IEA DHC | CHP

Proceedings of the 2nd IEA DHC Annex TS3 and TS4 Industry Workshop:

Digitalization for optimizing integrated district heating systems

3rd of November 2021 as a web meeting

Hosted by:
Fraunhofer-Institute for Energy Economics and Energy System Technology IEE

Organised by:
Austrian Institute of Technology AIT
Fraunhofer-Institute for Energy Economics and Energy System Technology IEE

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

Fraunhofer IEE

Digitalization for optimizing integrated district heating systems

Digital technologies are believed to make the whole energy system smarter, more efficient, and reliable and to boost the efficiency and the integration of more renewables into the system In the future, digital applications might enable district energy systems to fully optimise their plant and network operation while empowering the end consumer. Further on, digital technologies are a key enabler for sector coupling and hybridisation of the energy system. On the other hand, challenges need to be tackled, such as data security and privacy as well as questions about data ownership.

Aim of the Webinar was

- to discuss the role of digitalisation within a future CO_2 free and integrated energy system,
- to present activities, challenges and solutions from the industry perspective,
- to get an impression of current commercial solutions,

The webinar was directed towards:

- District heating network operators and energy suppliers
- Digitalization solution providers (soft- and hardware, consultancies)
- R&D institutes and universities
- Policy makers, energy authorities and associations

This Webinar was held in the framework of two international cooperation programs:

IEA DHC Annex TS3 “Hybrid Energy Networks“

IEA DHC Annex TS4 “Digitalisation of District Heating and Cooling“

More information at

https://www.iea-dhc.org/the-research/annexes/2018-2024-annex-ts4/

http://www.iea-dhc.org/the-research/annexes/2017-2020-annex-ts3

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Webinar Digitalization for optimizing integrated district heating systems

Block I: policy framework and the big picture of digitalisation of energy infrastructures

This Webinar is held in the framework of two international cooperation programs:

IEA DHC Annex TS3 “Hybrid Energy Networks“

IEA DHC Annex TS4 “Digitalisation of District Heating and Cooling“.

03. November 2021

Ralf-Roman Schmidt AIT, Austria, ralf-roman.schmidt@ait.ac.at (leader TS3)

Dietrich Schmidt, Fraunhofer IEE, Germany, dietrich.schmidt@iee.fraunhofer.de (leader TS4)

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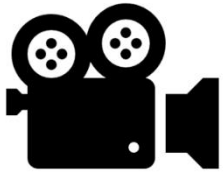
This webinar is recorded



The video file will be available after the webinar on the IEA DHC YouTube channel https://www.youtube.com/channel/UCuYcqLjJi8thrUJCjzLBaow

We will have a “group photo” at the end of the webinar, so please be prepared to turn on your webcam (participation voluntarily)

Webinar Etiquette

- **The microphone should be muted by default**
  - They should only be switched on if you are speaking.
- **Only one person speaks at a time**.
  - Requests to speak are reported via chat (**"rts"**),
  - the moderator will ask then the speakers to speak.
  - Please state your name and institution before you speak
- **Please turn off your webcam!**
  - No general video transmission in order to reduce the bandwidth.
  - The camera can be used at short notice for spoken contributions.
  - We will make a “group-photo” at the end of each block
- **Caution with humor and sarcasm!**
  - much of the original effect between the lines can be lost

Agenda Block I - policy framework and the big picture of digitalisation of energy infrastructures

9:30	Testing of technical connections
10:00	Introduction into the Webinar (Dietrich Schmidt, Fraunhofer IEE)
	National R&D perspectives for the digitalisation of the energy sector (Stefan Krengel, Project Management Juelich)
	The role of digitalisation with a focus on buildings and district heating (Ksenia Petrichenko, IEA Paris)
	The European framework (Matteo Pozzi, DHC+/ Euroheat and Power)
	Q&A to all presenters
11:00	End of Block I

Agenda Block II - Digitalization of district heating systems

12:00	**Testing of technical connections**
12:30	Introduction into the IEA DHC Annex TS4 project (Dietrich Schmidt, Fraunhofer IEE)
	The utility perspective on digitalisation of district heating (Julia Westerweck, Wärme Hamburg)
	Digitalisation solutions for heat infrastructures (Milan Jungic, Danfoss)
	Digitalisation potentials: Research test facility for innovative DH systems (Anna Kallert, Fraunhofer IEE)
	Interactive session and Q&A to all presenters
14:00	**End of Block II**

Agenda Block III - Hybrid energy system

15:00	**Testing of technical connections**
15:30	Introduction into the IEA DHC Annex TS3 project (Ralf-Roman Schmidt, AIT)
	The TSO perspective on sector coupling and district heating (Anders Bavnhøj Hansen, Energinet)
	Analysing systemic benefits in an integrated expansion planning model (Henrik Schwaeppe, RWTH Aachen University)
	Interactive session and Q&A to all presenters
17:00	**End of Block III**

The IEA technology cooperation program (TCP) on district heating and cooling (DHC)

- **a platform for international experts**
  - dedicated to helping to make DHC and CHP powerful tools for energy conservation and the reduction of environmental impacts of supplying heat
  - Current members: Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, Italy Korea, Norway, Sweden, United Kingdom, United States of America.
- **The projects within the IEA DHC TCP are either**
  - Funded through a **cost-sharing** approach (by the member states)
  - Funded through a **task-sharing** approach (the participants contribute resources in-kind for connecting existing national and international projects), e.g. Annex TS3 and TS4
- **More information:** http://www.iea-dhc.org/home.html

Thank you for your attention!

Webinar Digitalization for optimizing integrated district heating systems - Block I

03. November 2021

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NATIONAL R&D PERSPECTIVES FOR THE DIGITALISATION OF THE ENERGY SECTOR

Dr. Stefan Krengel, 3rd November, 2021

ENERGY RESEARCH PROGRAMMES

- Strategic element of energy policy since 1977
- 2018:
  - launch of current 7th program
  - Common program of BMWi and BMBF
  - > 500 Mio € per year

7TH RESEARCH PROGRAM „INNOVATIONS FOR THE ENERGY TRANSITION”

- Primary goal of research funding:
  - Support the transition to a climate neutral energy supply
  - Increasing the usability of innovative energy technologies
- Research on technologies and concepts that offer
  - Significant increases in efficiency
  - Integration of renewable energies
  - Ensuring security of supply
  - And a rapid transfer of research results to the application and into the market
- Key ideas
  - Technology-open approach
  - Adoption of new trends: sector coupling or the digitisation of the energy sector
  - Offer opportunities for innovative companies in the national market

7TH RESEARCH PROGRAM

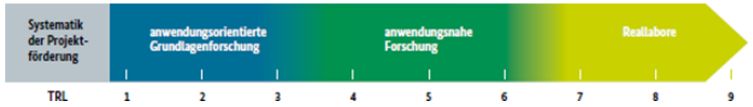
- Four focus areas
  - Energy in the end use sector (buildings and communities, industry, mobility)
  - Energy supply and electricity generation (wind, PV, bioenergy, geothermal etc.)
  - System integration (power supply system, grids, energy storage and sector coupling)
  - Cross-system research topics (system analysis, “energy transition and society”).
- Digitalisation is a major R&D topic in all of the focus areas
  - digital twins, digital planning, digital concepts for district heating and cooling networks, plant monitoring and asset management,…
  - However: Digitalisation processes are currently more advanced in the area of electricity than in the area of heat supply
- Current development
  - Additional support for climate neutral heat supply

CALL 2021: KomTechE

- Special focus on utilisation of communication technologies in buildings, electrical networks, city districts and district heating networks
- 39 proposals (100 Mio. €, 198 partners, thereof 25 % research)
- Support by “service project” National 5G Energy Hub
  - Platform with standardised interfaces for data collection and data processing is offered to all projects
- Main aspects with DHC context, projects to start in 2022:
  - Wireless monitoring of thermal networks
  - Digitalisation of network operation and planning
  - Area-wide roll-out of digital processes the network
  - Digitalisation of heat transfer stations and network nodes

NEW PILLAR 7TH RESEARCH PROGRAM: LIVING LABS

- Focus on the transfer of technologies and innovations into daily life
  - Preparing the market for innovative solutions
- Concentration energy system relevant problems to push forward the energy transition
  - City districts und multi-energy infrastructure, district heating, Hydrogen production and use, Digitalization
- Improved integration of additional funding formats for plant technology and infrastructure



LIVING LABS FOR THE ENERGY TRANSITION

currently 5 Living Labs in city districts

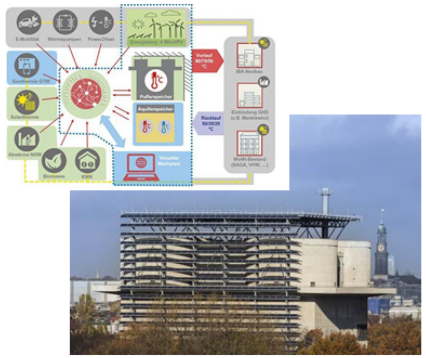
LIVING LABS FOR THE ENERGY TRANSITION TRANSURBAN.NRW 17M€

© stock.adobe.com/struvictory

- Regulatory sandbox for the energy transition: performed in former coal-mining region in North Rhine-Westphalia
- Objective: Transform fossil-based district heating networks into low-carbon supply systems
- Fifth generation energy systems can enable transition to climate-friendly supply
- Support by digital monitoring, control processes and cloud applications (E.ON ectogrid™)

TransUrban.NRW will show how the high-temperature energy infrastructure can be converted to a low-temperature energy system.

LIVING LABS FOR THE ENERGY TRANSITION
IW³ 22 M€



© HAMBURG ENERGIE/Daniel Sumesgutner

- Objective: Intelligent combining renewable energy quantities (sources, storage, consumer) in multi-energy network
- A virtual power plant will efficiently regulate the energy supply of districts and distributed feed-in
- Concept based on BlockChain technology
- Combination of research & practical application

IW³ will develop and implement a verification system for thermal flows combined with market-oriented efficiency.

CONCLUSION

- Technology-open program on energy research in Germany
- Digitalisation is one key aspect across all focus areas
- Research aims to demonstration and application of innovations in real environment
- „Wärmewende“ becomes more important

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The role of digitalisation with a focus on buildings and district heating

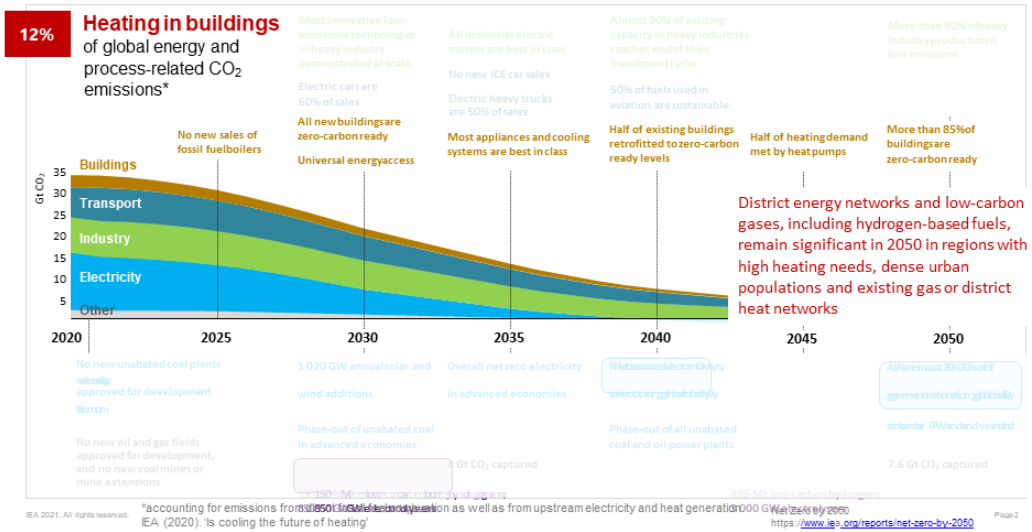
IEA DHC Technology Collaboration Programme

Webinar ‘Digitalisation for optimising integrated district heating systems’

3 November 2021

Ksenia Petrichenko, PhD, Energy Policy Analyst, International Energy Agency

Heating in buildings is crucial for following the path to Net Zero by 2050



*accounting for emissions from electricity generation as well as from upstream electricity and heat generation

IEA (2020). ‘Is cooling the future of heating’

Net Zero by 2050
https://www.iea.org/reports/net-zero-by-2050

Deep retrofit and decarbonisation of heating are key for NZE 2050

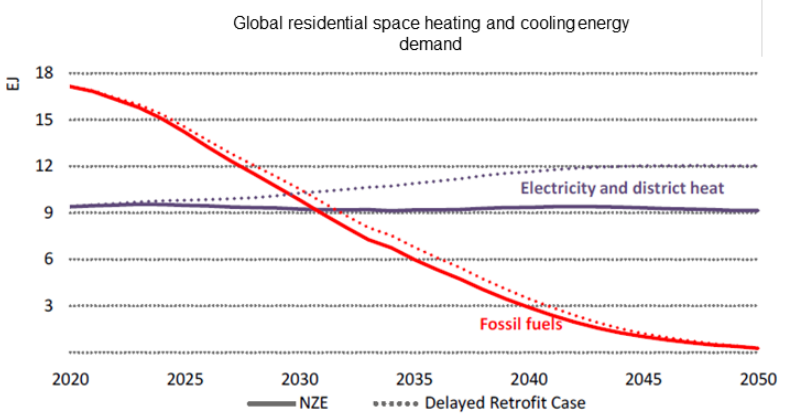
Reduction in emissions from buildings

By 2030

250 MtCO2 Due to digitalisation and smart controls enable efficiency gains

By 2030

350 MtCO2 Due to behaviour changes: lower temperature settings for space heating or reducing excessive hot water temperatures

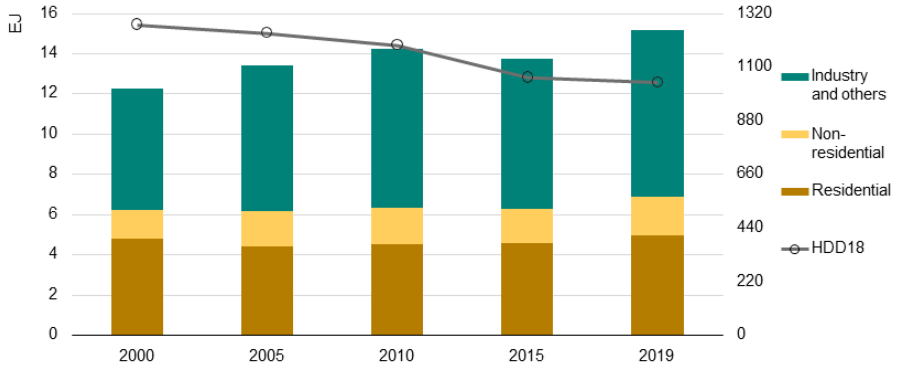


IEA. All rights reserved.

Delays in the ramp up of retrofit rates and depth would be almost impossible to catch up, placing further strain on the power sector and pushing up fossil fuel demand

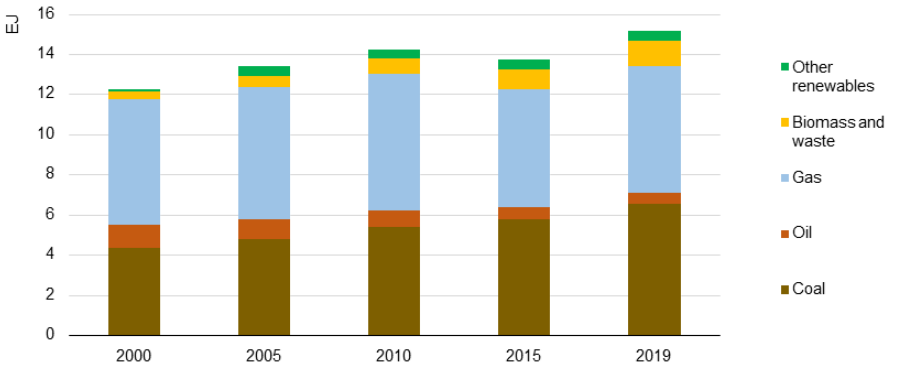
Net Zero by 2050
https://www.iea.org/reports/net-zero-by-2050

The share of heat production for buildings is constant since 2000



Globally, district heat covers around 9% of global space and water heating demand, as buildings efficiency is increasing and distribution temperatures are decreasing

Fossil fuels are still meeting the bulk of district heat production



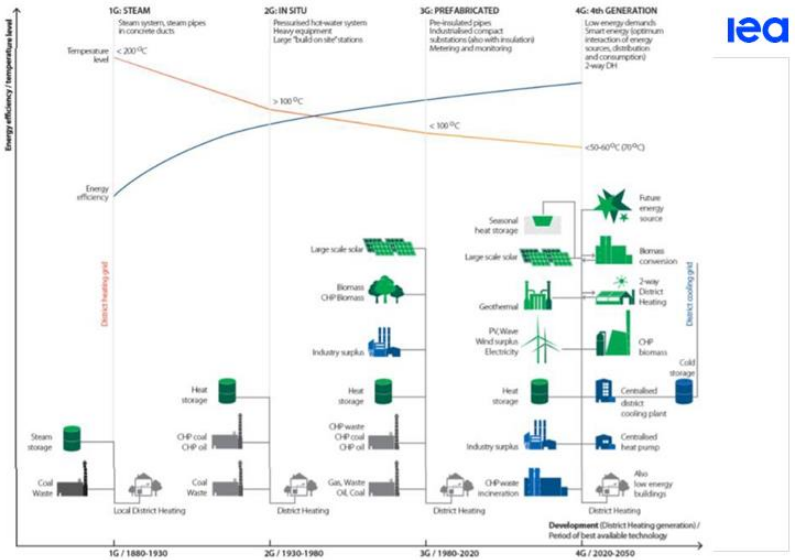
Biomass, waste and other renewables sources covering just a bit over 10% of global district heat production

4GDH

The 4th Generation District Heating (4GDH) system - a coherent technological and institutional concept, which by means of smart thermal grids assists the appropriate development of sustainable energy systems.

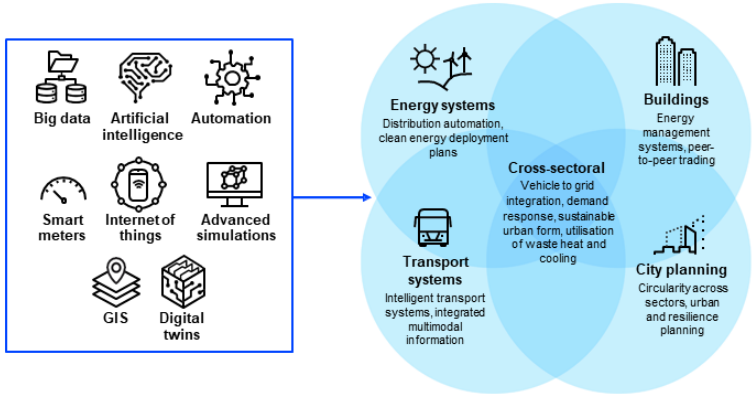
4GDH systems provide the heat supply of low-energy buildings with low grid losses in a way in which the use of low-temperature heat sources is integrated with the operation of smart energy systems.

It requires the development of an institutional and organisational framework to facilitate suitable cost and motivation structures



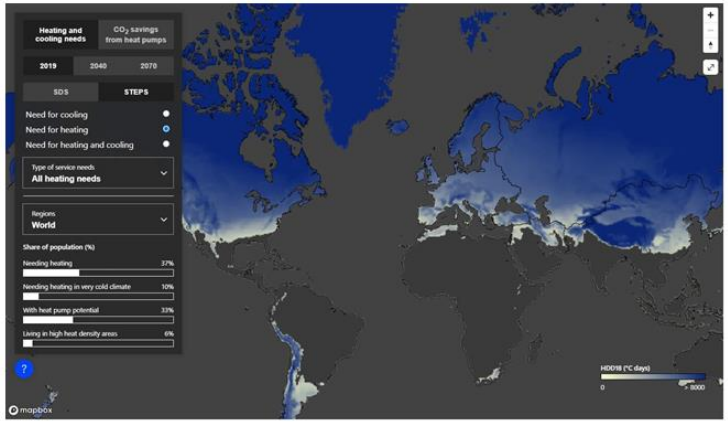
Lund H., et.al. (2014). 4th Generation District Heating (4GDH)Integrating smart thermal grids into future sustainable energy system

Digitalisation opens opportunities for system-wide and cross-sector efficiency



Digital tools offer integrated solutions to accelerate net-zero transitions across sectors and systems

Targeted solutions by climate and building stock



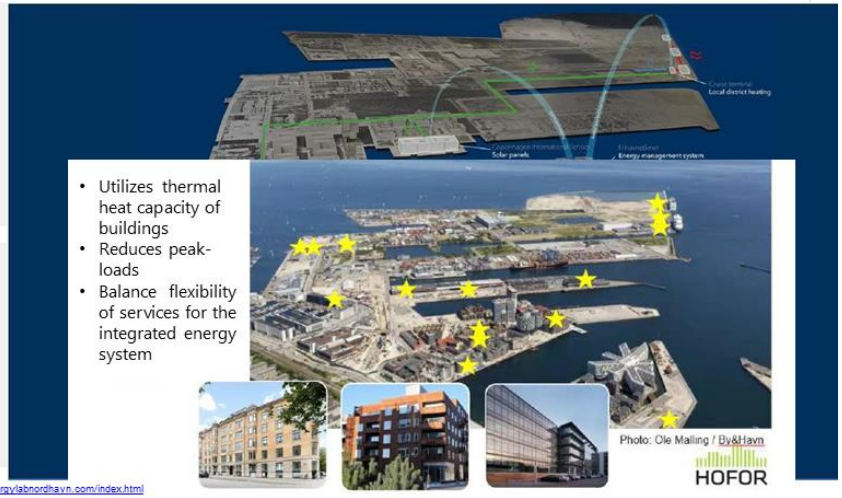
Local knowledge to enhance the understanding of heat demand and heat resources is fundamental to asses the cost effectiveness of district heat systems and possible integration with cooling networks

 IEA (2020), Is cooling the future of heating?, https://www.iea.org/commentaries/is-cooling-the-future-of-heating. All rights reserved.

Nordhavn in Denmark – urban living lab for testing solutions towards carbon neutrality

Objective:
to develop new methods and solutions for the design and operation of a cost-effective, multi-carrier energy system of the future based in a city district as a highly visible real-life laboratory.

Demonstration project that shows how electricity, heating, EE buildings, electric transportation, automation and use of data can be integrated into intelligent, flexible and optimised energy system



http://www.energylabnordhavn.com/index.html

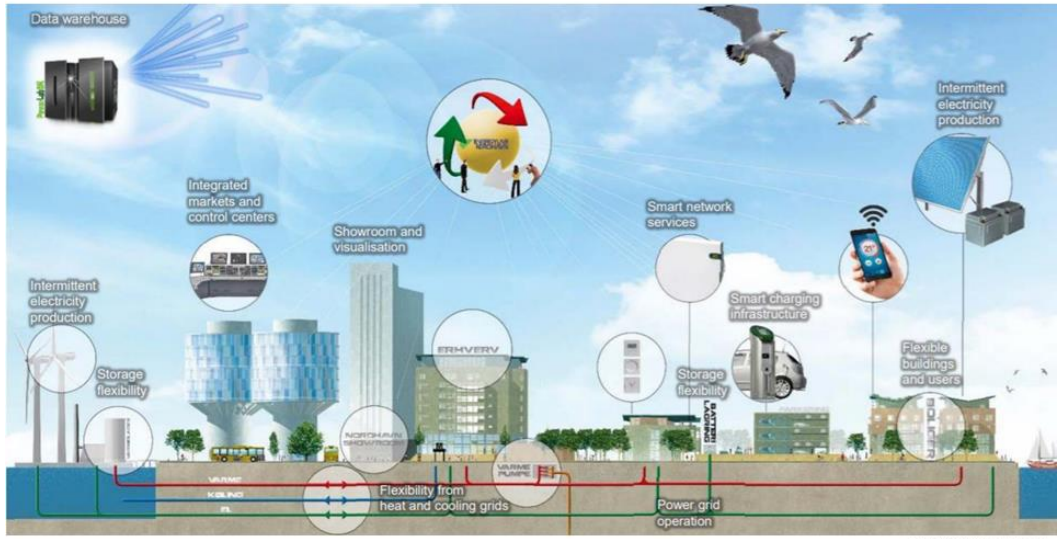


Illustration by Claus Lunau

Photo: By & Havn/Ole Malling

A deep transformation of energy systems supported by digitalisation

Energy systems are undergoing transformation → More flexibility is needed, with active participation of consumers → Digitalisation is key; enabling policies are crucial

- **Digitalisation** can help leverage opportunities:
  - Create a more interconnected and responsive energy systems (both electricity and heat)
  - Support carbon emissions reduction
  - Help to minimise system cost and need for new investment
  - Improve stability, resilience and security

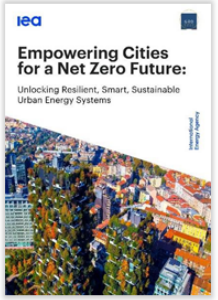
Digital Demand-Driven Electricity Networks Initiative (3DEN)

The IEA is providing actionable guidance to policy makers on the policy, regulatory, technology and investment context needed to accelerate progress on **power system modernisation** and effective **utilisation of demand side resources**.

More info: www.iea.org/programmes/digital-demand-driven-electricity-networks-initiative

National policymakers can create the right enabling environment to promote digitalization

1. Design inclusive policies and programmes with **people at their core**
2. **Build capacity** across digitalisation, decarbonisation and efficiency of the energy system
3. Ensure timely, robust and transparent **access to data**
4. Ensure the **availability of finance** and promote **financial innovation**
5. Promote the development and uptake of **international standards and benchmarks**
6. Create opportunities for **sharing and learning**



Source

THANK YOU!

Ksenia Petrichenko, PhD, Energy Policy Analyst, International Energy Agency
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DHC+ TECHNOLOGY PLATFORM

Under the umbrella of EUROHEAT & POWER

Digitalisation of DHC: a European perspective

Matteo Pozzi, Optit / Vice-Chair DHC+ Technology Platform

Introduction

- Digital Innovation is having a profound impact on the Heating & Cooling sector
- Digital technologies
  - make the whole energy system smarter, more efficient, and reliable
  - boost the integration of renewables and management of increasingly complex systems
  - are needed to fully optimize district energy systems while empowering the end consumer
- IoT, automation, AI, and big data hold big promises
  - Challenges: security, privacy, data ownership
  - New business models and policy interventions are needed

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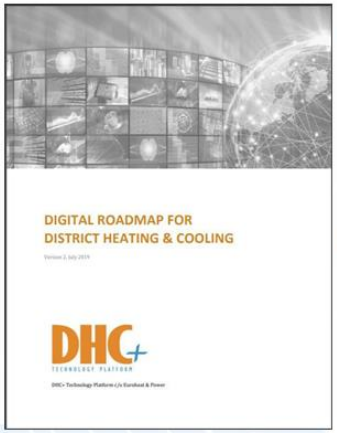
Digital Heat Roadmap



- The DHC+ issued the second release of the Digital Roadmap for DHC already in July 2019
  - Production, distribution, building, consumption
  - Design and planning, asset management, sector coupling and integration of multiple sources
  - Horizontal topics: Big Data, AI, bockchain
- JRC Technical report Digitalisation: Opportunities for heating and cooling (May 2019)

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Industry 4.0

- Digitalisation of the Heat & Cooling industry follows early focus on Industry 4.0, i.e. “the comprehensive transformation of the whole sphere of industrial production through the merging of digital technology and the internet with conventional industry” that already in 2012 was aiming at Smart Grids as key focus area.
- Several funding opportunities (including H2020) were focused on digital enabling technologies, while the European Structural and Investment Funds provided no less than 100 billion € to Member States to make investments in innovation
- Significant incentives were introduced at national level, most notably in Germany, Italy, France and the UK with loans, tax credits and funding.

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Policy Lanscape

EU action plan – Digitalising the energy sector

- Action plan will help develop a competitive market for digital energy services and infrastructure that are cyber-secure, efficient and sustainable.
  - Outlines how different EU policy and funding instruments will work together to exploit the benefits of digital solutions in the energy sector
  - Supports sector integration, prosumer participation and interoperability of data, platforms and services
  - 5 focus areas: Data-sharing infrastructure, Empowering citizens, Uptake of digital technologies, Cybersecurity, climate neutral solutions for ICT
- The Roadmap feedback period closed on 10 September 2021
- Public Consultation open until 24 January 2022
- Commission Adoption planned for Q2 2022

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Policy Landscape

Energy Efficiency Directive – EU 2018/2002 (formerly Directive EC 2012/27).

- Focus is on empowering and informing DHC consumers
- Article 9 – metering
  - 9a - Building-related metering
  - 9b - Sub-metering & cost-allocation
  - 9c - Remote readability
  - Relates to building-level, individual smart meters that should be readable remotely (if new)
- Article 10 – billing
  - Relates to frequency, consumption-based measurements, minimum level of information provided to consumers, privacy, e-billing, cyber security
- Article 11 – Cost
  - Consumers should not bear cost of access to metering, billing and consumption info

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Policy Landscape

Public Sector Information Directive – EU 2019/1024

- Governs the re-use of data generated by public sector bodies
  - enable access of 3rd parties for commercial and non-commercial purposes (create apps, supply services)
- 2019 revision broadens the scope of the 2003 Directive to include data from public undertakings, i.e. the ones operating in water, energy, transport and postal services
- The data generated by the DHC operators can fall under the Directive if they meet the requirements to be considered as ‘public undertakings’
- Upcoming impact assessment and consultation on the Implementing Act for a list of High-Value Datasets
  - Act meant to be published in Q1 2021 (currently delayed)
  - No immediate threat of additional burden for DHC operators.

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GDPR

General Data Protection Regulation n. 2016/679

- Smart Meters can collect data with high granularity (hourly or less), a marked shift with respect of traditional meters, used only for billing purposes.
- Several studies have concluded that smart meter data may considered personal data (as they reveal personal behaviors) and should therefore be covered by the GDPR
- The Danish Energy Agency and Department of Justice have proposed that to the extent that such processing is in the public interest (e.g. to save energy) or for the purposes of legitimate interests (e.g. improving energy efficiency) district heating operators need not request consent from customers to read remotely smart meters more frequently than required for billing purposes
- Blockchain presents additional challenges to GDPR rules application

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Funding

Horizon Europe - Partnerships

- Key Digital Technologies
  - aims to strengthen electronics value chains to ensure EU technological sovereignty in global competition
  - Link between this partnership and (i) sustainability policy and (ii) smart networks partnership, means that DHC networks are an attractive research project due to potential for decarbonisation and uptake of cutting-edge digital technologies
  - EC contribution: €1.8 billion between 2021-2027
    - participating Member States make a similar contribution,
    - additional €2.5 billion via industrial associations (AENEAS, Inside and EPoSS)
  - First calls expected December 2021
- Smart networks and services
  - aims to strengthen Europe's scientific and industrial leadership, achieve SDGs
  - EC contribution: €900 million 2021-2027
    - To be matched by private sector

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Funding

Horizon Europe - Calls for Funding

Open/Forthcoming Calls

- Reinforcing digitalisation related know how of local energy ecosystems
- Circular and low emission value chains through digitalisation
- Smarter buildings for better energy performance
- Smart-grid ready and smart-network ready buildings, acting as active utility nodes (Built4People)
- Demand response in energy-efficient residential buildings

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Funding

Life Programme

- LIFE Clean Energy Transition sub-programme
  - Accelerating technology roll-out, digitalisation, new services and business models and enhancement of the related professional skills on the market
- Open Calls
  - Creating the conditions for a global improvement of smart readiness of European buildings
  - Establish innovative business models and contractual schemes for smart and sector-integrating energy services

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Thank you for your attention!

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Webinar Digitalization for optimizing integrated district heating systems

Block II: Digitalization of district heating systems

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AIT Austrian Institute of Technology – Tomorrow Today

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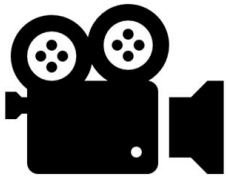

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  - Requests to speak are reported via chat (“**rts**”),
  - the moderator will ask then the speakers to speak.
  - Please state your name and institution before you speak
- **Please turn off your webcam!**
  - No general video transmission in order to reduce the bandwidth.
  - The camera can be used at short notice for spoken contributions.
  - We will make a “group-photo” at the end of each block
- **Caution with humor and sarcasm!**
  - much of the original effect between the lines can be lost

Agenda Block II
- Digitalization of district heating systems

12:00	Testing of technical connections
12:30	Introduction into the IEA DHC Annex TS4 project (Dietrich Schmidt, Fraunhofer IEE)
	The utility perspective on digitalisation of district heating (Julia Westerweck, Wärme Hamburg)
	Digitalisation solutions for heat infrastructures (Milan Jungic, Danfoss)
	Digitalisation potentials: Research test facility for innovative DH systems (Anna Kallert, Fraunhofer IEE)
	Interactive session and Q&A to all presenters
14:00	End of Block II

Technology Collaboration Programme
by iea

IEA DHC Annex TS 4:
Digitalization of District Heating and Cooling:

- Optimized Operation and Maintenance of District Heating and Cooling Systems via Digital Process Management

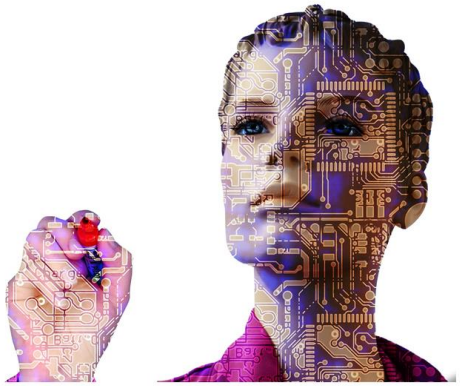
Industry workshop

03 November 2021

Dietrich Schmidt

Fraunhofer IEE

Our future Energy system will be digital!



INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING INCLUDING COMBINED HEAT AND POWER

Aims of DHC Annex TS4

- The project aims at **promoting the opportunities** of the integration of digital processes into DHC schemes and to clarify the role of digitalisation for different parts within the operation (and maintenance) of the district heating and cooling system.
- Furthermore, the implementation of these technologies is going to be **demonstrated**.
- On the other hand **new challenges** need to be tackled, such as data security and privacy as well as questions about data ownership

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING INCLUDING COMBINED HEAT AND POWER

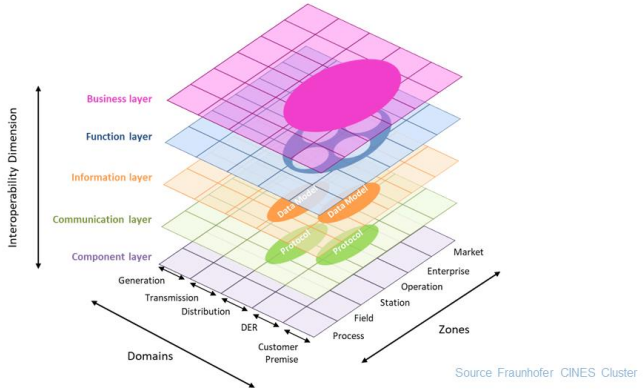
Goals of DHC Annex TS4

- **Create** awareness for the advantages of the implementation of digital processes to the various stakeholders and users
- **Provide** a state-of-the-art overview of the digitalization of district heating schemes in terms of R&D projects, demonstrators and case studies
- **Evaluate** non-technical barriers and enablers for digitalizsation processes in district heating and cooling schemes such as business models, legal aspects and policy instruments

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING INCLUDING COMBINED HEAT AND POWER

10

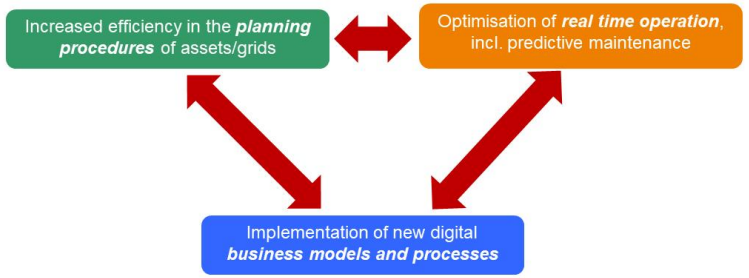
Digitalization concepts



Source Fraunhofer CINES Cluster

11

Our focus areas for a digitalization in DHC



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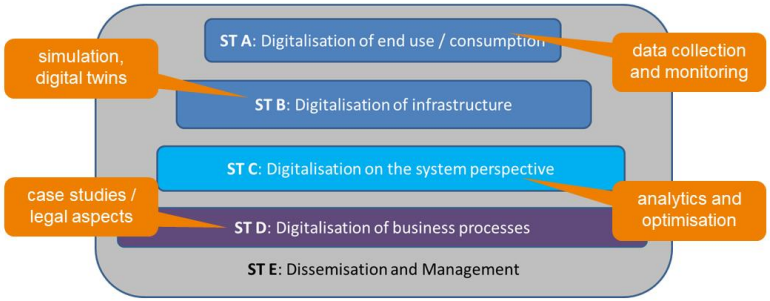
DHC Annex TS4 working structure



13

Digitalisation of end use / consumption

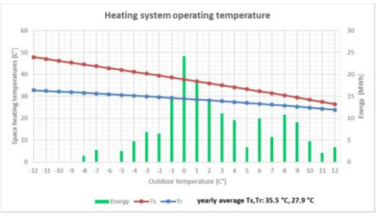
Improved control of heating system with focus on lowering:

- Supply temperature
- Return temperature
- Peak load

⇒ Large potential as the actual heat demand is much lower than the design load

Strategy for developing the building service package:

a. Define the potential for lowering the temperatures in the building
b. Stimulate the use of all radiators
c. Data mining to identify anomalies in the SH operation
d. Troubleshooting and improved hydraulic balance of the system



INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING INCLUDING COMBINED HEAT AND POWER

14

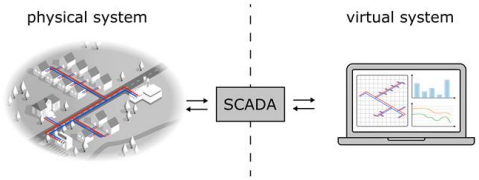
Digitalisation of infrastructure / digital twins

„A digital twin is a connected, virtual replica of a physical product, asset, or system."

A. Rasheed et al., Digital Twin: Values, Challenges and Enablers (2019)

Interdisciplinary topic including

- Data-driven modeling
- Machine learning
- Numerical modeling
- Simulation
- Analytical models
- Internet of things
- DHC domain knowledge



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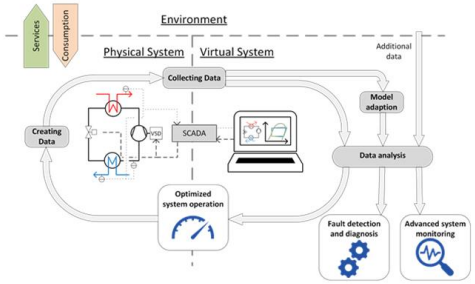
Digitalisation of infrastructure / digital twins

Possible use cases

- Optimization of operation and control
- Fault detection and diagnosis
- Scenario evaluation / What-If Analysis
- Predictive maintenance / Asset management
- Visualization / Virtualization



From project „Digital twins for large-scale heat pump and refrigeration systems" http://digitaltwins4hprs.dk/

16

Digitalisation on system perspective

OPERATIONAL OPTIMIZATION

= CONTROL = ONLINE

Active interaction with the network, i.e. real interventions in the operation of the network. Think of **modifying the control of temperatures or flow rates** in the network in order to achieve a certain **objective on the network or energy system scale** (e.g. peak shaving or increasing the share of renewable energy in the energy system).

ANALYTICS

= DIAGNOSIS = OFFLINE

No active intervention in the direct operation of the network. These tasks however relate to the **analysis** of the network performance in order to optimize the efficiency and sustainability of the network.

17

Digitalisation of business processes

The core issues are to

1. Examine the **cost drivers for operating and maintaining** a DHC network and qualify the economic potential for improvements based on tools and insights provided by digitalisation.
   Best **practice examples** are to be included to give proof and validate the ROI model.

2. Collect thoughts and ideas for **new potential business models** that can be enabled through digitalisation. This can be the energy provider offering services to the end-user.
   It could also be business models that put demand response and thermal storage capacity in buildings into play.

18

cooperation with other initiatives

- German Heat & Power Association (AGFW)
- DHC+
- Danish Board of District Heating (dbdh)
- IEA EBC Annexes on:
  “Demand Response of Buildings in DHC networks / Annex 84” &
  “Data-Driven Smart Buildings / Annex 81”
- And others…
  as IEA HPT Annex 57 „Flexibility by implementation of heat pump in multi-vector energy systems and thermal networks“

19

First conclusions

Digital technologies are **believed to make** the whole energy system:

- smarter,
- more efficient, and
- reliable and
- to boost the efficiency and
- the integration of more renewables into the system.

- In the future, digital applications might enable district energy systems to **fully optimize their plant and network operation** while **empowering the end consumer**.
- For a wider integration of digital processes challenges such as **data security and privacy** as well as questions about data ownership need to be handled and solutions need to be worked out.
- A key question is where is the way from the **buzz word digitalization to real business models**, products and market ready services.
- The strength of the presented project is the **very close exchange** between system manufacturers, utilities and service providers with the research community.

Technology Collaboration Programme
by iea

Contact us!

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www.iea-dhc.org/the-research/annexes/2018-2024-annex-ts4/

The utility perspective on digitalisation of district heating

Dr. - Ing. Julia Westerweck, Wärme Hamburg GmbH
Julia.Westerweck@waerme.hamburg

Wärme Hamburg

Wärme Hamburg at a glance

Since more than 120 years Wärme Hamburg is a reliably partner of the City of Hamburg regarding district heating

1894
Town hall of Hamburg
First supply with district heating

District heating grid has length of
845km and **12** generating units

Company´s current installed heat capacity is about
1.800 MW

The heart of the Company represent about
654 employees & **54** trainees as well as dual students

Main customers are the City of Hamburg, huge housing companies and industrial units with about **11.000** contracts

Wärme Hamburg provides heat for about
520.000 residential units

Each household reduces carbon footprint by
ø **1 tonne** CO_2 compared to traditional heating system after coal phase-out

We deliver heat and comfort throuth our grid by ~**22%** of Hamburg´s heat market - With rising trend!

2

Smart Meter Rollout Hamburg

- Creation of modern district heating infrastructure
- Cross-linking, automated and controlled housing stations
- Automated meter recording (billing)
- Online data management of operational data in housing stations, refreshment every 15 min of all housing stations
- Realization of database for future products and services

Vision: **integrated real-time management of heat production, delivery and consumption**

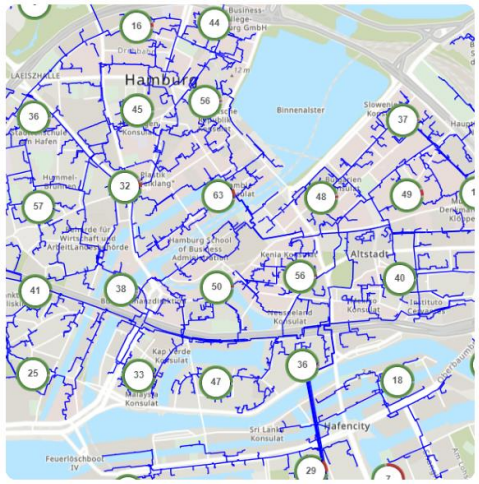

Transfer station with Smart-Meter

3

SAM Portal @ Wärme Hamburg

Application examples
- Search: return flow rate > 60 °C and customer A
- Show spread of flow and return flow
- General data like minimum, max, average
- Alarm settings, watch function
- Heat map: polygon, sum of ongoing consumption of individual streets, strands or districts

- data of heat meter (~**11.700 available**) analysed, sorted by highest flow rate and highest return flow rate (e.g. 95°C/90°C): possible trouble on secondary site, next stept: contact to customer
- Analysis of index circuit at summer: further reduce flow temperature below 90°C optional

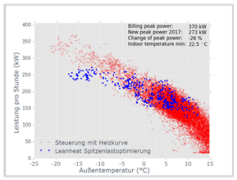


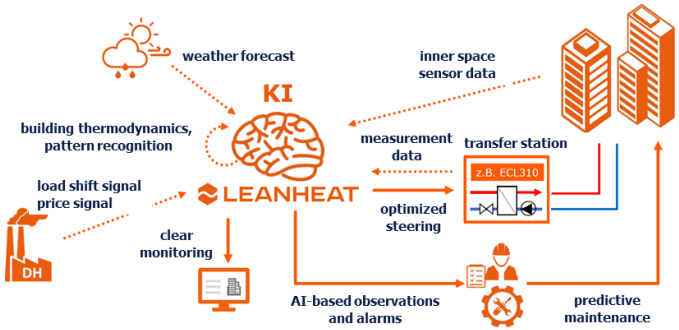
4

Load management and peak shaving with IoT & AI

- real time data from heat meter and heating controller, using IoT
- connection and communication between customer and supplier
- optimization with AI
- steering and shift signals depending on network requirements

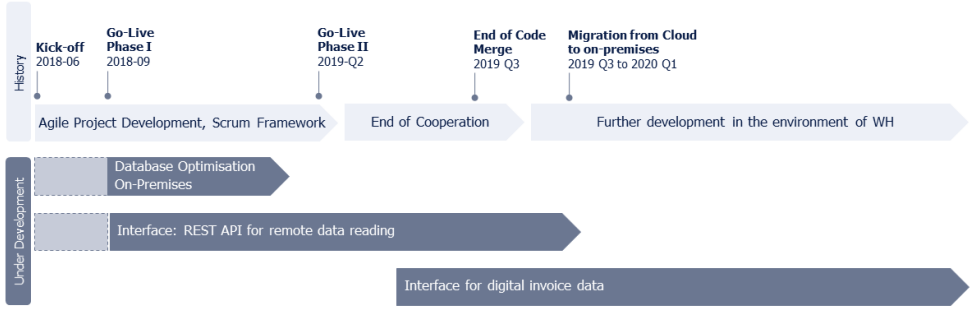
→ 20% evg. reduction of peak load





5

Development of the customer portal over time



- 2021: Cooperation initiated with Key Customer for further development of the customer portal.
- 5 pilot customers from the association of housing companies (VNW) can provide their input.

- Registration is increasingly in demand
- The market reports our portal as a **frontrunner for customer centricity** in district heating provider – most comprehensive offer.

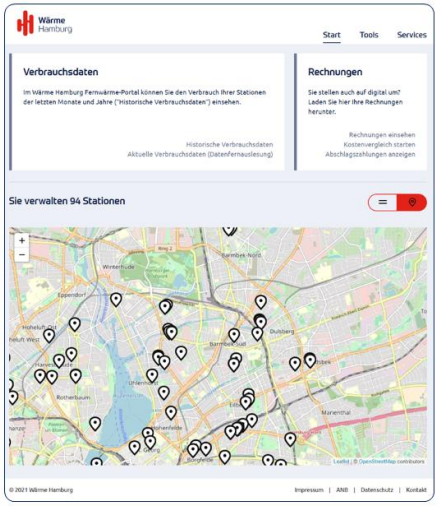
6

Functional areas at a glance

- Overview of the properties supplied with district heating
- Extensive detailed view of the heat station
- Historical consumption values for each transfer station
- Remote data reading with real-time key figures
- Efficiency monitoring
- Convenient service area

Target Group

- Wärme Hamburg's business customers, i.e. > 4,000 customers with 12,500 transfer stations



7

Functions in detail

Link to Demo: http://portal.waerme.hamburg/

- All properties supplied with district heating can be displayed at a glance, compared with each other (**efficiency monitoring**), managed and grouped according to your own ideas and requirements.
- The customer has access to the **current consumption and contract data**, the billing and current instalment payments.
- The **historical consumption** values of individual properties can be compared with each other.
- As a business customer with a remote data transmission module installed, the **"live" key figures of the meter** are displayed. Current consumptions per hour, month or year can be displayed graphically.
- Both the costs and the consumption of the properties can be compared. In this way, the customer always retains an **overview of his annual heat procurement costs** for individual properties or the entire portfolio..
- In the **Service Area**, changes of ownership and an imminent change of property management, if any, can be triggered.
- General **commercial enquiries** about billing, the contract or even technical support can be requested directly via the customer portal.
- The customer finds his responsible direct technical or commercial **contact person** with telephone number and e-mail address for each of his installations.
- **24/7, the customer has access** to current and historical invoice documents.

8

Station overview, hourly data and interfaces to source systems

Sales tool: Augmented-Reality-App

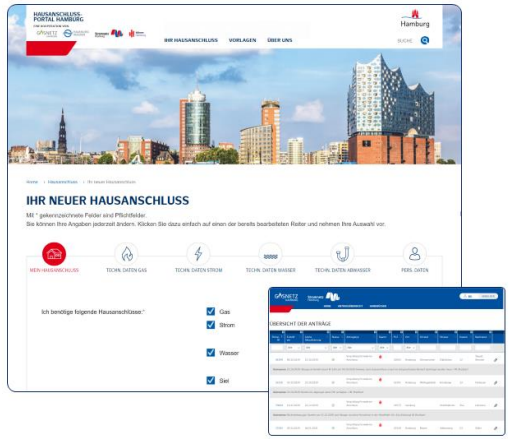
- application for mobile devices
- visualisation of technical installations at on-site appointments
- different functionalities:
  - AR-projection
  - explanations of components
  - flow-animation
  - notes
  - screenshots
  - save projects

House Connection Portal

- B2C-Portal for end customers
- Connection requests for new connections, changes, disconnections as well as construction for electricity, gas, water and district heating
- Focus on process optimisation for incoming requests by querying via online portal
- Workflow-supporting integrated employee portal

Target Group

- Predominantly volume business with individual customers



Wärme Hamburg

Für die Menschen, für die Stadt.

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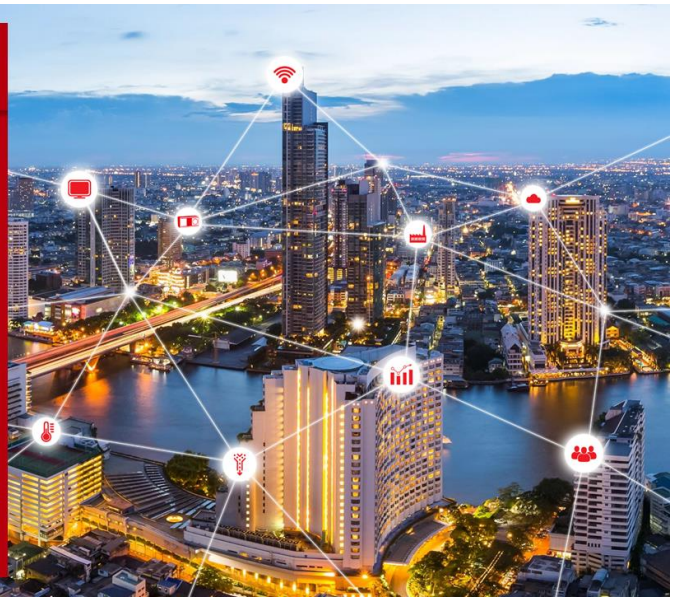
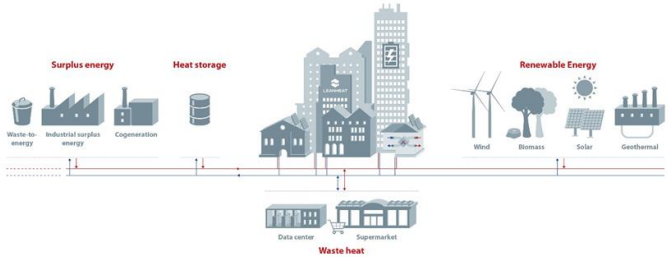
Danfoss Climate Solutions for Heating

Your partner for District energy solutions

Complete **management** and **optimization** solution for **District Energy** systems



Our definition of a **state-of-the-art** District Energy system



- From single source to **multisource**
- From fossil to **renewables** & **surplus energy**
- From high temperature to **low temperature**
- From one-way to **bidirectional**
- Positive **regulatory trends** across the globe
- Changing **customer structure** & increased **investments** (Engie, Veolia, Fortum,...)

2 | District Energy & Buildings 2020 Classified as Business ENGINEERING TOMORROW

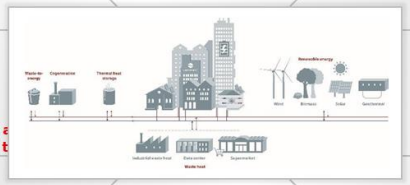
Main Challenges in District Energy

ΔT Optimization
Economical balance between temperature and flow

Optimal Network Design
With new connections and new buildings

Decentralization – incre… energy source complexi…
In production: more heat sources including renewables

Decarbonization
Legislation and environmental care / energy efficiency



Peak energy demand
Drives up overall cost (OPEX as well CAPEX)

Legacy SCADA
Make data integration difficult and time consuming

Increase focus on Business models
Create attractive business environment for future

Resiliance
Secure high efficiency of operation and coverage of customer needs by providing undisturbed district energy distribution (or service), also in most demanding and unexpected conditions.

3 | District Energy & Buildings 2020 Classified as Business ENGINEERING TOMORROW

Digitalization is enabling the **4th (5th) generation district energy**

Digitalization through the entire district energy system – from plants and homes – is enabling **smarter**, more **efficient** and **reliable** systems

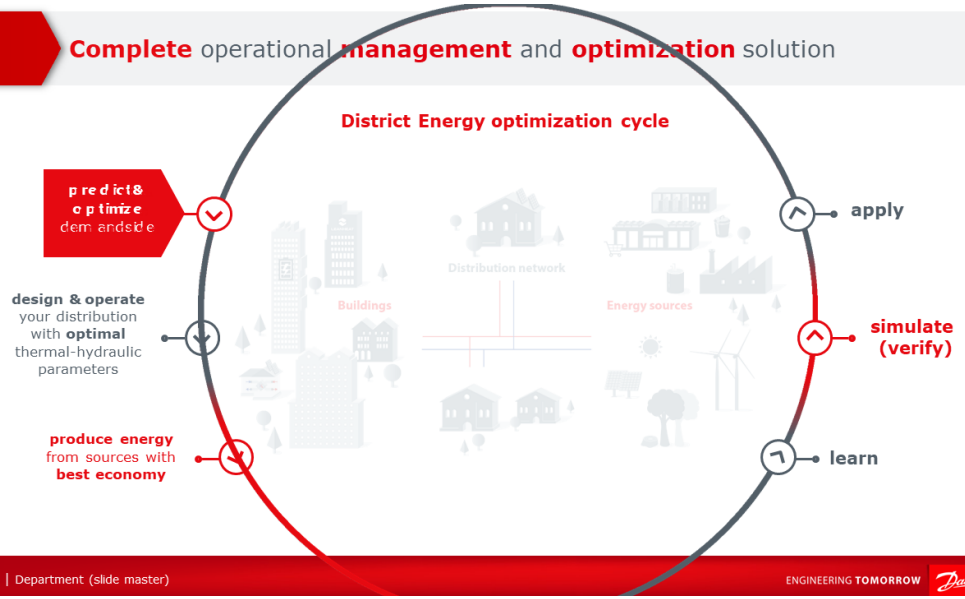
Demand

Distribution

Production

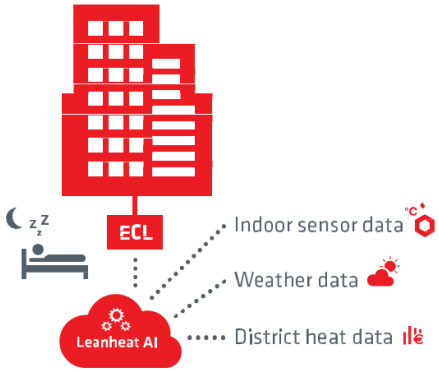
4 | Department (slide master) ENGINEERING TOMORROW

Complete operational **management** and **optimization** solution



Why District Energy with **Danfoss?**

DEMAND PREDICTION & OPTIMIZATION



Leanheat AI

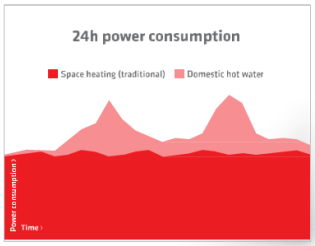
- Short & long-term demand prediction
- Auto-commisioning & self-adaptive

- **Optimize demand side heating parameters**
- **Optimize distribution & production according to needs of demand**
- **Optimize demand by utilizing building thermal capacity for peak shaving**

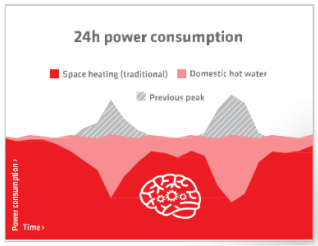
“Knowing how your consumers will behave is the basis for optimal operation of your district energy system.”

Understand and **optimize** your consumers

Traditional building automation



Optimized by LeanHeat AI



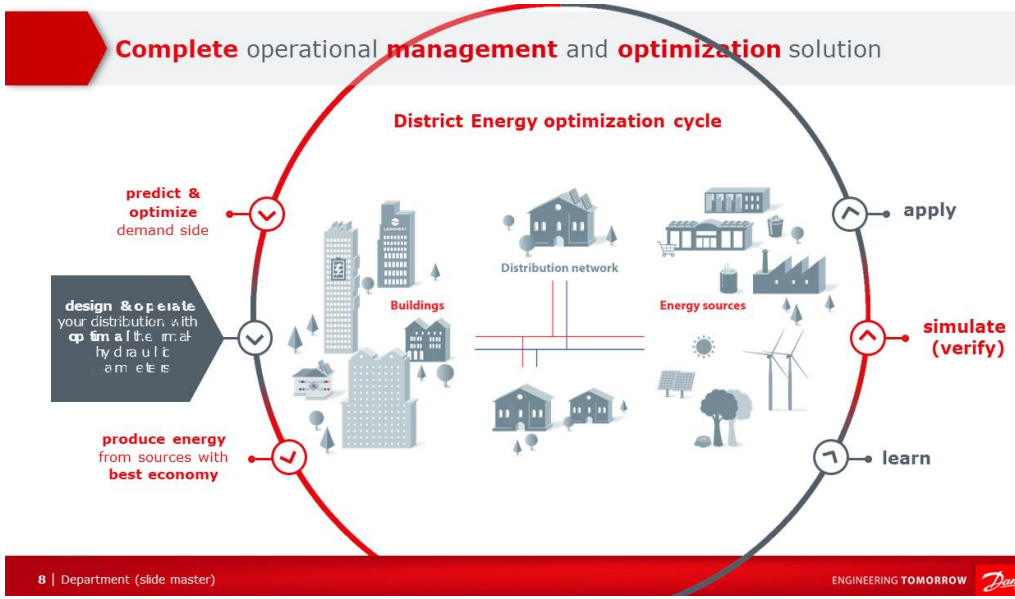
Benefits

Cut peak power by **20%**

New products and services

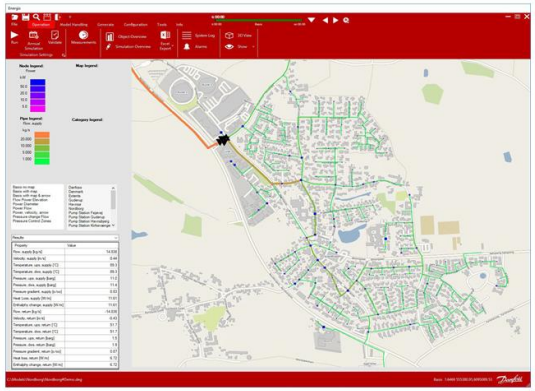
Optimal production with demand response

Complete operational **management** and **optimization** solution



Design & **operate** your heat distribution **optimally**

Leanheat Network



Effectively build and **maintain** district heating and cooling hydraulic network models

Simulate hydraulic and thermal conditions in district energy distribution systems

Optimize hydraulic conditions in the network

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Design & **operate** your heat distribution **optimally**

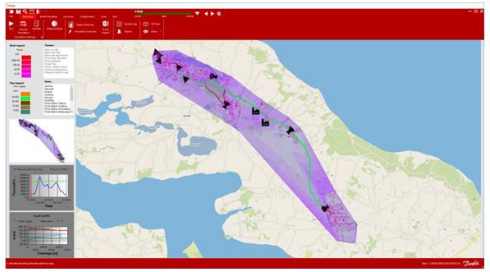
Leanheat Network as **an development support tool**

Optimization of expansions, refurbishments and new connections

Analysis of impact of expansion, refurbishments and new connections on the rest of the network

Development of **contingency plans**

Database of knowledge about network



17%
Investment reduction

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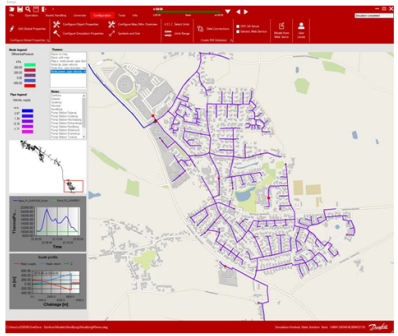
Design & **operate** your heat distribution **optimally**

Leanheat Network as **an on-line operational support tool**



Calculate optimal hydraulic parameters and **apply** them

Overview of the **temperature, flow and pressure** at any point in the network

Overview of **the composition of production sources** at any point in the network

Simulation of future conditions based on weather prognosis

What-if analysis for daily operating challenges and critical events

Planning of interventions with **effective execution** and **quality of services**

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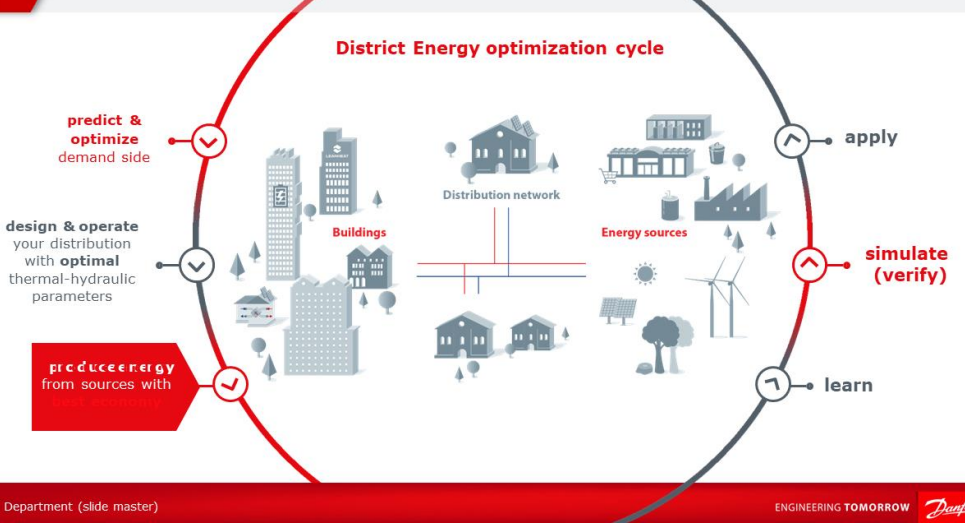
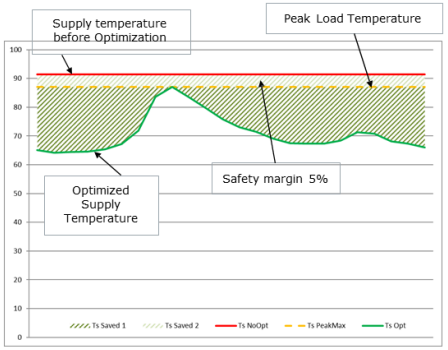
Complete operational **management** and **optimization** solution



Optimize your supply temperature

Leanheat Production Temperature Optimization



Savings Potential:

Big annual **costs savings**	**Less maintenance** and **repair** of pipeline
Energy savings according to EU	**ROI** between 1/2 to 2 years

> **To reduce heat losses and primary energy costs in the district heating network, the supply temperature must be kept as low as possible.**

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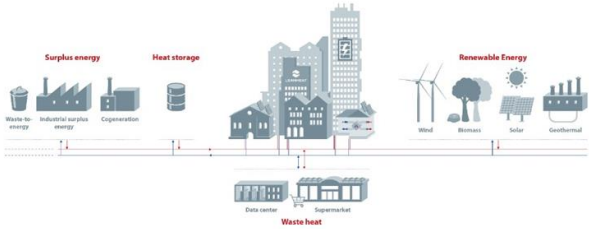
Plan and Optimize your production mix

Leanheat Production Optimization

Complex district energy systems:
Number and type of heat sources ➔ Techno-economical optimization



Savings of 1-3 % on total fuel **costs**

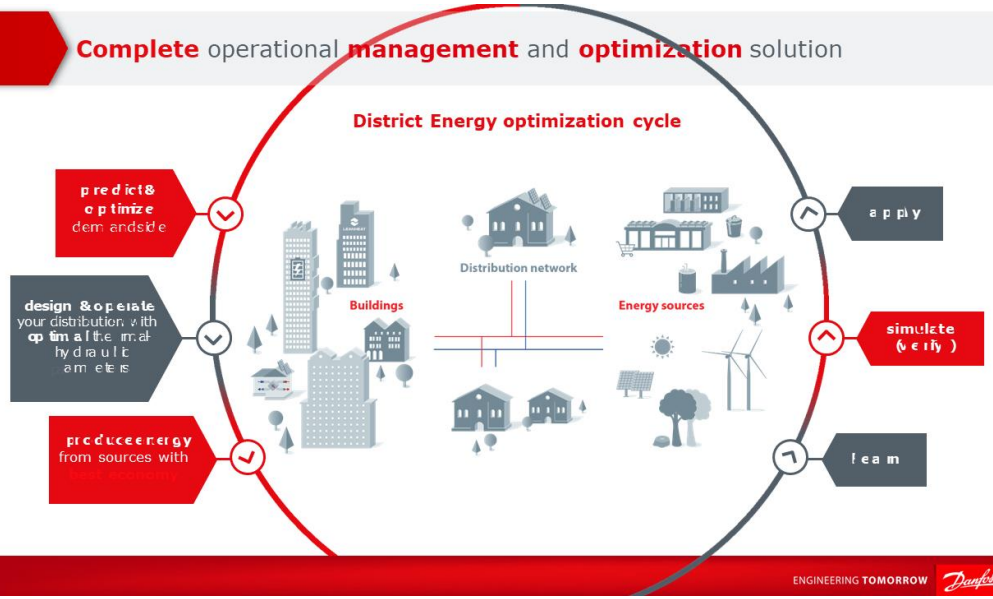
Better utilization of thermal energy storage

Time savings in production planning process

> **Techno-economical optimization of diverse production has one of biggest cost-saving potentials in modern District Energy systems.**

ENGINEERING TOMORROW

Complete operational **management** and **optimization** solution



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Improve control with **Leanheat Monitor**

- Make data integration easier and less time consuming
- Lower IT investment & maintenance costs
- Enable data extraction and interpretation easy
- Integrate devices with different protocols

Up to **30%** improved efficiency compared to traditional SCADA

Open, connected and transparent	**Modern web-based solution**	**Customized for district energy**	**Lower investment and predictable operation costs**

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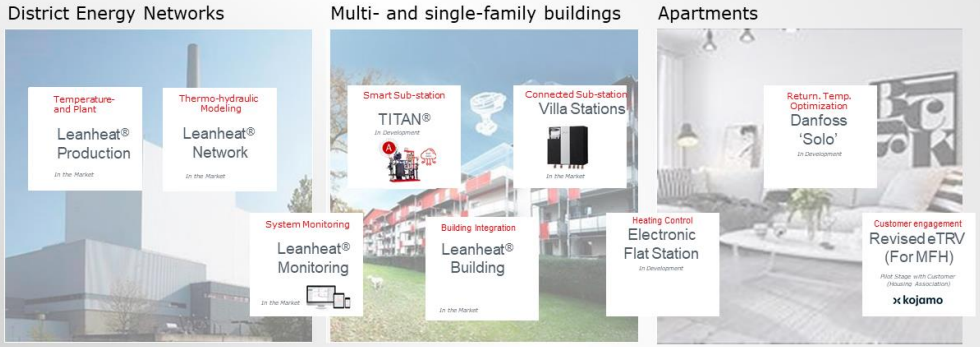
Danfoss Heating offers an end-to-end portfolio of products and software services to utilities



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Danfoss Heating, **your partner** for district energy solutions.

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milan.jungic@danfoss.com

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Industry workshop of IEA DHC Annex TS3 & 4 "Digitalization for optimizing integrated district heating systems", November 3rd 2021, online

Joint Project: EnEff:Wärme: UrbanTurn:
Transformation of the urban district heating supply

Gefördert durch: Bundesministerium für Wirtschaft und Energie aufgrund eines Beschlusses des Deutschen Bundestages

FKZ 03EN3029

Laufzeit: 48 Mon
02.2021 – 01.2025

Dr. Anna Kallert, Head of Department Thermal Energy Systems Technology, Fraunhofer IEE, Kassel

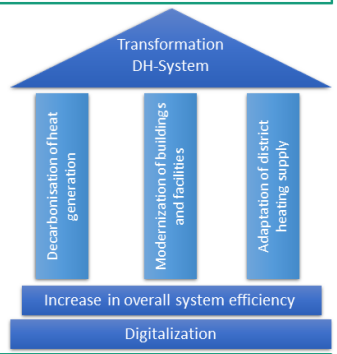
AGFW · BRUGG Pipes · Danfoss · GEF Ingenieur AG · hcu HafenCity Universität Hamburg

Fraunhofer IEE

Project goals

The main target is to develop and derive technical solutions for the transformation, decarbonisation and the digitalization of district heating supply, taking into account volatile pressures and temperatures using regenerative energy and waste heat sources

- Deriving **measures to transform existing district heating systems** taking into account digitalization
- Development of **new approaches for operational management and control** in the context of the digitization of heating networks
- **Verification of the approaches** through software-based and experimental investigations (digital twin)
- Development of **proposals for the amendment of the technical regulations** and **new design criteria** for the system components (characteristic system behavior)
- Creation of a **catalog of measures** for network operators and energy suppliers



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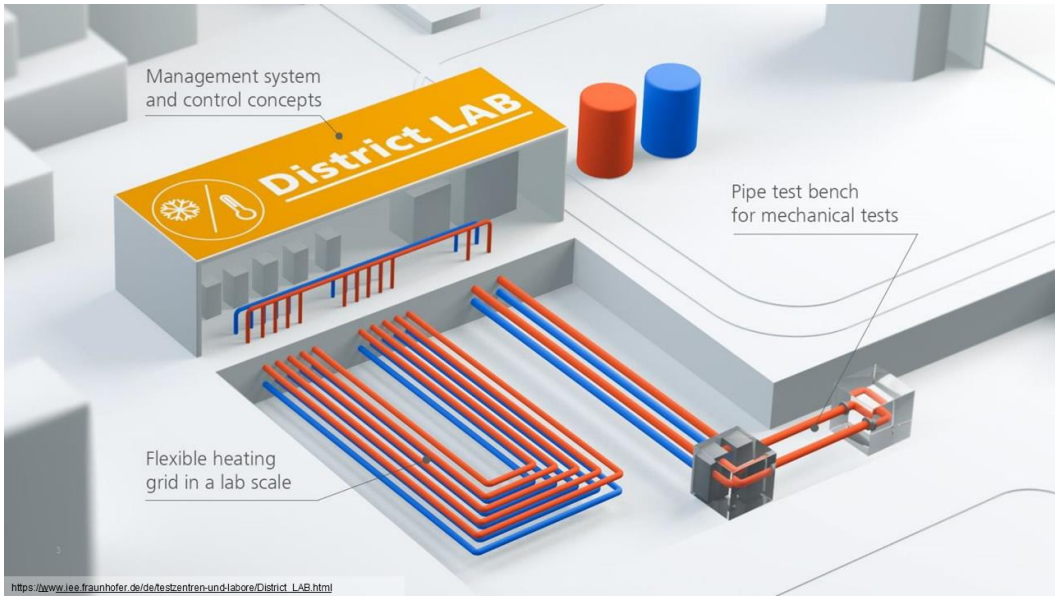
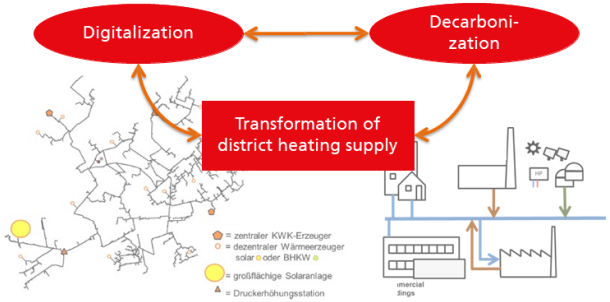


Challenges of transformation strategies for existing heating networks

Deriving measures to transform existing district heating systems taking into account digitalization



- Identification of new requirements, barriers and potentials in the transformation of heating networks
- Identification of existing design criteria of existing heating networks
- Parameterization of investigation scenarios for experimental investigations

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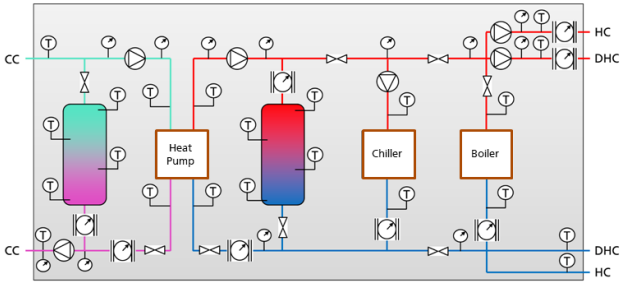
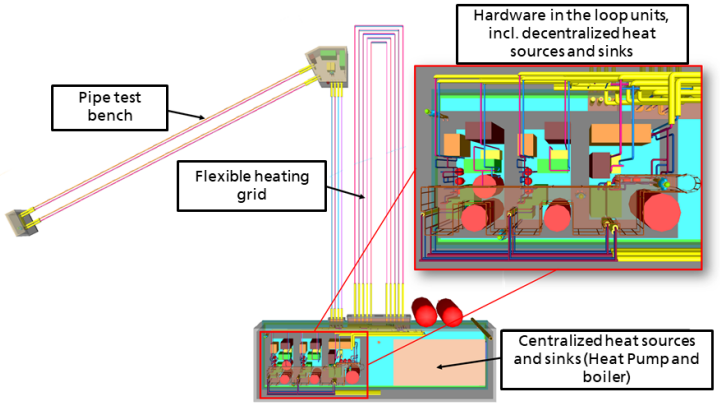
Software-based investigation of selected technologies at DistrictLAB



- Development and validation of a central control system as an interface for operating and regulating the test facility
- Creation and verification of a "digital twin" of the test facility (flexible heating network)
- Development of a virtual, reaction model "pipe-soil interaction" (pipe test section)
- Preparation of a measuring point plan for the implementation of investigations at the District LAB

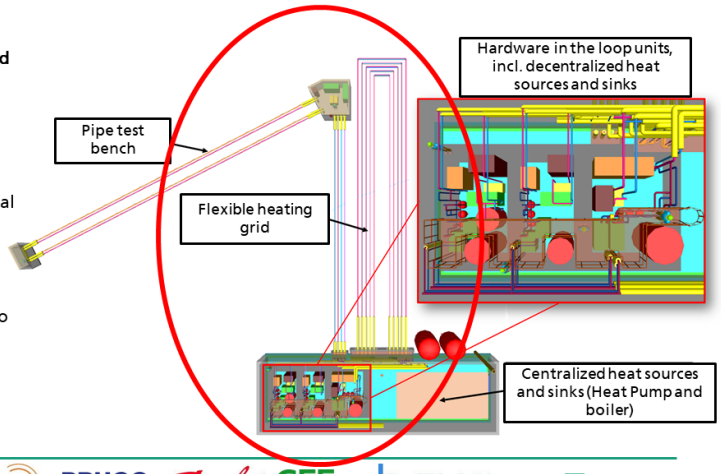
Experimental investigations at the DistrictLAB test facility



Experimental investigations at the DistrictLAB test facility

Investigation flexible heating grid

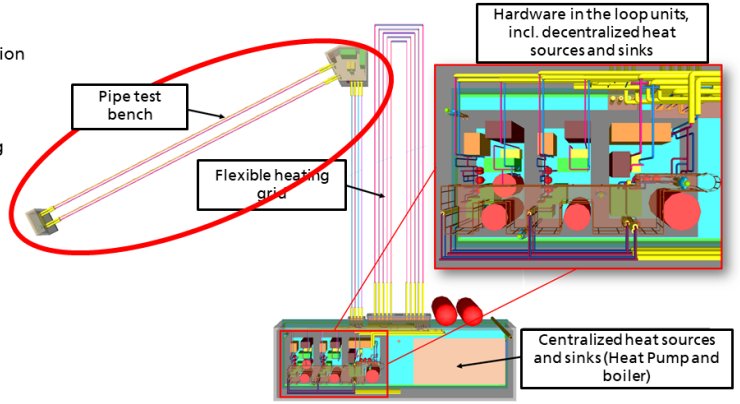
- Investigations of different supply scenarios (e.g. decentralized of bi-directional feed-in of volatile energy sources)
- Identification of possible critical operating variables (pressure, temperature, volumetric flow rate)
- Evaluation of the examined supply scenarios with regard to their potentials as well as obstacles



Experimental investigations at the DistrictLAB test facility

Investigation pipe test bench

- Investigation of the interaction of pipeline and soil under consideration of dynamic operating conditions
- Investigation of the bedding reaction conditions under fluctuating pressures and temperatures
- Identification of new requirements or criteria for bedding materials and installation techniques



Verification and extension of design criteria for thermal grids with volatile feed-in

Goals

- Analysis of the measured data with regard to thermal and hydraulic state changes
- Review of the range of validity of common design criteria for heat networks with high temperature and pressure fluctuations
- Development of a proposal for the extension of existing design criteria
- Creation of a catalog of measures for network operators and energy suppliers

Working items:

- Description of characteristic, thermo-hydraulic state changes
- Influence on the service life as well as the limit load capacity of system components
- New design and evaluation criteria for future district heating supply solutions

Fraunhofer

Dr.-Ing. Anna Marie Kallert

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Phone: + 49 561 804-1876

Gefördert durch:
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Digitalisation of end use

- consumption: Improved control of heating system

Digitalisation of infrastructure

- digital twins

Digitalisation on system perspective

- OPERATIONAL OPTIMIZATION = CONTROL = ONLINE
- ANALYTICS = DIAGNOSIS = OFFLINE

Digitalisation of business processes

- cost drivers for operating and maintaining
- new potential business models

Technology Collaboration Programme
by IEA

Webinar Digitalization for optimizing integrated district heating systems

Block III – Hybrid energy systems

This Webinar is held in the framework of two international cooperation programs: IEA DHC Annex TS3 “Hybrid Energy Networks“ and IEA DHC Annex TS4 “Digitalisation of District Heating and Cooling“.

3rd November 2021

Ralf-Roman Schmidt AIT, Austria, ralf-roman.schmidt@ait.ac.at (leader TS3)

Dietrich Schmidt, Fraunhofer IEE, Germany, dietrich.schmidt@iee.fraunhofer.de (leader TS4)

More information at
https://www.iea-dhc.org/the-research/annexes/2018-2024-annex-ts4/
https://www.iea-dhc.org/the-research/annexes/2017-2021-annex-ts3

The Austrian participation in the IEA DHC Annex TS3 and TS4 is financed by the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK)

Federal Ministry Republic of Austria Climate Action, Environment, Energy, Mobility, Innovation and Technology

IEA Research Cooperation

Fraunhofer IEE

AIT Austrian Institute of Technology TOMORROW TODAY

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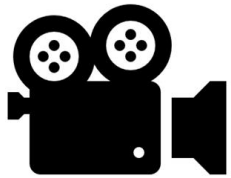
This webinar is recorded

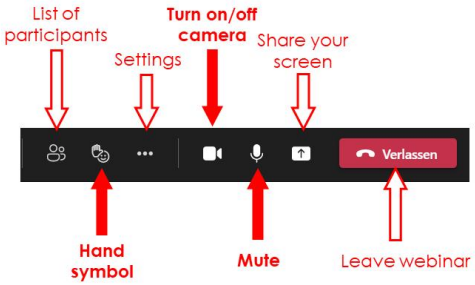


The video file will be available after the webinar on the IEA DHC YouTube channel
https://www.youtube.com/channel/UCuYcqLjJi8thrUJCjzLBaow

We will have a “group photo” at the end of the webinar, so please be prepared to turn on your webcam (participation voluntarily)

Webinar Etiquette

- The **microphone should be muted** by default
- Requests to speak are reported via the **hand symbol**
- Please **state your name** and institution before you speak
- Please **turn off your webcam**!
  The camera can be used for spoken contributions.
- We will make a “**group-photo**” at the end of each block



Agenda

15:30	**Welcome and introduction into the IEA DHC Annex TS3 project** *(Ralf-Roman Schmidt, AIT)*
	The TSO perspective on sector coupling and district heating *(Anders Bavnhøj Hansen, Energinet)*
	Analysing systemic benefits in an integrated expansion planning model *(Henrik Schwaeppe, RWTH Aachen University)*
	Interactive session - Q&A to all presenters - Evaluating SWOT factors for hybrid energy networks
17:00	End of Block III

- **Introduction into the IEA DHC Annex TS3 project** *(Ralf-Roman Schmidt, AIT)*

The IEA technology cooperation program (TCP) on district heating and cooling (DHC)

- **a platform for international experts**
  - dedicated to helping to make DHC and CHP powerful tools for energy conservation and the reduction of environmental impacts of supplying heat
  - Current members: Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, Italy, Korea, Norway, Sweden, United Kingdom, United States of America.
- **The projects within the IEA DHC TCP are either**
  - Funded through a **cost-sharing** approach (by the member states)
  - Funded through a **task-sharing** approach (the participants contribute resources in-kind for connecting existing national and international projects), e.g. Annex TS3 and TS4
- **More information:** http://www.iea-dhc.org/home.html

IEA DHC Annex TS3: Hybrid Energy Networks

- **An international cooperation project within IEA DHC**
- **Aim:** To promote the opportunities and to overcome the challenges for district heating and cooling (DHC) networks in an integrated energy system context
- **Funded** through a task-sharing approach (participants contribute resources in-kind)
- **Coordination team:** Ralf-Roman Schmidt (AIT, lead); Dennis Cronbach (Fraunhofer IEE, Subtask D), Anton Ianakiev (NTU, Subtask C); Anna Kallert (Fraunhofer IEE, Subtask C); Daniel Muschick, (BEST, Subtask B); Peter Sorknæs (Aalborg University, Subtask A), Inger-Lise Svensson (RISE, Subtask C), Edmund Widl (AIT, Subtask B)
- **Runtime:** Fall 2017 – March 2022
- **More information at** https://www.iea-dhc.org/the-research/annexes/2017-2021-annex-ts3

Motivation

- **Integrated energy systems/ sector coupling / integration is considered one of the key measures for decarbonizing the energy system.**
- District heating and cooling (DHC) networks are **traditionally linking the heating & cooling and the electricity sector** (+ the gas sector) through combined heat and power (CHP) plants.
- However, **the role of CHP plants will significantly change**
  - competition for renewable fuels with hard-to-decarbonise sectors
  - increasing share hydro, wind and PV, less CHP electricity required

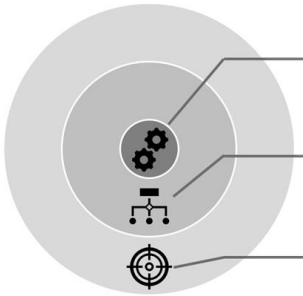
→ **We will need other heat (and cold) sources**
→ **We will need other coupling points to provide flexibility**

Relevant sector coupling technologies

- Waste and ambient heat, solar and geothermal energy often require **heat pumps** (HPs) for upgrading their temperature level;
- **electric boilers** (eBs) enable high temp. heat generation at fast gradients and low costs;
- **power-to-gas** (PtG)[1] processes generate fuels, that can be used in
- **CHP** plants for generating electricity and heat.

[1] PtG process itself generate significant amounts of waste heat, so a proper term would be power-to-gas&heat (PtG&H) or combined heat and gas (CHG) plants

Hybrid Energy Networks: a classification approch*



Layer	Minimum	Maximum
Technology	Single coupling points, central controls of network and coupling points	Multiple and diverse coupling points, high operational flexibility, advanced controls, automation and analytics
Organization	Minimum permissible ownership of coupling points, traditional business models and services offered	Diverse ownership, high share of prosumers, innovative business models and services offered
Strategic	Central structures, integration of coupling points as a reaction to market pressure	Decentralized structures, integrated planning and design, optimized interaction and decarbonization

**This classification differs from the 4G DHC networks concept (Lund et. al=) → the main characteristic of a HEN is the integration between the different networks, and not the supply temperature or the time period where the different generations were dominating.*

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IEA DHC

Fraunhofer IEE

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

Webinar on “Digitalization for optimizing integrated district heating systems”

Block III – Hybrid energy systems

Wednesday, 3rd November 2021, 9:00 to 17:00 (CET)

Contact: Ralf-Roman Schmidt (AIT); ralf-roman.schmidt@ait.ac.at

This Webinar is held in the framework of two international cooperation programs: the IEA DHC Annex TS3 „Hybrid Energy Networks“ and the IEA DHC Annex TS4 “Digitalisation of District Heating and Cooling”. More information at https://www.iea-dhc.org/the-research/annexes/2018-2024-annex-ts4/ and https://www.iea-dhc.org/the-research/annexes/2017-2021-annex-ts3 The Austrian participation in the IEA DHC Annex TS3 and TS4 is financed by the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK)

Federal Ministry
Republic of Austria
Climate Action, Environment, Energy, Mobility, Innovation and Technology

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THE TSO PERSPECTIVE ON SECTOR COUPLING AND DISTRICT HEATING

Industry workshop "Digitalization for optimizing integrated district heating systems 2021-11-03

Anders Bavnhøj Hansen (abh@energinet.dk)
Chief engineer
Energinet, System Perspective

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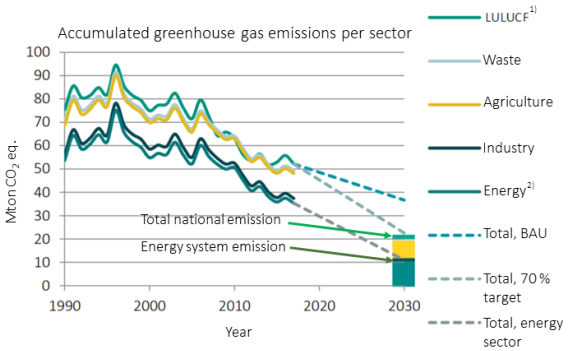
DENMARK HAS A 70 % CLIMATE GAS REDUCTION REDUCTION TARGET TOWARDS 2030

The target very relevant for TSO system planning



The 70 % reduction entails that:

- The CO_2 emission for the society should be reduced to 22,5 Mton CO_2 equivalents
- The emission from the energy sector should be reduced to 10-12,5 Mton CO_2/year
- To obtain long term climate national neutral target a negative emission on 10 Mton CO_2/year is set as boundary condition

1) Effect of changes in land use and forestry.
2) Energy incl. domestic transport.

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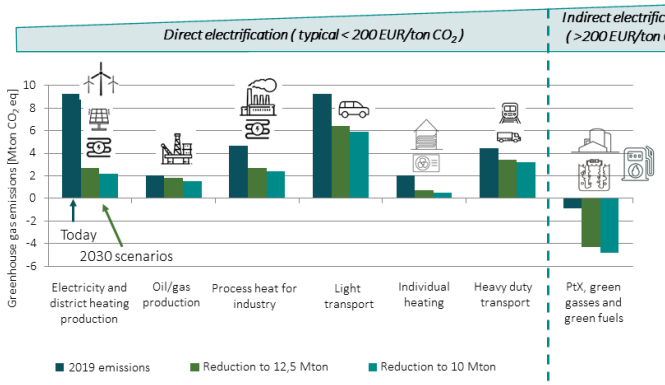
A 70 % REDUCTION REQUIRES SIGNIFICANT DIRECT AND INDIRECT ELECTRIFICATION



To reach 70% climate gas reduction:

- Heat pumps large scale in District heating
- 50% electrification of industry proces heat
- 0.5 to 1 mio EV's
- Conversion of oil burners and up to 70% of individual natural gas burners
- Production of electrobased fuels (PtX)

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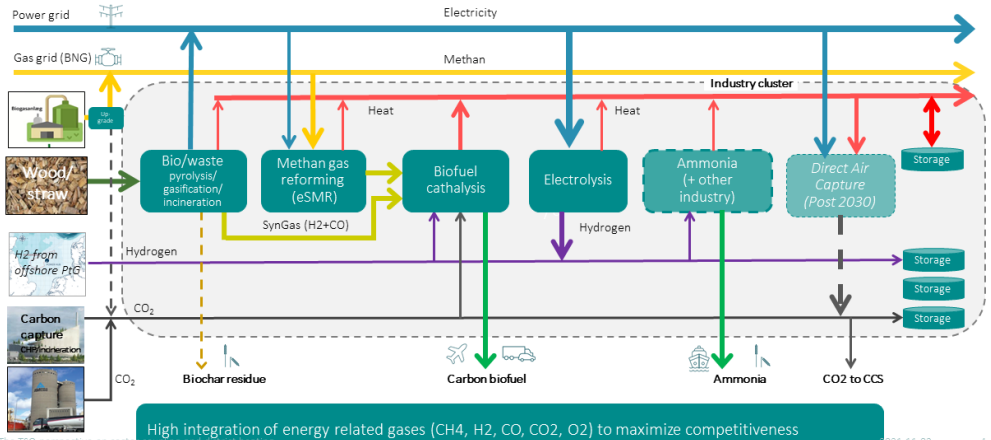
ENERGY CLUSTER CASE IN A SMART ENERGY SYSTEM



EXAMPLE ON SECTOR COUPLING CLUSTER AREAS

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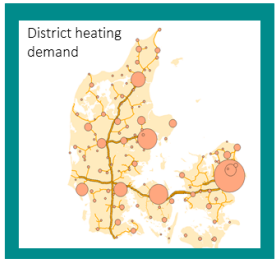

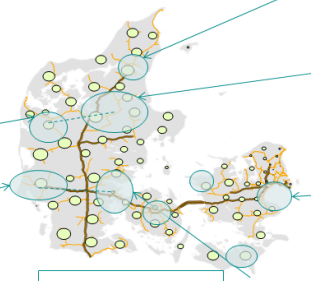

Region @ Holstebro-Herning
- Access to offshore el
- Very large bio gas (CO2) basis
- Moderate DH demand

Region @ Esbjerg
- Access to offshore el (and H2 from PtG)
- Large DH demand
- Bio gas in region (CO2), but if access invest in 15 km pipeline from Ribe

Region Aalborg
- Large heating demand
- Large biogas (CO2) basis
- Large CO2-basis from cement industry

Region Hobro-Århus Nord
- Caverns for storage of H2, CO2, O2 etc.
- Strong E-grid node (Tjele)
- Large biogas (CO2) basis
- Moderate DH demand (incl. Århus demand high)

Copenhagen area
- Carbon sources from Bio CHP and waste incineration
- Very high heat demand for use of excess heat

Region Trekantsområde
- Refinery
- Biogas
- Large DH demand

Exist. Gas net
Biogas (with CO_2)
Examples of clusters
Examples of H_2 lines

ENERGY ISLANDS PROJECTS

PERSPECTIVES ANALYSED IN SCENARIOS

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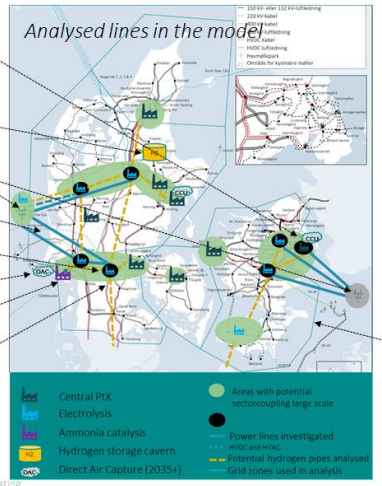
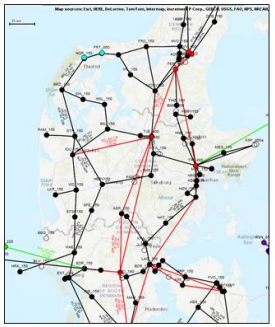
CO2 capture on biomass and waste CHP
Hydrogen in caverns
Energy hubs/islands potential offshore elektrolysis
HVDC/HVAC alternatives
PtX units, refinary of Jetfuel etc.
CO2 Direct Air Capture (DAC)
RE ammonia production
Hydrogen infrastructure incl. potential export to Germany



Grid model



Market zones analysed to handle grid congestion - a part of the Smart Energy System

BALANCING THE DANISH POWER SYSTEM

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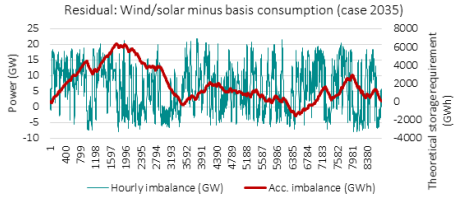

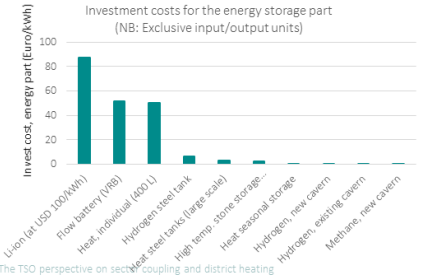

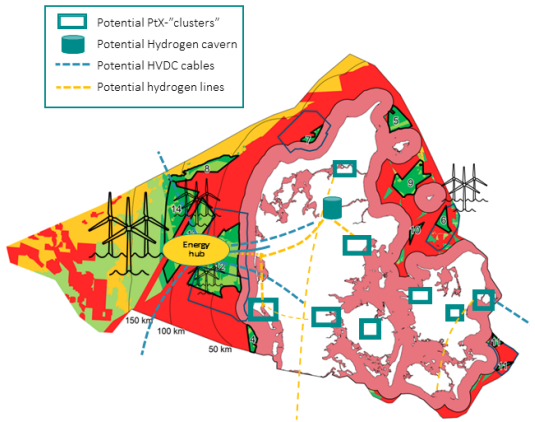

Further information at: http://www.energinet.dk/Sys35

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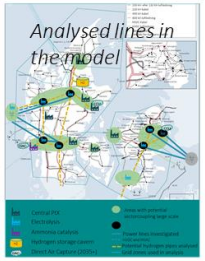
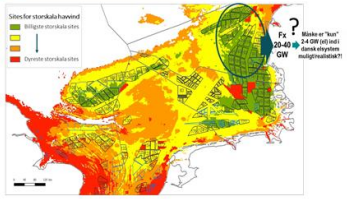
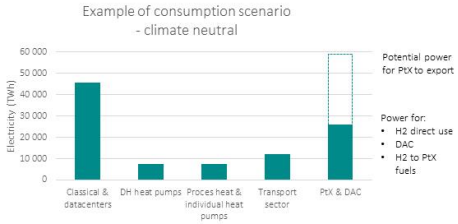
PERSPECTIVES ANALYSED IN SCENARIOS







- Transition towards DK climate neutrality requires 12-16 GW offshore wind (depending on PV capacity)
- The Danish offshore ressources gives potential for production of more PtX for export – a case with extra 25 TWh H2 analysed and handled in the system

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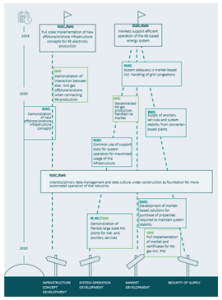
SUMMING UP

- 70% climate gas reduction in DK towards 2030 analysed
- Reduction towards climate neutral system in DK analysed.
  Negative emission on 10 MTon CO2 from energy system assumed to balance non-energy climate gas
- DK Offshore windpower potentials very high (more than needed for climate neutral DK)
  – a climate neutral scenario with export of up to 25 TWh PtX fuel also analysed
- Direct Air Capture used for CCU and CCS towards climate neutral scenario
- Sector coupling in large clusters used for efficient system integration of Power, H2, CO2, Heat
- A coupling of clusters with specific hydrogen lines analysed
- Offshore electrolysis at Northsea hub analysed – and concepts might be relevant
- The integrated energy system requires digitalization and further development of market- and operation solutions

R&D roadmap



https://en.energinet.dk/Analysis-and-Research/Analyses/System-perspectives-for-the-70pct-target-and-large-scale-offshore-wind

Systemic benefits of district heating

Analysing systemic benefits of district heating with an integrated transmission and generation expansion planning model in 2050+

Henrik Schwaeppe, Luis Böttcher, Klemens Schumann, Lukas Hein, Philipp Hälsig, Simon Thams, Paula Baquero Lozano, Albert Moser

First presented at Smart Energy Systems, 7th International conference, 21-22/09/21. Shown at IEA DHC industry workshop 03/11/21.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 863922.

Introduction

- Climate change requires radical change in systemic thinking
  - Sector integration to reduce greenhouse gas emissions
  - Several approaches to sector integration
- District energy as part of the solution [SNE20]
  - Electricity, heat & cooling provided from various energy sources
  - Provides tap water, space heating and process heat
- People hesitant to invest in district heating connections [HAG20]
  - Investment and operational comparable to conventional boilers
  - Fear of monopoly etc.
- Spend more effort on enhancing district heating (DH)?
  - Does DH reduce the cost and emissions of thermal supply?
  - Can DH offer benefits to other sectors?

[SNE20] Sneum, D. M. (2020). Flexibility in the interface between district energy and the electricity system. PhD thesis. Technical University of Denmark.
[HAG20] Duijvestijn, M., Peeters, N., van der Lubbe, M., Bolhuis, M. (2020). Resistance against heat networks. Report. The Hague University of Applied Sciences

Agenda


What are systemic benefits of DH?


Introduction of an integrated transmission and generation expansion planning model


Exemplary investigation on systemic benefits and results

Future outlook on applications

First presented at Smart Energy Systems, 7th International conference, 21-22/09/21. Shown at IEA DHC industry workshop 03/11/21.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 863922.

Versatility and flexibility as systemic benefits

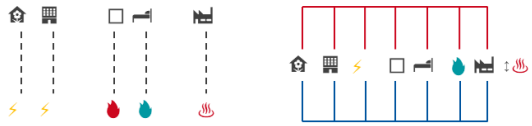
[DEA21] Danish Energy Agency (2021). Technology Data. https://ens.dk/en/our-services/projections-and-models/technology-data

1 Tank: Large-Scale Hot Water Tanks
2 PTES: Pit Thermal Energy Storage
3 Li-Ion: Lithium-ion NMC battery (Utility-scale)
Heat storage depiction: Flaticon.com

Versatility

- Decentral heating makes use of one technology
- District heating: versatile and efficient options
  - High share of renewables: heat pumps
  - Low share of renewables: CHP plant / fuel boiler
  - Use of excess heat sources / storage

Figure 1: Decentral heating vs. district heating options

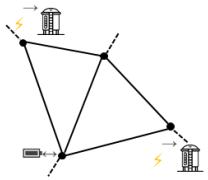


Flexibility

- Large-scale heat storage magnitudes cheaper than grid-scale battery storage
- Uni-directional charging only (electrically), but:
  - **temporal load shifts**
  - **locational load shifts**

Table 1: Cost of energy storage in 2050
according to [DEA21]

	Tank[1]	PTES[2]	Li-Ion[3]
Capacity	175 MWh_{th}	4500 MWh_{th}	8 MWh_{el}
Cost [€/MWh]	3.000	470	255.000
Roundtrip Efficiency	98 %	70 %	92 %



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Integrated Transmission & Generation Expansion Planning

[HS21] Schwaeppe, H., Moser, A., Paronuzzi, P., Monaci, M. (2021). Generation and Transmission Expansion Planning With Respect to Global Warming Potential. Conference paper.
[DEA21] Danish Energy Agency (2021). Technology Data. https://ens.dk/en/our-services/projections-and-models/technology-data

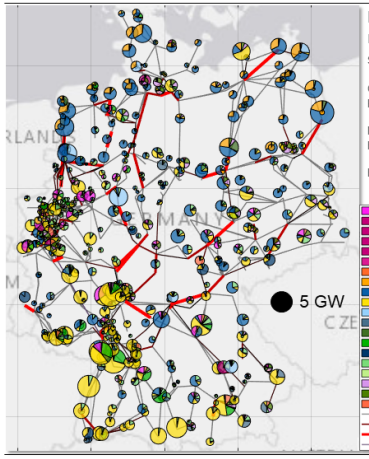

Figure 2: Expansion results of exemplary scenario 2050+

Onshore wind: 128.2 GW
Photovoltaic: 166.9 GW

Natural Gas PP: 47.0 GW
Fuel Cell PP: 8.4 GW

Electrolyzer: 23.9 GW

Single-stage linear expansion planning [HS21]

- Minimize total cost of expansion and operation

$$\min \sum \boldsymbol{CAPEX} + \boldsymbol{OPEX}$$

Constraints

- Compliance with CO2 restrictions
- Demand coverage (electric, heat, gas)

Decision Variables

- Transmission grid expansion
- Nodal capacity investment
- Hourly operational decisions

Exemplary Inputs

- Existing power plants & high voltage grid
- 575 electrical and decentral thermal nodes
- 182 district heating nodes
- Bottom-up electrical and thermal demand
- Weather data, potential data
- Cost parameters [DEA21]

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Integrated Transmission & Generation Expansion Planning

Heat storage depiction: Flaticon.com

Potential investigations

- Operational decisions and limits in hourly resolution
- Determination of energy volumes and required imports
- Cost analyses
- CO2 emissions […]

Nodal heating configuration

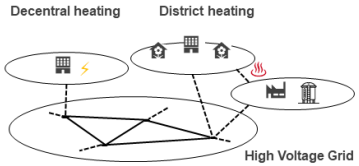


Figure 3: Aggregated electrical operational balance

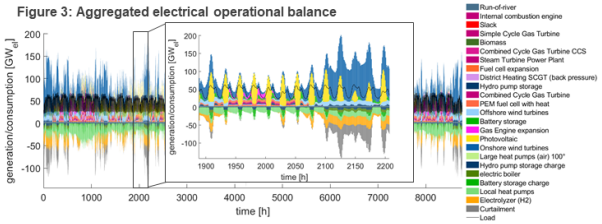
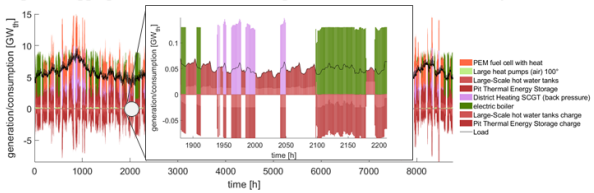


Figure 4: Aggregated thermal district heating balance and individual network operation



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Exemplary investigation on systemic benefits in 2050+

1 annuity interest rate = 0 %

Increase heat storage potential (2x)

Increase district heat share (2x)

DH share 10 % - Heat storage 6 GWh (x182)	Heat storage 12 GWh
DH Share 20 %	DH share 20% - Heat storage 12 GWh

- Sensitivity analysis on district heating penetration and storage availability
- **Cost of heat grid expansion not included**
- **DISCLAIMER**
  Showcasing a potential application;
  not a validated scenario

	Total annual system cost[1]	Annual CO_2 balance	District heating supply
DH share 10 % - Heat storage 6 GWh (x182)	20.93 billion EUR	31.48 million t CO_2eq	2.94 EUR / MWh
Heat storage 12 GWh	- 19.3 million EUR	+ 0.02 million t CO_2eq	- 0.64 EUR / MWh
DH Share 20 %	- 717.0 million EUR	- 0.66 million t CO_2eq	+ 3.12 EUR / MWh
DH share 20% - Heat storage 12 GWh	- 782.7 million EUR	- 0.70 million t CO_2eq	+ 2.17 EUR / MWh

1. Investing in district heating decreases total system cost in the long run → **Invest in heat networks?**
2. Investing in district heating decreases CO_2 emissions → **Preferred solution?**
3. DH supply reduces total economic costs, but becomes itself more expensive → **Subsidies?**

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What we will do

- Continue to develop our software
- Solvers for up-scaling to European level
- Refine energy system scenarios

Why you want to get in touch with us

- Conduct system studies with novel types of models
- *You want to investigate yourself?*
  PlaMES provides you with a web interface (in development)
- *Detailed analyses on distribution level?*
  PlaMES also develops tools for analyzing energy sharing communities, distribution & transmission grids

Thank you for listening!

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Chair of High Voltage Grids and Energy Economics
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Interactive session

- Evaluating SWOT factors for hybrid energy networks

Hybrid Energy Networks: a SWOT assessment

See also: Ralf-Roman Schmidt; Benedikt Leitner; **A collection of SWOT factors (strength, weaknesses, opportunities and threats) for hybrid energy networks**; Energy Reports, special issue for the 17th International Symposium on District Heating and Cooling, 6th-9th September 2021, Nottingham, UK; https://doi.org/10.1016/j.egyr.2021.11.183

In 2018, a **cooperation between IEA ISGAN Annex 6 and IEA DHC Annex TS3** started. A first shared document is a SWOT analysis.

The SWOT analysis aims at supporting the general understanding of the properties and characteristics of a Hybrid Energy Network

Method: a structured expert involvement:

- First: collection of SWOT factors
- Second: comprehensive discussion phase
- *Third: (not yet carried out): survey*

	Helpful to achieving the objective	Harmful to achieving the objective
Internal origin (attributes of the organization)	Strengths	Weaknesses
External origin (attributes of the environment)	Opportunities	Threats

Hybrid Energy Networks: a SWOT assessment

See also: Ralf-Roman Schmidt; Benedikt Leitner; **A collection of SWOT factors (strength, weaknesses, opportunities and threats) for hybrid energy networks**; Energy Reports, special issue for the 17th International Symposium on District Heating and Cooling, 6th-9th September 2021, Nottingham, UK; https://doi.org/10.1016/j.egyr.2021.11.183

STRENGTH
- Higher degrees of freedom for planning/ operation;
- higher security of supply, resilience, flexibility
- counteract limitations of the el. network + reduce losses
- New business models (ancillary services, markets)
- decarbonization of DHC network
- (booster) HPs support Integrate low temp. heat sources
- economic added value (investment in coupling points)

WEAKNESSES
- additional investments into coupling points
- increasing level of complexity
- Present electricity tariffs and taxes are a barrier
- regulatory restrictions for electricity grid operators
- seasonality of the heat demand
- supply competition in DHC (especially in the summer)
- Only renewable, if fossil-free electricity is used

OPPORTUNITIES
- More research, products, demo projects, trainings etc.
- improved performance of coupling points/ controls
- Digitalization supports handling of the complexity
- Increasing PV and wind → more flexibility required
- Green financing options
- tendency for the reduction of DHC temperatures

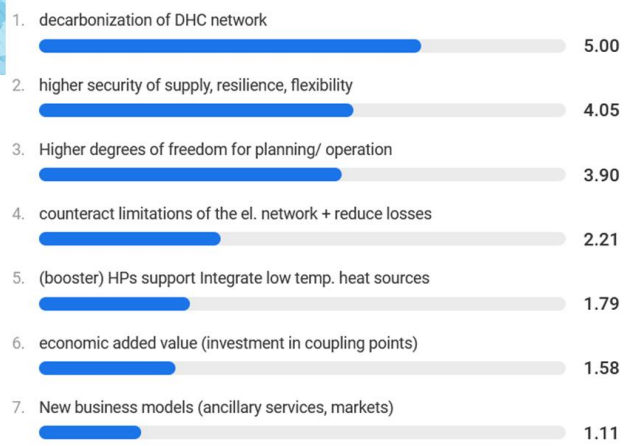
THREATS
- a possible disruptions of existing business models;
- overall higher electricity demand
- Changing regulatory framework / market design
- market development (alternative flexibility providers)
- availability of waste heat as a source for HPs
- Availability of suitable DHC infrastructures?

Interactive session - evaluating SWOT factors for hybrid energy networks

Join at
slido.com
#689 719

Strengths

what are the main Strength of HEN?



Weaknesses

What are the main weaknesses of HEN?

Opportunities

What are the main Opportunities for HEN?

Threats

What are the main Threats of HEN?

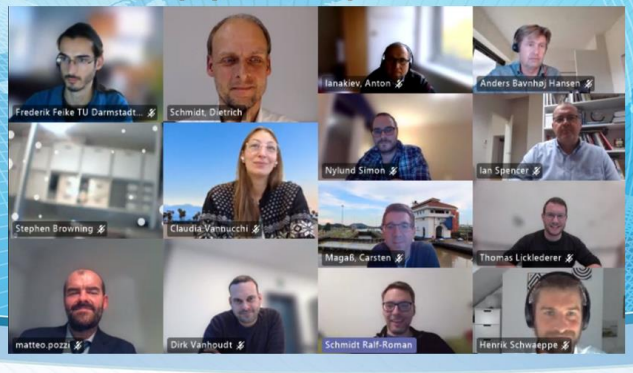
any other aspects you want to add?

Training
security threats, system hacki
separated business units
electricity trading
Time Shift Elec

Outlook

- **Finalizing the work in the Annex and reporting in winter/ spring**
  - Contribution still possible!
- Presentation of selected results in a **journal papers**
- Development of a short **fact sheet/ summary for policy makers** + recommendations + **a guidebook!**
- **(national) workshop** on the TS3 results in Spring 2022 (Austria?)

Group photo - please smile



In total up to 90 participants

Thanks for your active participation!

- **The slides will be available at** https://www.iea-dhc.org/the-research/annexes/2017-2021-annex-ts3
- **Contact:**
  - Ralf-Roman Schmidt, ralf-roman.schmidt@ait.ac.at (leader TS3)
  - Dietrich Schmidt, dietrich.schmidt@iee.fraunhofer.de (leader TS4)