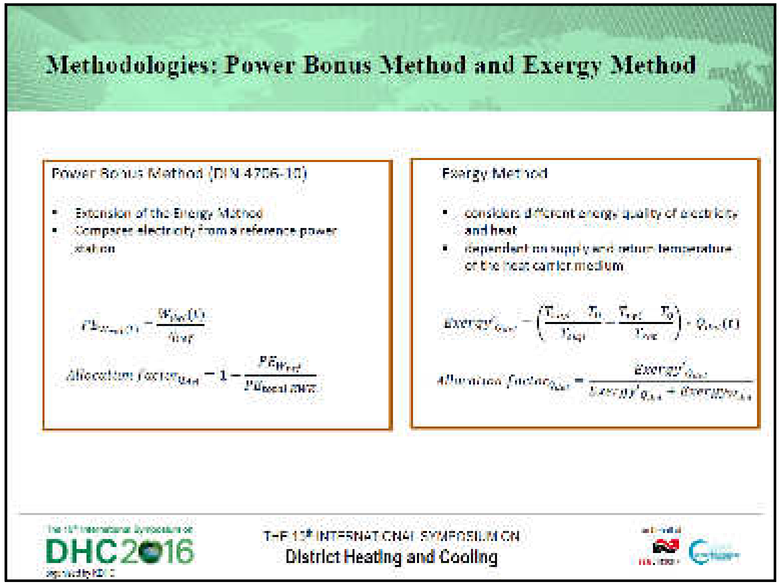
Methodologies: Power Bonus Method and Exergy Method
Power Bonus Method (DIN 4706-10)
Extension of the Energy Method
Compares electricity from a reference power station
Exergy Method
considers different energy quality of electricity and heat
dependent on supply and return temperature of the heat carrier medium
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# FLEXYNETS

## A NEW GENERATION OF INTELLIGENT LOW EXERGY DISTRICT HEATING AND COOLING NETWORKS

**6 Sep 2016**

**Ilyes Ben Hassine, Dirk Pietruschka**
**ZAFH- Hochschule für Technik Stuttgart**



## Content

- FLEXYETS at a glance
- The FLEXYNETS concept
- Purposes of FLEXYNETS
- Tools of FLEXYNETS
- Current and next steps



## FLEXYETS at a glance

- H2020 project
- Program: EE13 – Technology for district heating and cooling
- Started Summer 2015 for 3 years
- Budget around 2 m. €
- Managed by EURAC (I)
- 6 EU Partners: 2 academic and 4 industrials
- investigates different configurations of low-temperature DHC networks, where heating and cooling supply can be as distributed as the consumers



## The concept of FLEXYNETS

- FLEXYNETS spins off from the water-loop systems used for air-conditioning in some commercial buildings
- Heat pumps operating contemporarily for heating & cooling
- Extension of water-loop concept to district level
- At least one extra device to balance residual heating or cooling demand

## Purposes of FLEXYETS

- To reduce heat & electricity losses: target T below 40°C
- To integrate effectively multiple energy generation sources
- To exploit limits of thermal capacity design
- To develop and implement control strategies
    - Substation low-level
    - Network high-level
    - Interaction with electricity (& gas) grid
- To formulate guidelines for design and operation



## Tools of FLEXYNETS

- Analysis of settlement typologies
- Simulation of substation and network: from stationary to dynamic
- Test rig at EURAC
    - A distribution network with several storages
    - ORC system (4 kWe)
    - Absorption chiller (35kW)
    - Medium-T solar loop with a back-up boiler (40kW)
    - Reversible heat pumps and dissipation systems

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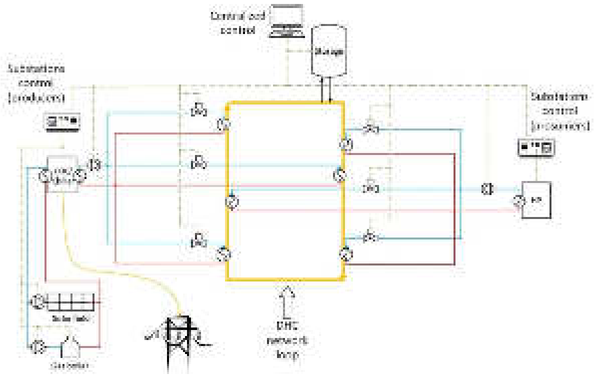
## Test rig at EURAC

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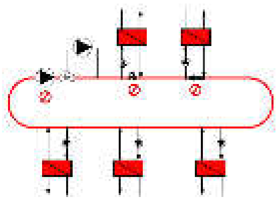
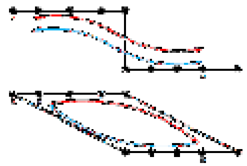
## Current activities





- Simulation
    - Substations in Trnsys
    - Network: dynamic two- and single- pipe
- Test rig
    - Designed
    - Commissioning Winter 2016

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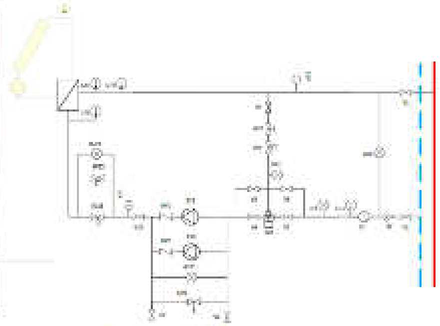
Presentation 9:

Ilyes Ben Hassine, HfT Stuttgart, Germany

FLEXYNETS - A NEW GENERATION OF INTELLIGENT LOW EXERGY DISTRICT HEATING AND COOLING NETWORKS

## Current activities



EnEff:Stadt

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## Next steps

- Simulation: integrate substations with network model in Trnsys
- Simulation: multi-energy vectors for interaction with other grids
- Test rig: installation and commissioning
- Control: implement on low-level

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## Thank you for your attention!

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