IEA DHC | CHP

Proceedings of the 1st IEA DHC Annex TS3 and TS4 Industry Workshop:

Digitalization for optimizing integrated district heating systems

9th of September 2020 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

Webinar on
"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

Date: Wednesday, 9th September 2020, from 10:00 to 17.00 (separated in three blocks)

Webinar organization: Ralf-Roman Schmidt, Ralf-Roman.Schmidt@ait.ac.at +43 664 235 19 01
Dietrich Schmidt, dietrich.schmidt@iee.fraunhofer.de +49 561804-1871

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

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** *(Ralf-Roman Schmidt, AIT)*
	The era net call on digitalization *(Michael Hübner, Austrian ministry BMK, requested)*
	National R&D perspectives for the digitalisation of the energy sector *(Carsten Magaß, Project Management Juelich)*
	~~**The role of digitalisation for future energy systems** *(Kathleen Gaffney, IEA Paris)*~~
	The European framework *(Alessandro Provaggi, Euroheat and Power)*
11:00	*End of Block I*

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 era net call on digitalization** *(Michael Hübner, Austrian ministry BMK, requested)*~~
	The utility perspective on digitalisation of district heating *(Bernd Rüger & Carina Noll, Stadtwerke München)*
	Digitalisation solutions for heat infrastructures *(Martin Brüssau, SAMSON)*
	Business opportunities from digitalisation *(Steen Schelle Jensen, KAMSTRUP)*
	Interactive session and Q&A to all presenters
14:00	*End of Block II*

Block III – Hybrid energy systems

15:00	*Testing of technical connections*
15:30	**Introduction into the IEA DHC Annex TS3 project** *(Ralf-Roman Schmidt, AIT)*
	The utility perspective on sector coupling and district heating *(tbd)*
	Technologies for Hybridisation (*Oddgeir Gudmundsson, Danfoss)*
	Sector coupling between hydrogen and district heating *(Hans Böhm, EI Linz)*
	Interactive session and Q&A to all presenters
17:00	*End of Block III*

Index

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“.

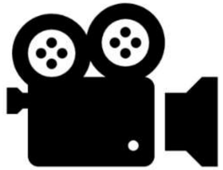
9. September 2020

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

Fraunhofer IEE
AIT AUSTRIAN INSTITUTE OF TECHNOLOGY TOMORROW TODAY

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 (Ralf-Roman Schmidt, AIT)	
	National R&D perspectives for the digitalisation of the energy sector (Carsten Magaß, Project Management Juelich)	
	~~The role of digitalisation for future energy systems (Kathleen Gaffney, IEA Paris)~~	canceled
	The European framework (Alessandro Provaggi, DHC+/ Euroheat and Power)	
	Interactive session and 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 era net call on digitalization (Michael Hübner, Austrian ministry BMK)
	The utility perspective on digitalisation of district heating (Bernd Rüger & Karina Nold, Stadtwerke München)
	Digitalisation solutions for heat infrastructures (Martin Brüssau, SAMSON)
	Business opportunities from digitalisation (Steen Schelle Jensen, KAMSTRUP)
	Interactive session and Q&A to all presenters
14:00	**End of Block II**

IEA DHC|CHP

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

5

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)
	Technologies for Hybridisation (Oddgeir Gudmundsson, Danfoss)
	GIS-based automated design of DH networks (Joseph Jebamalai, Comsof)
	Sector coupling between hydrogen and district heating (Hans Böhm, EI Linz)
	Interactive session and Q&A to all presenters
17:00	**End of Block III**

IEA DHC|CHP

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

6

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

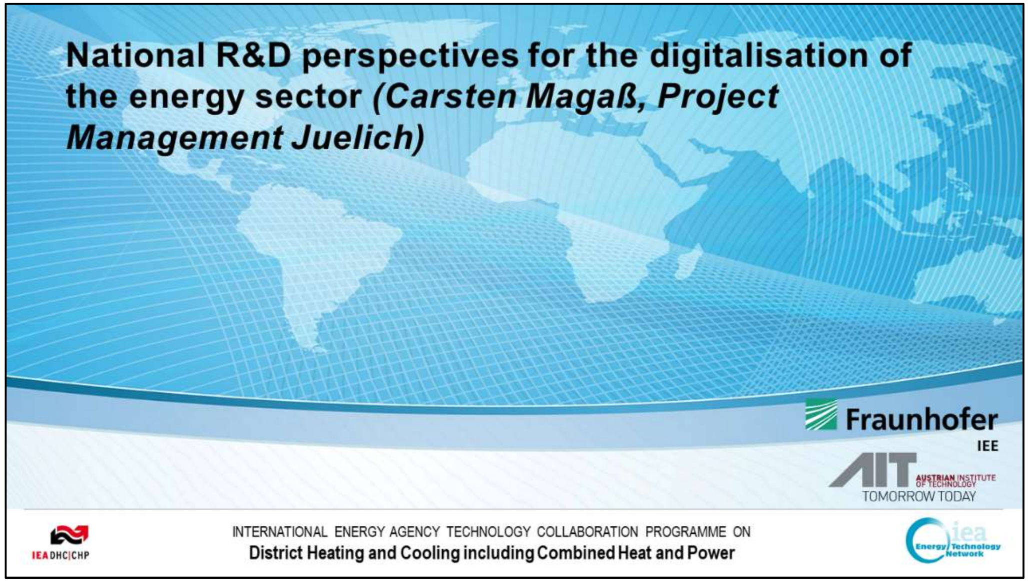
- **a platform for international experts**
  - dedicated to helping to make DHC and CHP powerful tools for energy conservation and the reduction of environmental impacts of supplying heat
  - Current members: Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, Korea, Norway, Sweden, United 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

Update: Italy recently joined!

IEA DHC|CHP

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

7


National R&D perspectives for the digitalisation of the energy sector (Carsten Magaß, Project Management Juelich)
Fraunhofer
IEE
AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY
IEA DHC|CHP
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power
iea Energy Technology Network


The European framework (Alessandro Provaggi, DHC+/ Euroheat and Power)
Fraunhofer
IEE
AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY
IEA DHC|CHP
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power
iea Energy Technology Network


DHC+
TECHNOLOGY PLATFORM
Under the umbrella of
EUROHEAT & POWER
The European framework for energy integration and digitalization in DHC
Alessandro Provaggi – Head DHC+ Platform

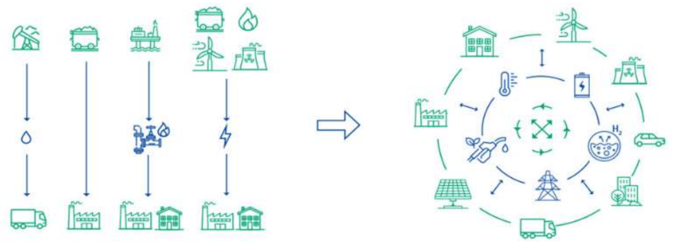

From the Green Deal…
A zero pollution Europe
Preserving Europe's natural capital
Transition to a Circular Economy
Sustainable Transport
Farm to Fork
Achieving Climate Neutrality
European Green Deal
Towards a Green CAP
Clean, Reliable and Affordable energy
Financing the transition
Take everyone along (Just Transition Mechanism)
DHC+ TECHNOLOGY PLATFORM


…To the Green Recovery
Ursula von der Leyen @vonderleyen · Apr 28
As we start to rebuild our economies after the coronavirus, we need to invest in smartly. Our compass will remain the #EUGreenDeal, which can transform our economies and societies to confront climate change. For the future of our planet and our children. #GreenRecovery
Frans Timmermans @TimmermansEU · Apr 28
The EU is ready to show climate leadership and take us out of the current economic crisis in a way that will increase our resilience.
We will translate the #EUGreenDeal into concrete recovery measures with quick results.
2:05 77.7K views

Energy system integration

The energy system today : linear and wasteful flows of energy, in one direction only

Future EU integrated energy system : energy flows between users and producers, reducing wasted resources and money



DHC+ TECHNOLOGY PLATFORM

What the strategy say about the role of DHC?

- *"Modern **low temperature district heating systems should be promoted,** as they can connect local demand with **renewable** and waste energy sources**,** as well as **the wider electric and gas grid** – contributing to the optimisation of supply and demand across energy carriers".*
- *"On the circular economy side, **facilitate reuse waste heat** from industrial sites and **data centres**, through strengthened requirements for connection to DHC, energy performance accounting and contractual frameworks".*

DHC+ TECHNOLOGY PLATFORM

And about energy integration + digitalization ?

- *"Consumers play an active role in a 'multi-directional' system by exchanging heat in smart networks".*
- *"Heat pumps and smart district heating to provide opportunities for "arbitrage" between electricity and gas markets".*
- *"Union to maintain and leverage its leadership in clean technologies such as smart grid technologies and district heating system".*
- Section on "A digitalised energy system and a supportive innovation framework"

DHC+ TECHNOLOGY PLATFORM

EU funding opportunities are scaling up !

- **RES and digitalization are the priority !**
- **Green Deal call : 1 Billion extra of funding opportunities**
- **EU and Budget Horizon Europe under negotiation with EP**
- **390 billion recovery funds to focus on energy and digital**

- **Focus digitalization: 5G, AI, cloud, cybersecurity, supercomputing**

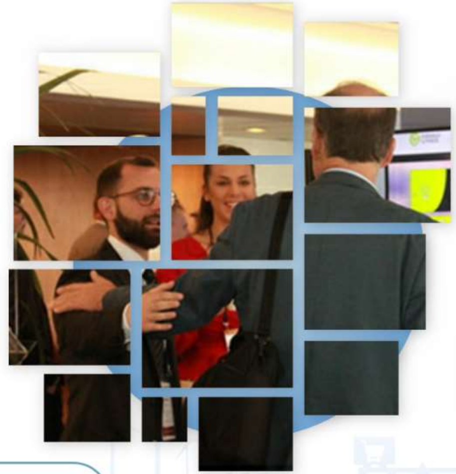
DHC+ TECHNOLOGY PLATFORM

Some tips

- Digital solutions as enabler for the operation of multi-source DHC networks.
- Digital transformation and digital infrastructure to co-create and test solutions with local communities, including changes in social practices and behaviour.
- So not only energy efficiency/optimization but usability, and secure operation ensuring optimal comfort for users and a healthier environment.
- Address skills gaps!

DHC+ TECHNOLOGY PLATFORM

DHC+ support for projects



- GENERAL SUPPORT FOR:
  - Partners searching for your consortium
  - Consortium building /search
  - Networking
  - Dissemination and Communication
  - Demo sites
  - Funding Opportunities monitoring

DHC+ TECHNOLOGY PLATFORM

ONGOING PROJECTS

DHC+ TECHNOLOGY PLATFORM

Thank you for your attention!

DHC+ TECHNOLOGY PLATFORM

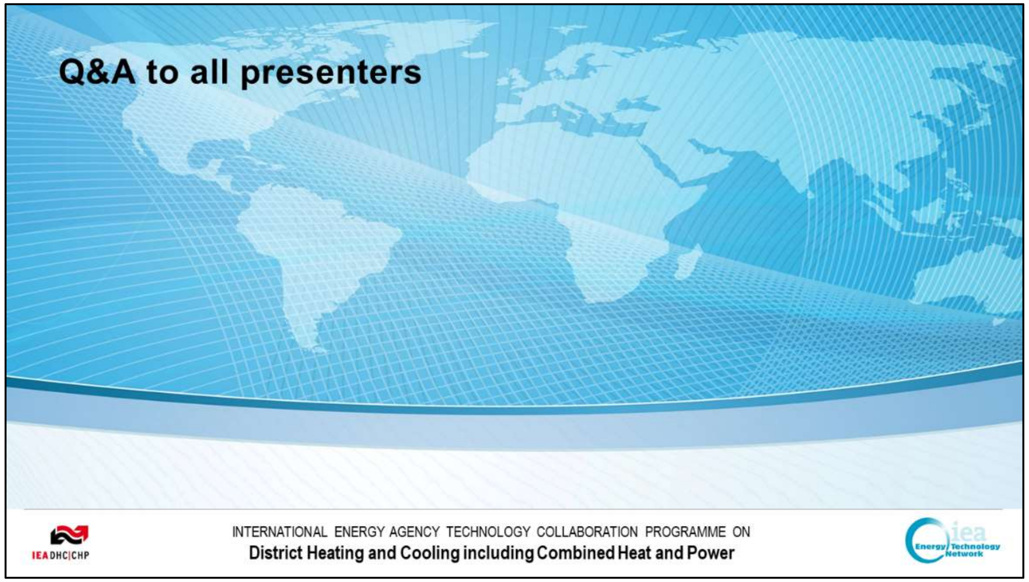
Under the umbrella of EUROHEAT & POWER

Stay in touch!

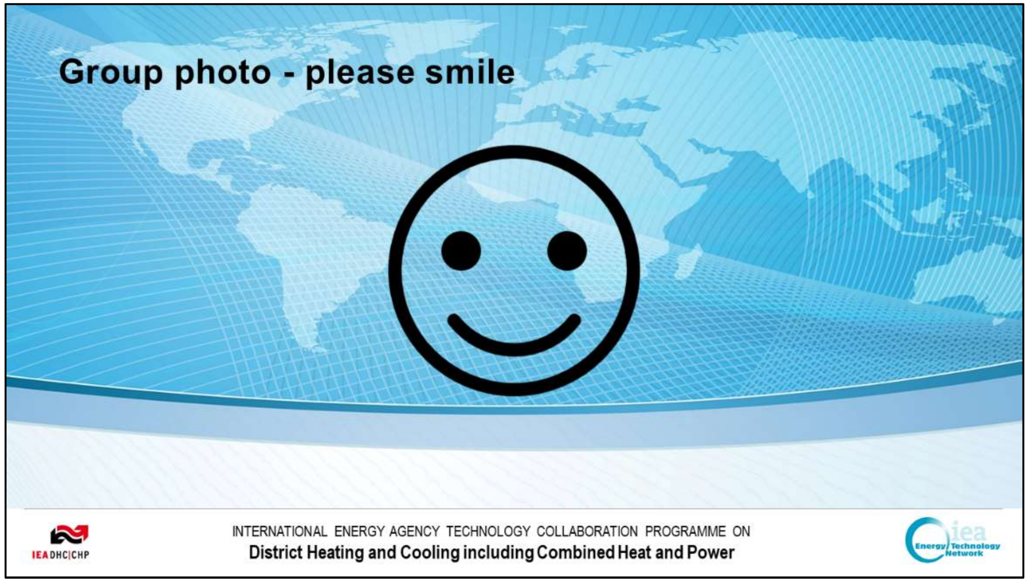
ap@euroheat.org

alessandro-provaggi

@aprovaggi


Q&A to all presenters
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power


Summary and next steps
We will make the recording of the webinar available on the IEA DHC YouTube channel https://www.youtube.com/channel/UCuYcqLjJi8thrUJCjzLBaow and send out the presentation slides
If you want to join the IEA DHC Annex TS3 or TS4, please contact
Ralf-Roman Schmidt, ralf-roman.schmidt@ait.ac.at (leader TS3)
Dietrich Schmidt, dietrich.schmidt@iee.fraunhofer.de (leader TS4)
AND: contact your national IEA DHC representative for funding opportunities https://www.iea-dhc.org/home/
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power
23


Group photo - please smile
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power


Thank you for your attention!
Webinar Digitalization for optimizing integrated district heating systems - Block I
9. September 2020
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/
http://www.iea-dhc.org/the-research/annexes/2017-2020-annex-ts3-draft.html
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

Webinar Digitalization for optimizing integrated district heating systems

Block II: Digitalization of district heating systems

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“.

9. September 2020

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)

Fraunhofer IEE
AIT AUSTRIAN INSTITUTE OF TECHNOLOGY TOMORROW TODAY

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-draft.html

IEA DHC|CHP
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

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)

IEA DHC|CHP
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power
2

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

IEA DHC|CHP
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power
3

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 era net call on digitalization (Michael Hübner, Austrian ministry BMK)
	The utility perspective on digitalisation of district heating (Bernd Rüger & Karina Nold, Stadtwerke München)
	Digitalisation solutions for heat infrastructures (Martin Brüssau, SAMSON)
	Business opportunities from digitalisation (Steen Schelle Jensen, KAMSTRUP)
	Interactive session and Q&A to all presenters
14:00	**End of Block II**

IEA DHC|CHP
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power
4

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)
	Technologies for Hybridisation (Oddgeir Gudmundsson, Danfoss)
	GIS-based automated design of DH networks (Joseph Jebamalai, Comsof)
	Sector coupling between hydrogen and district heating (Hans Böhm, EI Linz)
	Interactive session and Q&A to all presenters
17:00	**End of Block III**

IEA DHC|CHP
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

Introduction into the IEA DHC Annex TS4 project
(Dietrich Schmidt, Fraunhofer IEE)

IEA DHC|CHP
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

Technology Collaboration Programme
by iea

IEA DHC Annex TS 4:
Digitalisation of District Heating and Cooling:
Optimised Operation and Maintenance of District Heating and Cooling Systems via Digital Process Management

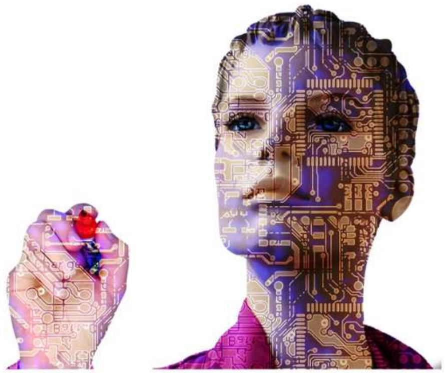
9th of September 2020

Dr. Dietrich Schmidt
Fraunhofer IEE

Fraunhofer
IEE

IEA DHC|CHP
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

Our future Energy system will be digital!



IEA DHC|CHP
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

Presentation 5:
D. Schmidt: Introduction into the IEA DHC Annex TS4 project

Background: Digitalisation

- District heating and cooling networks are **traditionally** operated with a limited number of controls.
- A wider implementation of information and communication technologies, as in many other industries, opens up for better network management based on real time measurement data.
- **Opportunities**:
  - offering flexibility by integrating digital processes and demand side management (peak shaving)
  - Enabling the integration of fluctuating heat sources (renewables)
  - New business models for district heating provider

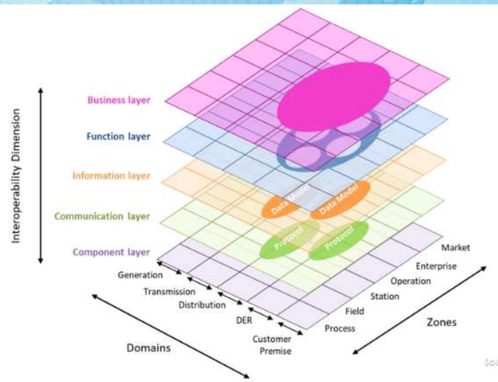
Aim of the proposed DHC Annex

- The new 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.

principle goals of the task shared Annex

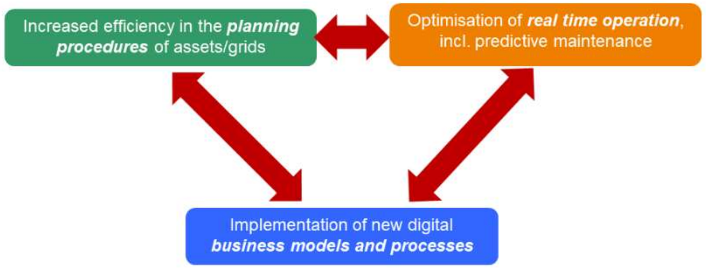
- **Create** awareness for the advantages of the implementation of digital processes to the various stakeholders and users
- **Provide** a state-of-the-art overview of the digitalisation of district heating schemes in terms of R&D projects, demonstrators and case studies
- **Evaluate** non-technical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

Digitalisation concepts



Source Fraunhofer CINES Cluster

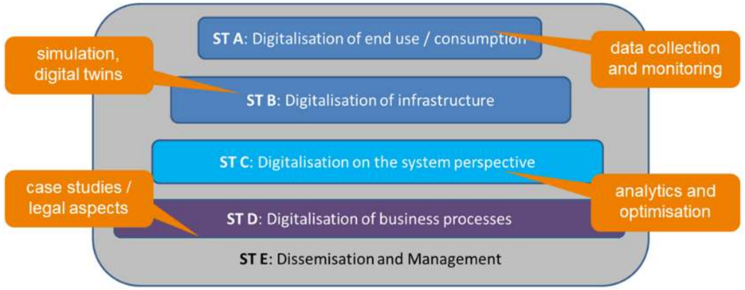
Our focus areas for a digitalisation in DHC



INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

13

DHC Annex TS4 working structure



INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

14

Annex TS4 1st Preparation Phase meeting

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

15

cooperation with other initiatives

- **German Heat & Power Association (AGFW)**
  - Offer to support the upcoming Annex via different means
  - Strong interest to support the dissemination
- **DHC+**
  - Offer to support the upcoming Annex via different means
  - Strong interest to support the dissemination
- **Danish Board of District Heating (dbdh)**
  - Happy to support the Annex and dissemination
- **IEA EBC Annex proposals on:**
  "Demand Response of Buildings in DHC networks" &
  "Data-Driven Smart Buidlings"
- And others…

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

16


Technology Collaboration Programme
by iea
Thank you for your attention!
Contact:
(Proposed OA:) Dietrich SCHMIDT
Fraunhofer Institute for Energy Economics and Energy Technology (IEE) / Germany
+49 561 804 1871
dietrich.schmidt@iee.fraunhofer.de
IEA DHC|CHP
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power


The era net call on digitalization (Michael Hübner, Austrian ministry BMK)
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

The utility perspective on digitalisation of district heating *(Bernd Rüger & Karina Nold, Stadtwerke München)*

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

---

Stadtwerke München SW//M

The utility perspective on digitalization of district heating Leakage localisation[1] and integration of geothermal energy[2]

Dr.-Ing. Bernd Rüger, Dr.-Ing. Karina Nold
09.09.2020, IEA DHC Annex TS3, TS4 Industry Workshop

SWM intern

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

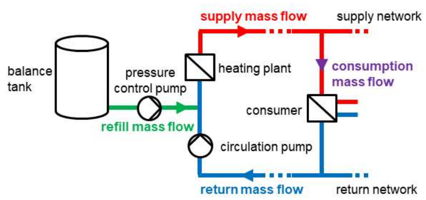
M/Wasser M/Bäder M/Strom M/Wärme M/net MVG

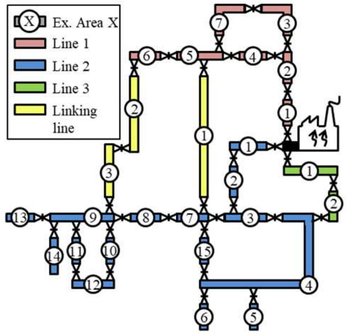
see https://www.enargus.de
[1]FKZ 03ET1624B and 03ET1236B (final report https://doi.org/10.2314/GBV:1027778887)
[2]FKZ 0324332A

Outline

- Applications
  - Leakage localisation
  - Integration of geothermal energy
- Challenges
- Wish list R&D-projects vs. operational needs

Fast localisation and reaction is important in case of large spontaneous leakages

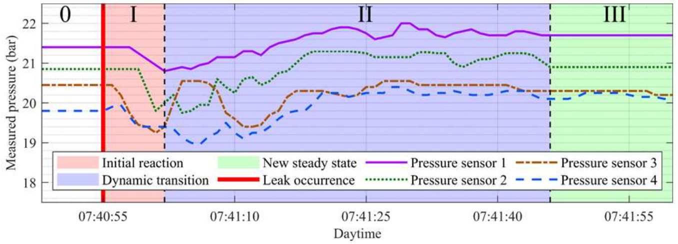




Balance tank can run empty within short time in case of large leakages ➔ imminent shutdown of network

District heating networks equipped with remote controlled motor driven valves ➔ separation is possible

Phases after occurrence of a leakage



- **Three phases occur:**
  I. Initial reaction – negative pressure wave travels through the network directly after leakage occurrence
  II. Dynamic transition – pressures change due to pressure control working
  III. New steady state – all oscillations declined
- Occurrence of a leakage changes hydraulic state of DHC networks and refill mass flow rises to compensate medium losses.

Approaches for leakage localisation

More details are presented at the 52. Kraftwerkstechnisches Kolloquium am 06. und 07. October 2020

Ostfalia Hochschule für angewandte Wissenschaften | iat Institut für Automatisierungstechnik | Otto von Guericke Universität Magdeburg Fakultät für Informatik

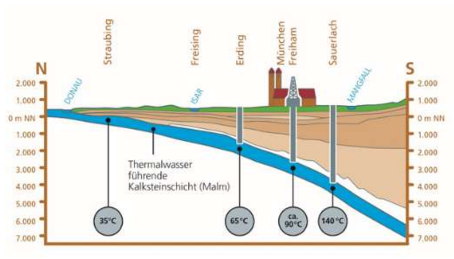
	Pressure wave evaluation	Numerical approach	Machine learning approach
Phase	I – initial reaction	III – new steady state	III – new steady state
Measurement data	Time frame with high temporal resolution	Point in time – values with high resolution	Point in time – values with high resolution
Classification rates ideal data* „real“ data*	$Z = 100\ \%$ $Z \sim 71\ \%$	$Z \sim 70\ \%$ $Z \sim 46\ \%$	$Z \sim 89\ \%$ $Z \sim 62\ \%$
Features	Identification of pipe possible with ideal data	Classification result depends on leakage size	Classification result depends on ML method
Contact information	Kai Vahldiek k.vahldiek@ostfalia.de	Dennis Pierl dpierl@iat.uni-bremen.de	Julia Koltermann julia.geissler@ovgu.de

*ideal data = simulated with appropriate models without noise; real = ideal data with noise added (but not measured data!)

District Heating - Vision 2040

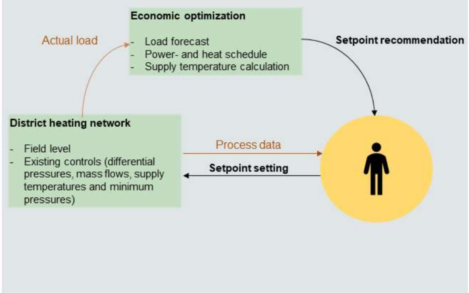
- SWM aims at providing 100% CO_2-neutral district heating by the year 2040
- This will be achieved by using predominantly **sustainable heat sources** from deep geothermal energy

North-south-sectional view of alpine upland

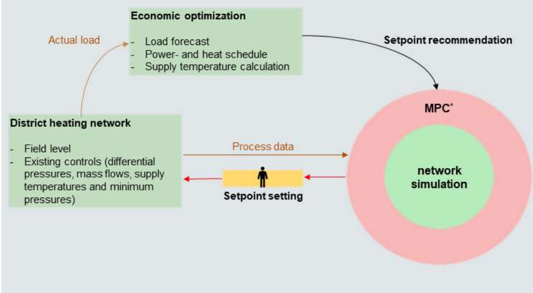


Integration of geothermal energy

Current operating scheme



Future operating scheme



*Model predictive control (MPC) validates hydraulic boundaries and reschedules optimal if necessary.

Presentation 7:
B. Rüger & K. Nold: The utility perspective on digitalisation of district heating

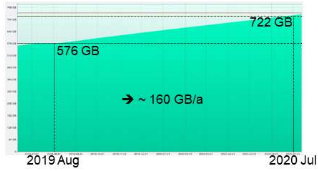
Outline

- Applications
- Challenges
  - Process data → technical restrictions
  - Accurate network models → available data base and skills
  - Knowledge about customer behaviour → lack of information
  - Non-technical
- Wish list R&D-projects vs. operational needs

27 09.09.2020 / IEA DHC Annex TS3, TS4 Industry Workshop v09 / NI-SK SW//M

Process data → technical restrictions

- **Available infrastructure meets current operational demands!**
- **New requirements coming up**
  - Collecting all data in a single data base with long time storage of highly resolved data (connectivity,…)
  - High data rate and high resolution of measurement values
  - Timestamping of measurements must be close to sensor
  - Performance of systems in transmission chain must be high enough (data losses, reliability,…)
  - … number of measurement devices might be too low



  - Unique measurement device IDs throughout all systems and documentation
- Solving this topics is technically possible.
- Costs originate from additional systems. Operation of improved systems is not much more expensive so far.
- Projects would not have been possible without funding.

28 09.09.2020 / IEA DHC Annex TS3, TS4 Industry Workshop v09 / NI-SK SW//M

Accurate network models → available data base and skills

- **Available data and skills meet current demand!**
- **New requirements coming up**
  - Not only GIS data but network models are needed
  - Measurement devices have to be placed at correct location in models and linked to measured data
  - Control of heat stations (and substations) has to be modelled sufficiently accurate
- Accurate network models can be established
- Effort depends strongly on the available skills and data base of the municipal utility

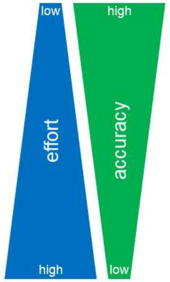
29 09.09.2020 / IEA DHC Annex TS3, TS4 Industry Workshop v09 / NI-SK SW//M

Accurate network models → available data base and skills

- **Available data and skills meet current demand!**
- **New requirements coming up**
  - Not only GIS data but network models are needed
  - Measurement devices have to be placed at correct location in models and linked to measured data
  - Control of heat stations (and substations) has to be modelled sufficiently accurate
- Accurate network models can be established
- Effort depends strongly on the available skills and data base of the municipal utility

29 09.09.2020 / IEA DHC Annex TS3, TS4 Industry Workshop v09 / NI-SK SW//M

Knowledge about customer behaviour → lack of information



- Best option is direct access to customer data (mass flow, pressures, temperatures,…)
  → smart meter data is promising, but…
- Next option is an online estimation of customer demand based on measurement data available
- Last **- and only option for prediction -** is to use customer profiles to estimate current and future demand
- Current challenge; different approaches are investigated

30 09.09.2020 / IEA DHC Annex TS3, TS4 Industry Workshop v09 / NI-SK SW//M

Non-technical

- IT Security due to critical infrastructure
- General Data Protection Regulation (Datenschutzgrundverordnung DSGVO)
- Acceptance of new automatic solutions
  - Is it worth it (additional function vs. assumed higher costs)?
  - Is it safe? Who is responsible?...
  - What about my job? Who does all the new work?…
- These non-technical issues are mission critical (change management, transition,…)

31 09.09.2020 / IEA DHC Annex TS3, TS4 Industry Workshop v09 / NI-SK SW//M

Wish list R&D-projects

- Software has to be integrated in existing systems (…maybe not all functions are wanted)
- Same data base for GIS and network models (bidirectional interfaces, versioning, planning, variants,…)
- Highly performant software even for medium to large grids (special applications leakage localisation and customer estimation)
- Open software and common data standards
- Software which allows including new/own applications

→ this is somewhat different to out-of-the-box solutions

Operational needs

- System requirements as low as possible
- Systems as simple as possible
  → fault clearance
- How many resources and what skills for operation?
- Adjustment to changes
  - network expansion/removal
  - new/lost customer
  - customer behaviour
  - DHC controls

→ auto-adjustment possible?

32 09.09.2020 / IEA DHC Annex TS3, TS4 Industry Workshop v09 / NI-SK SW//M

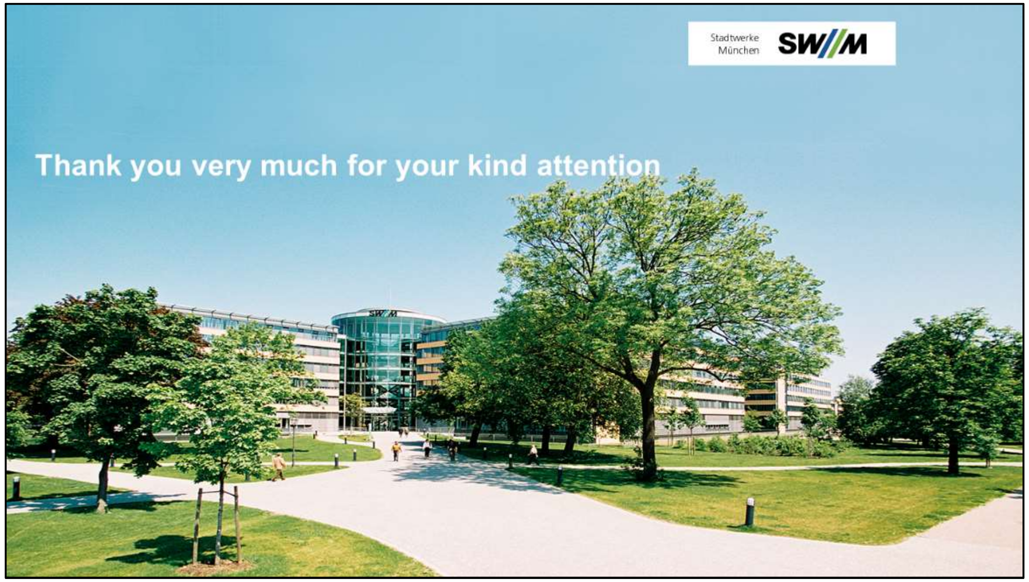
Conclusion and Outlook

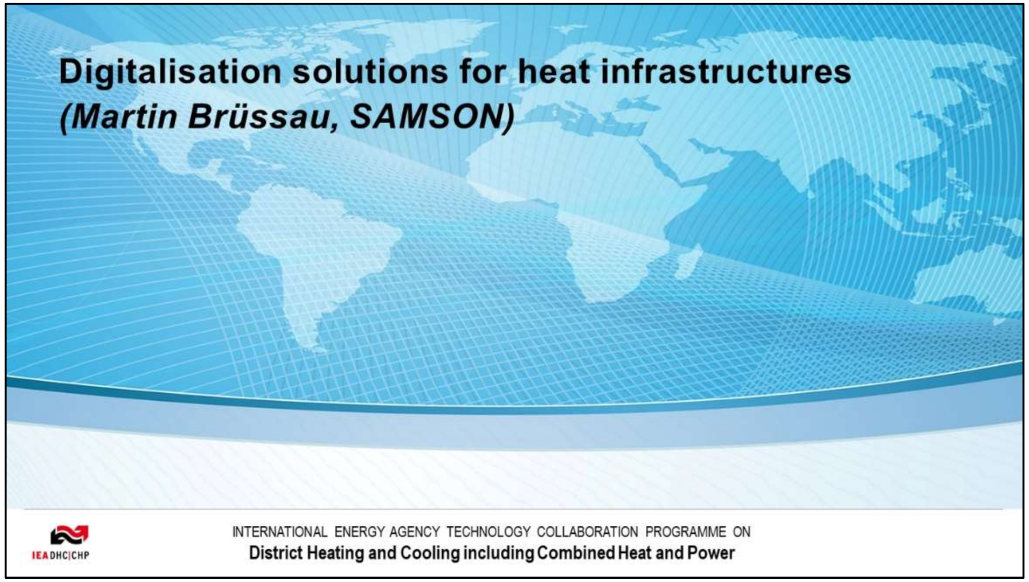
Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

- With leakage localisation and integration of geothermal heat two challenging applications have been presented
- There is research and development work needed for both applications – funding is gratefully acknowledged
- Challenges
  - Process data – Current system fulfil operational needs. Upgrading is technically possible.
  - Accurate network models → Effort depends strongly on the available skills and data base
  - Knowledge about customer behaviour → lack of information
  - Non-technical (IT Security, Data Protection, acceptance…)
- Wish list for R&D-projects ←→ operational needs

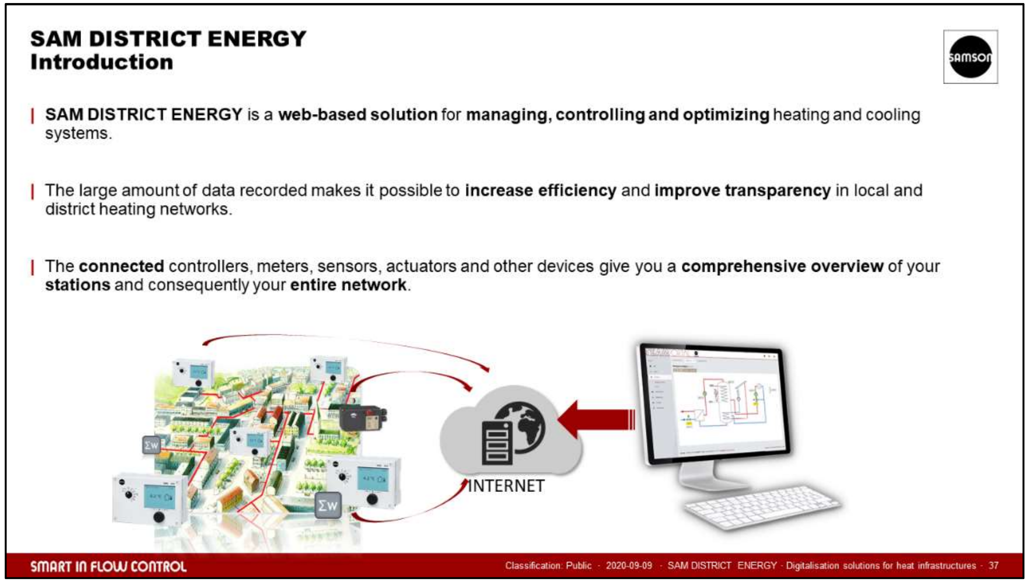
- We work on getting more information about our customers and are interested in customer load prediction
- Leakage localisation – One of three approaches is already used to evaluate measured data. Questions arise: Are approaches sufficient? How do they perform with measured data? What noise level do we have in practical? Do we need to improve algorithms or can we reduce noise?
- Integration of geothermal energy – First approach is defined; work in progress. Interested in other ideas.

33 09.09.2020 / IEA DHC Annex TS3, TS4 Industry Workshop v09 / NI-SK SW//M


Stadtwerke München SW//M
Thank you very much for your kind attention


Digitalisation solutions for heat infrastructures
(Martin Brüssau, SAMSON)
IEA DHC|CHP
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power


SAMSON
SAM DISTRICT ENERGY
Digitalisation solutions for heat infrastructures
SAM DIGITAL
SMART IN FLOW CONTROL
Classification: Public · 2020-09-09 · SAM DISTRICT ENERGY · Digitalisation solutions for heat infrastructures · 36

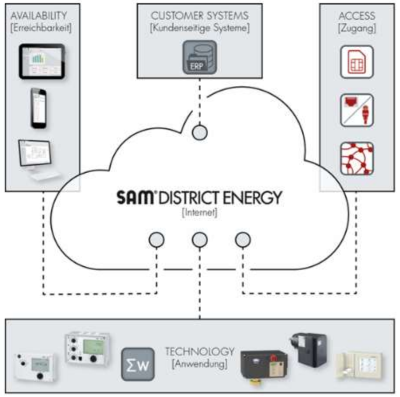

SAM DISTRICT ENERGY
Introduction
SAMSON
SAM DISTRICT ENERGY is a web-based solution for managing, controlling and optimizing heating and cooling systems.
The large amount of data recorded makes it possible to increase efficiency and improve transparency in local and district heating networks.
The connected controllers, meters, sensors, actuators and other devices give you a comprehensive overview of your stations and consequently your entire network.
INTERNET
SMART IN FLOW CONTROL
Classification: Public · 2020-09-09 · SAM DISTRICT ENERGY · Digitalisation solutions for heat infrastructures · 37


SAMSON
SAM DISTRICT ENERGY
Application
SAM DIGITAL
SAM DISTRICT ENERGY
SMART IN FLOW CONTROL
Classification: Public · 2020-09-09 · SAM DISTRICT ENERGY · Digitalisation solutions for heat infrastructures · 38

Structure

- Flexible connection over SAM-LAN, SAM MOBILE or SAM HOME
- Overview of stations and networks by connecting controllers, meters, actuators, differential pressure data and pumps

- Interfaces to customers' servers
- Worldwide access over personal accounts
- Responsive website design



Heat map

Visual analysis of the district heating network through relative **color coding of temperatures and pressures on a map** (heat map)

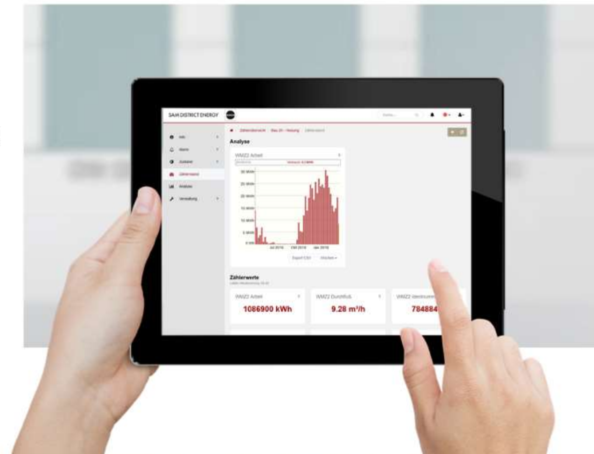
- **Dynamic detection of a network's point of worst efficiency**
- Show or hide stations according to dependencies
- Show values on a map
- Integration of **network route plans** on a map
- Overview of system status on a geographical map
- Interaction on a map

Sensor sharing and cross communication

- Exchange data between sensors
- No need to install outdoor sensors
- Control based on differential pressures and valve positions
- Easy to switch feed pumps
- Exchange data on external demand
- **Network pump control**

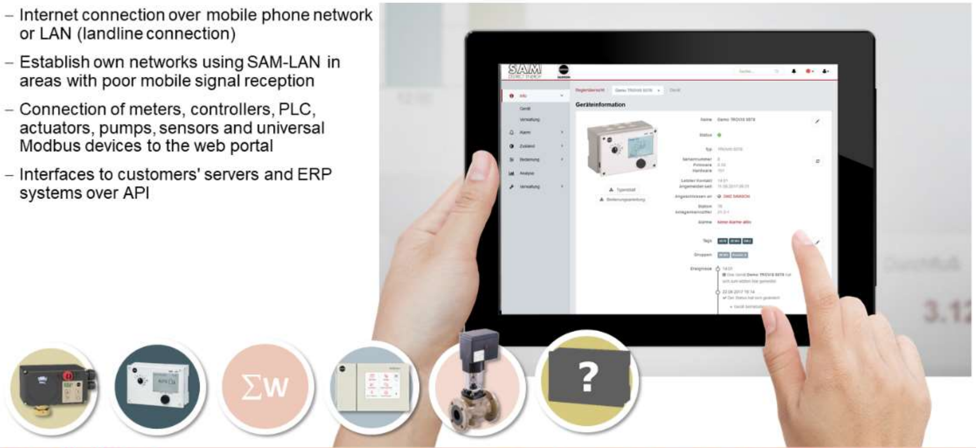
Reading data from meters

- Data export for billing
- **Network analysis** based on primary flow and return flow temperature
- Controller behavior with associated meter data for troubleshooting



Flexible connection

- Internet connection over mobile phone network or LAN (landline connection)
- Establish own networks using SAM-LAN in areas with poor mobile signal reception
- Connection of meters, controllers, PLC, actuators, pumps, sensors and universal Modbus devices to the web portal
- Interfaces to customers' servers and ERP systems over API



SMART IN FLOW CONTROL Classification: Public · 2020-09-09 · SAM DISTRICT ENERGY · Digitalisation solutions for heat infrastructures · 43

SAM® MOBILE

Wireless communication

SAM® DIGITAL
SAM DISTRICT ENERGY

SMART IN FLOW CONTROL Classification: Public · 2020-09-09 · SAM DISTRICT ENERGY · Digitalisation solutions for heat infrastructures · 44

SAM MOBILE GATEWAY

Basic functions

- Wireless connection using integrated modem
- Controller, actuator or Modbus universal device can be connected over Modbus

SMART IN FLOW CONTROL Classification: Public · 2020-09-09 · SAM DISTRICT ENERGY · Digitalisation solutions for heat infrastructures · 45

Summary of the added value

SMART IN FLOW CONTROL Classification: Public · 2020-09-09 · SAM DISTRICT ENERGY · Digitalisation solutions for heat infrastructures · 46

Added value

Impact on network control

- Analysis of water flow times and routes by tracking large changes in temperature
  Objective: model-based hydronic balancing
  Impact on changes to the network structure (create or connect meshes)
  Avoid extending networks through analysis
- Analysis of flow rates and energy along a pipeline section or area
  Objective: to record heat load simultaneity and identify reserves in hydronic networks
- Analysis of individual systems in poorly balanced zones
- Better utilization of network pumps through the use of additional, more flexible pressure sensors
- Control valves in network sections by transmitting pressure data

SAMSON AT A GLANCE

STAFF

- Worldwide 4,300
- Europe 3,300
- Asia 500
- Americas 200
- Frankfurt am Main, Germany 1,800

SALES SITES

- More than 50 subsidiaries in over 40 countries
- More than 200 representatives

MARKETS

- Chemicals and petrochemicals
- Power and energy
- District heating and cooling, building automation
- General industry
- Industrial gases
- Food and beverages
- Metallurgy and mining
- Oil and gas
- Pharmaceuticals and biotechnology
- Marine equipment
- Water and wastewater
- Pulp and paper

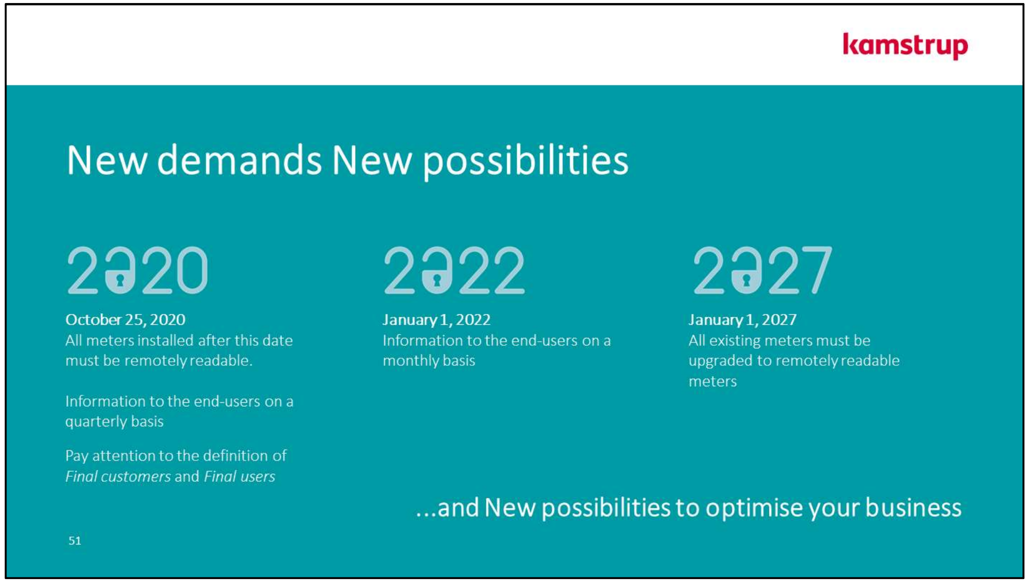
PRODUCTION SITES

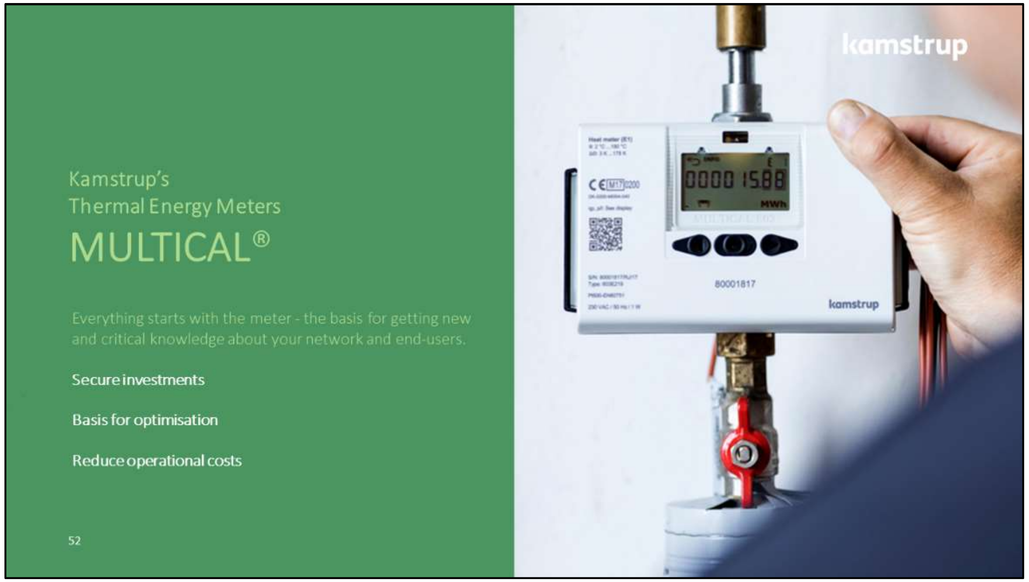
- SAMSON Germany, Frankfurt
- SAMSON France, Lyon
- SAMSON Turkey, Istanbul
- SAMSON USA, Baytown, TX
- SAMSON China, Beijing
- SAMSON India, Pune district
- SAMSON Russia, Rostov-on-Don
- SAMSON AIR TORQUE, Bergamo, Italy
- SAMSON CERA SYSTEM, Hermsdorf, Germany
- SAMSON KT-ELEKTRONIK, Berlin, Germany
- SAMSON LEUSCH, Neuss, Germany
- SAMSON PFEIFFER, Kempen, Germany
- SAMSON RINGO, Zaragoza, Spain
- SAMSON SED, Bad Rappenau, Germany
- SAMSON STARLINE, Bergamo, Italy
- SAMSON VDH PRODUCTS, the Netherlands
- SAMSON VETEC, Speyer, Germany

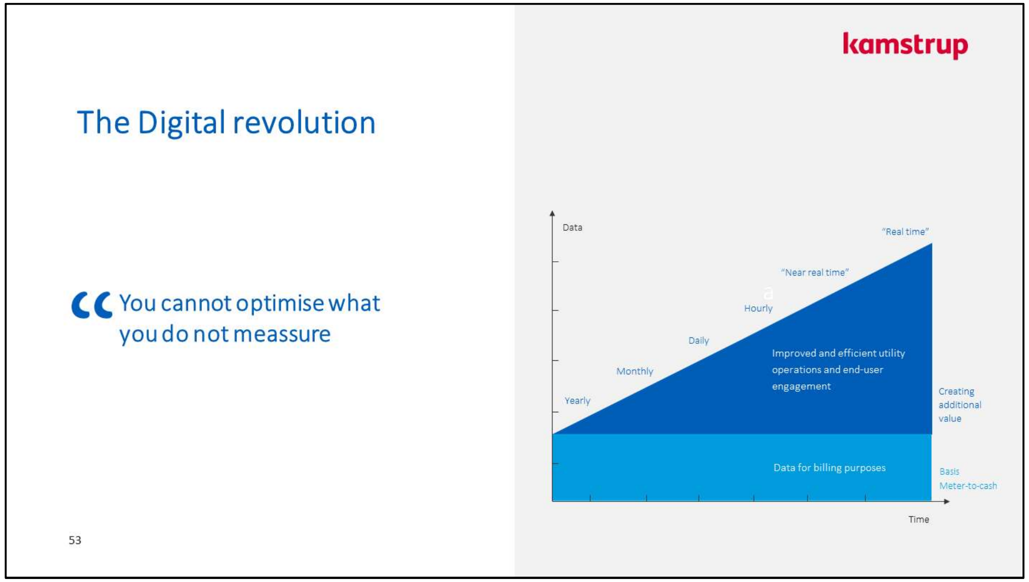
SAMSON AKTIENGESELLSCHAFT
60314 Frankfurt am Main, Germany
Internet: www.samson.de

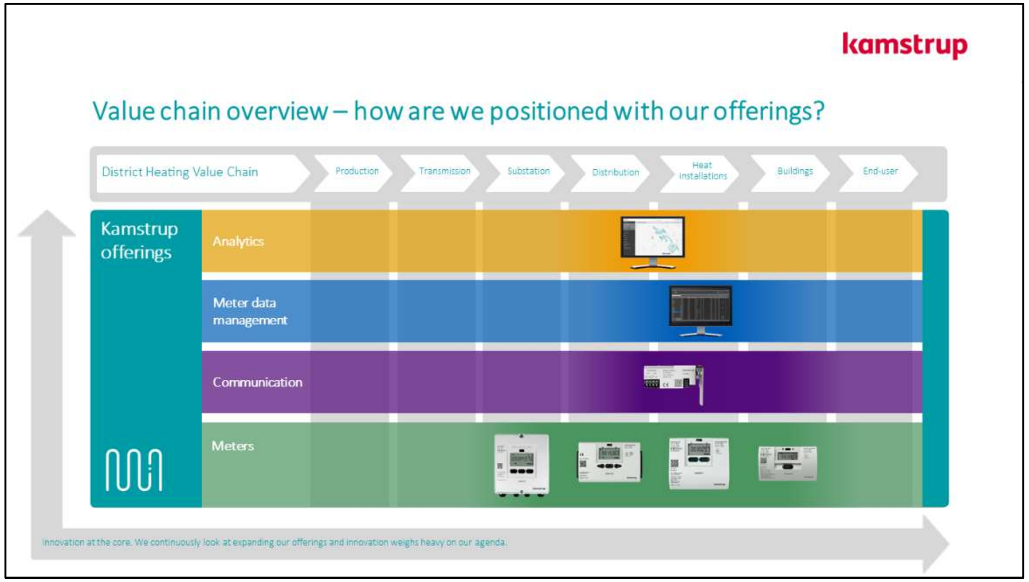

Business opportunities from digitalisation (Steen Schelle Jensen, KAMSTRUP)
IEA DHC|CHP
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

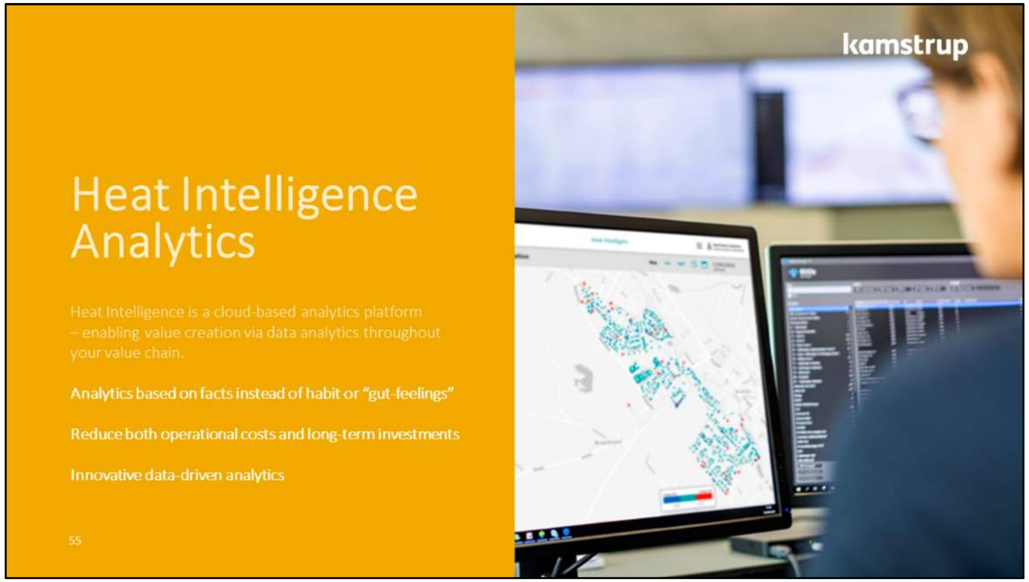

kamstrup
Business Opportunities for Digitalisation
Wednesday September 9, 2020
Steen Schelle Jensen
Head of Business Development

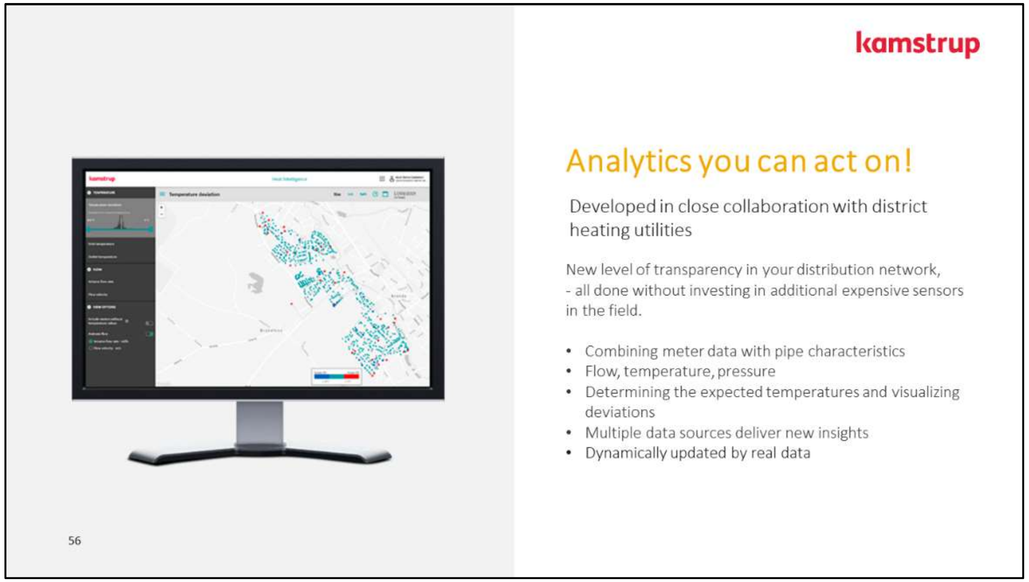

kamstrup
New demands New possibilities
2020
October 25, 2020
All meters installed after this date must be remotely readable.
Information to the end-users on a quarterly basis
Pay attention to the definition of Final customers and Final users
2022
January 1, 2022
Information to the end-users on a monthly basis
2027
January 1, 2027
All existing meters must be upgraded to remotely readable meters
...and New possibilities to optimise your business
51


kamstrup
Kamstrup's
Thermal Energy Meters
MULTICAL®
Everything starts with the meter - the basis for getting new and critical knowledge about your network and end-users.
Secure investments
Basis for optimisation
Reduce operational costs
52

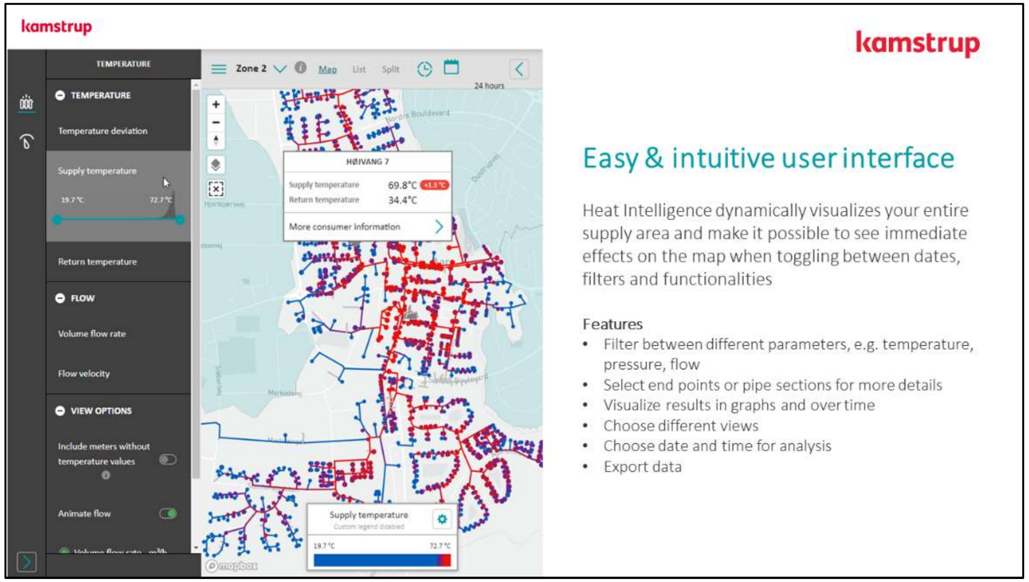

kamstrup
The Digital revolution
You cannot optimise what you do not meassure
Data
"Real time"
"Near real time"
Hourly
Daily
Monthly
Yearly
Improved and efficient utility operations and end-user engagement
Creating additional value
Data for billing purposes
Basis Meter-to-cash
Time
53

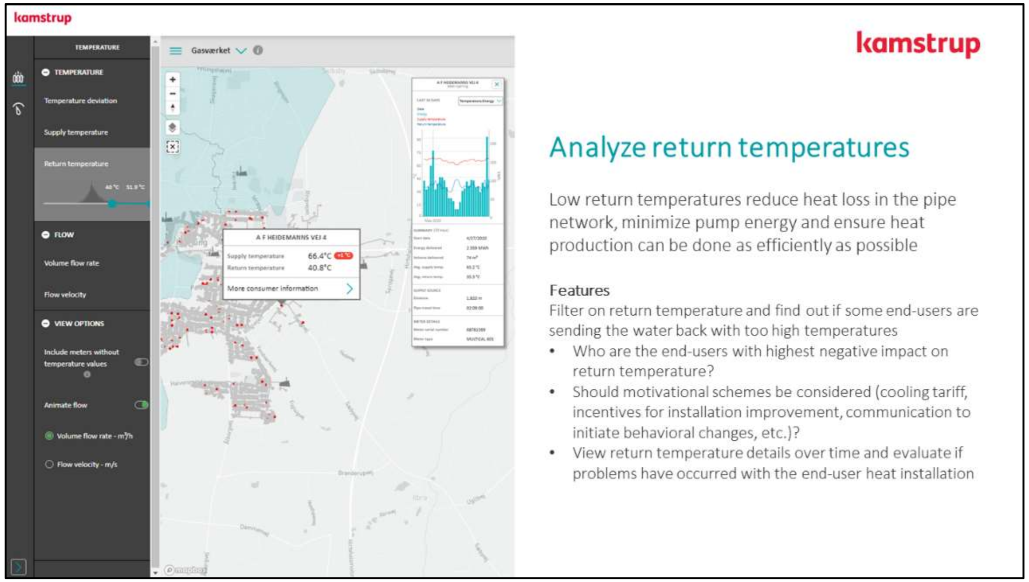

kamstrup
Value chain overview – how are we positioned with our offerings?
District Heating Value Chain
Production
Transmission
Substation
Distribution
Heat installations
Buildings
End-user
Kamstrup offerings
Analytics
Meter data management
Communication
Meters
Innovation at the core. We continuously look at expanding our offerings and innovation weighs heavy on our agenda.

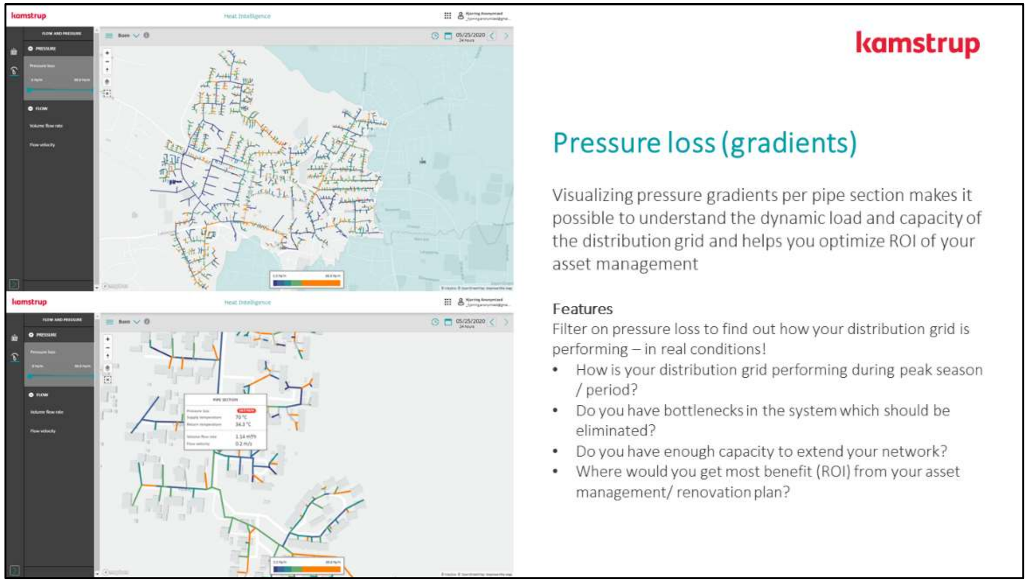

kamstrup
Heat Intelligence Analytics
Heat Intelligence is a cloud-based analytics platform – enabling value creation via data analytics throughout your value chain.
Analytics based on facts instead of habit or "gut-feelings"
Reduce both operational costs and long-term investments
Innovative data-driven analytics
55

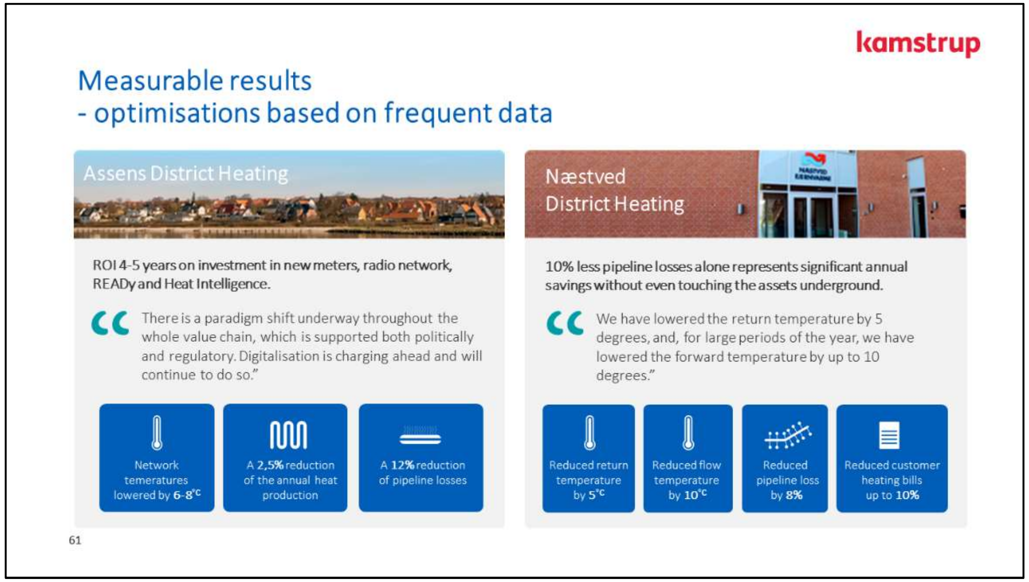

kamstrup
Analytics you can act on!
Developed in close collaboration with district heating utilities
New level of transparency in your distribution network,
- all done without investing in additional expensive sensors in the field.
• Combining meter data with pipe characteristics
• Flow, temperature, pressure
• Determining the expected temperatures and visualizing deviations
• Multiple data sources deliver new insights
• Dynamically updated by real data
56

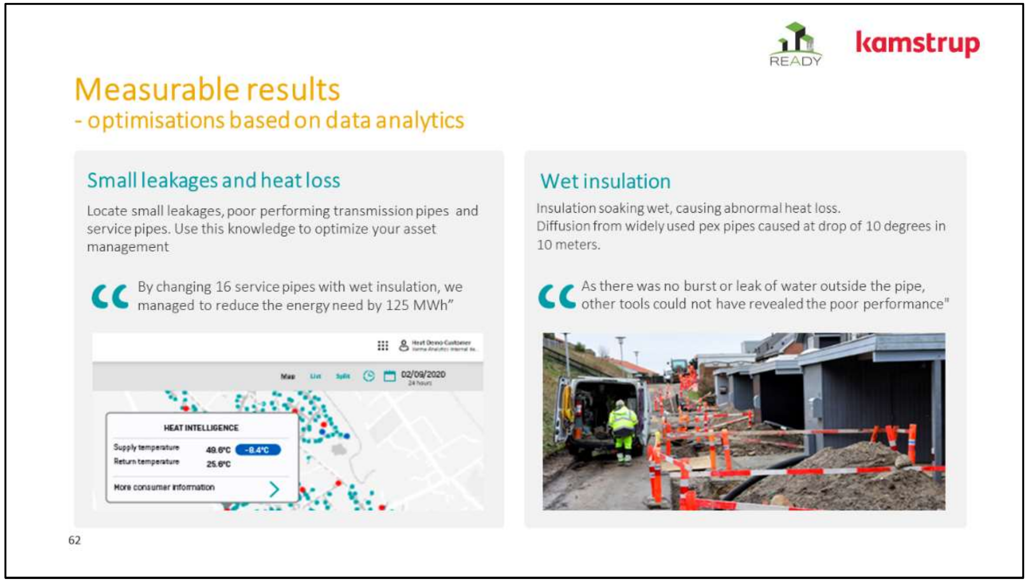

kamstrup
Data-driven asset management for maximum impact
• Operate closer to the limits while documenting your quality of delivery
• Locate high heat losses and find small and large leakages
• Find bypasses and analyse the impact of these on the system performance
• Monitor load and capacity and identify what stresses your network
Save energy
• Reduced heat loss
• Minimised pump operation
• More efficient production
Improved cost-efficiency and happy customers!
We ensure you get off to a hassle-free start for maximum value creation.
57
Digitalisation provides transparency and reduces losses

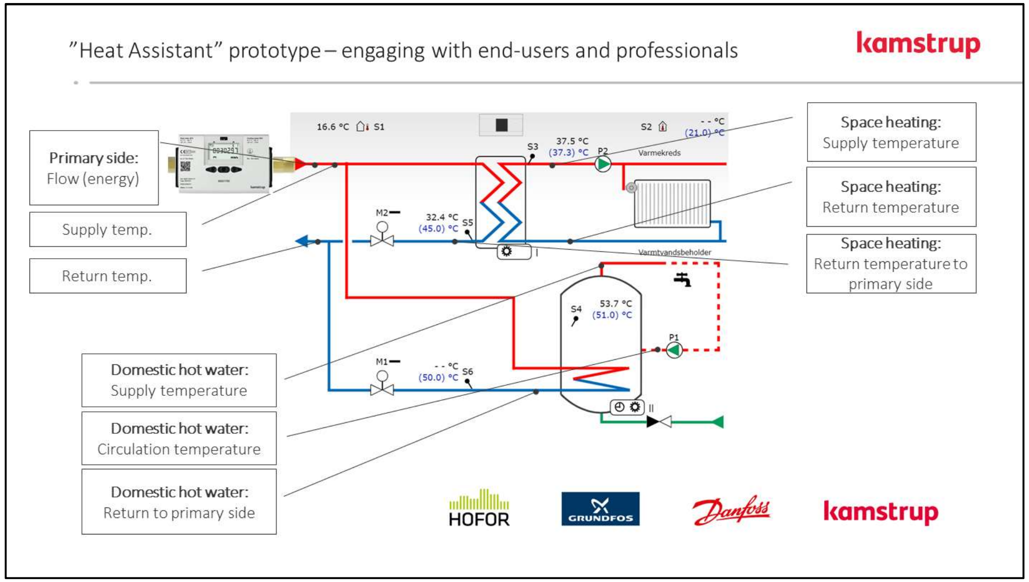

kamstrup
Easy & intuitive user interface
Heat Intelligence dynamically visualizes your entire supply area and make it possible to see immediate effects on the map when toggling between dates, filters and functionalities
Features
• Filter between different parameters, e.g. temperature, pressure, flow
• Select end points or pipe sections for more details
• Visualize results in graphs and over time
• Choose different views
• Choose date and time for analysis
• Export data

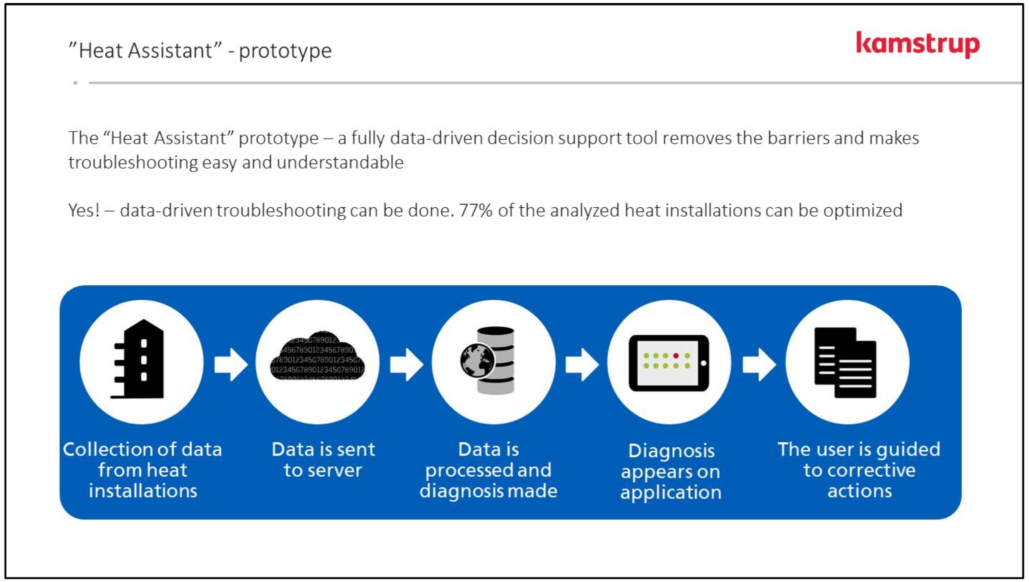

kamstrup
Analyze return temperatures
Low return temperatures reduce heat loss in the pipe network, minimize pump energy and ensure heat production can be done as efficiently as possible
Features
Filter on return temperature and find out if some end-users are sending the water back with too high temperatures
• Who are the end-users with highest negative impact on return temperature?
• Should motivational schemes be considered (cooling tariff, incentives for installation improvement, communication to initiate behavioral changes, etc.)?
• View return temperature details over time and evaluate if problems have occurred with the end-user heat installation


kamstrup
Pressure loss (gradients)
Visualizing pressure gradients per pipe section makes it possible to understand the dynamic load and capacity of the distribution grid and helps you optimize ROI of your asset management
Features
Filter on pressure loss to find out how your distribution grid is performing – in real conditions!
• How is your distribution grid performing during peak season / period?
• Do you have bottlenecks in the system which should be eliminated?
• Do you have enough capacity to extend your network?
• Where would you get most benefit (ROI) from your asset management/ renovation plan?

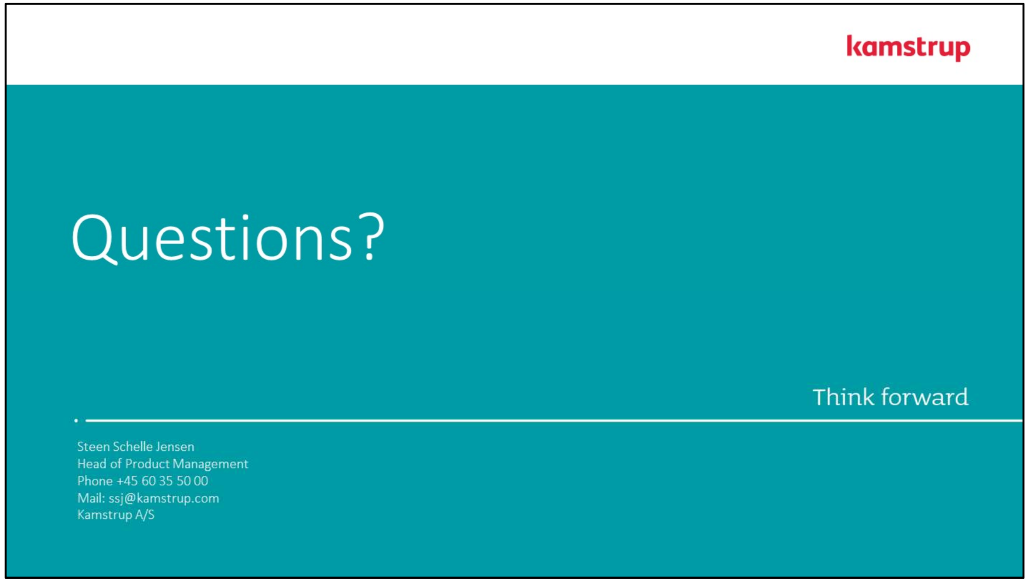


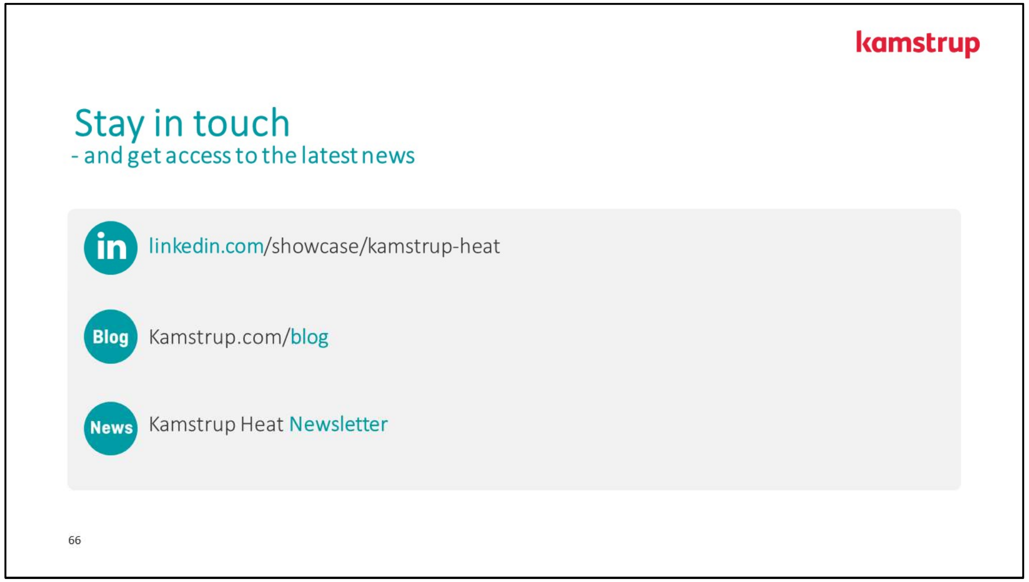


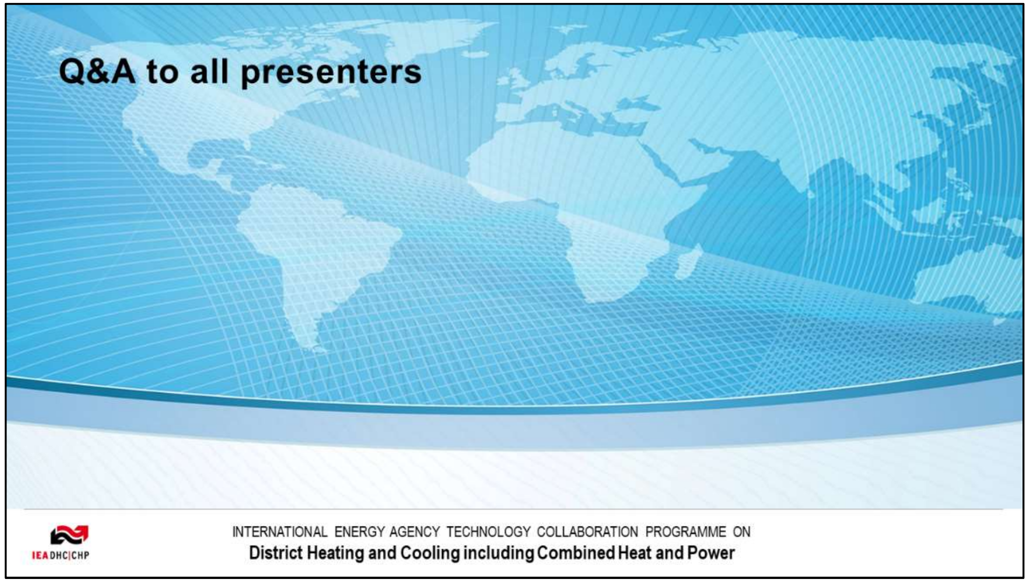




Presentation 9:
S.S. Jensen: Business opportunities from digitalisation


kamstrup
Questions?
Think forward
Steen Schelle Jensen
Head of Product Management
Phone +45 60 35 50 00
Mail: ssj@kamstrup.com
Kamstrup A/S


kamstrup
Stay in touch
- and get access to the latest news
in
linkedin.com/showcase/kamstrup-heat
Blog
Kamstrup.com/blog
News
Kamstrup Heat Newsletter
66


Q&A to all presenters
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power
IEA DHC|CHP


Summary and next steps
• We will make the recording of the webinar available on the IEA DHC YouTube channel https://www.youtube.com/channel/UCuYcqLjJi8thrUJCjzLBaow and send out the presentation slides
• If you want to join the IEA DHC Annex TS3 or TS4, please contact
▪ Ralf-Roman Schmidt, ralf-roman.schmidt@ait.ac.at (leader TS3)
▪ Dietrich Schmidt, dietrich.schmidt@iee.fraunhofer.de (leader TS4)
▪ AND: contact your national IEA DHC representative for funding opportunities https://www.iea-dhc.org/home/
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power
68
IEA DHC|CHP


Group photo - please smile
+ many others without webcam
(in total about 80 participants)
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power
IEA DHC|CHP


Thank you for your attention!
Webinar Digitalization for optimizing integrated district heating systems - Block II
9. September 2020
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/
http://www.iea-dhc.org/the-research/annexes/2017-2020-annex-ts3-draft.html
Fraunhofer
IEE
AIT
TOMORROW TODAY
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power
IEA DHC|CHP

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

9. September 2020

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

Fraunhofer IEE
AIT AUSTRIAN INSTITUTE OF TECHNOLOGY TOMORROW TODAY

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

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)

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

2

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

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

3

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)
	Technologies for Hybridisation (Oddgeir Gudmundsson, Danfoss)
	GIS-based automated design of DH networks (Joseph Jebamalai, Comsof)
	Sector coupling between hydrogen and district heating (Hans Böhm, EI Linz)
	Interactive session and Q&A to all presenters
17:00	**End of Block III**

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

4

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

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

IEA DHC Annex TS3: Hybrid Energy Networks - District Heating and Cooling Networks in an Integrated Energy System Context

Introduction into international DHC Annex TS3

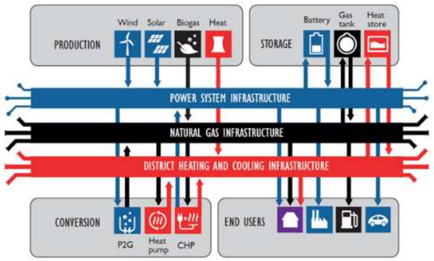
Ralf-Roman Schmidt
AIT, Austria

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY TOMORROW TODAY

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

IEA DHC Annex TS3: Background

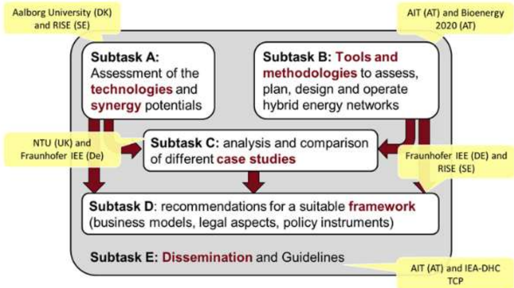
- The integration of the electricity/ gas grids and heating/ cooling networks is considered as one of the key measures for decarbonizing the energy system (aka "sector coupling"). This
  - triggers important **synergies**, that couldn't be realised by optimizing the sectors individually.
  - is connected to several **challenges**, such as an increasing competition between the energy domains and a higher complexity.



INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power 7

IEA DHC Annex TS3: aim and structure

- **Aim**: to promote the opportunities and to overcome the challenges for DHC networks in an integrated energy system context. The Annex
  - provides a holistic approach for assessing, planning and operation,
  - considers technical aspects (system configuration, operational strategy) and strategic aspects (business model, regulatory frame).

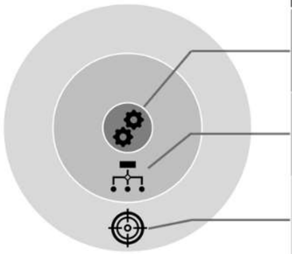


INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power 8

IEA DHC Annex TS3: sector coupling technologies

- **Electric boilers (eBs)**
  - transform electricity into heat (low invest. costs, high temperatures and fast gradients).
  - can be economically viable at very few operating hours (compared to HPs).
- **Power-to-heat and cold (PtH/C) technologies (heat pumps, HPs)**
  - use electricity to move heat from a cool space to a warm space (high conversion efficiency)
  - high dependency of the efficiency on the temperature lift between heat sink and source
  - enable the use of cost-efficient and high capacity thermal storage (high load cycles possible)
- **Power-to-gas (PtG) processes (i.e. electrolysis)**
  - uses electricity to transform water into oxygen and hydrogen.
  - If cost-efficient gas storages are available, cost-efficient seasonal storage is possible
  - recovering the associated waste heat in DHC networks increases its efficiency
- **Combined heat and power (CHP) plants**
  - generate high temperature heat for DHC networks and electricity,
  - hydrogen has a limited applicability in existing gas CHPs

IEA DHC Annex TS3: 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

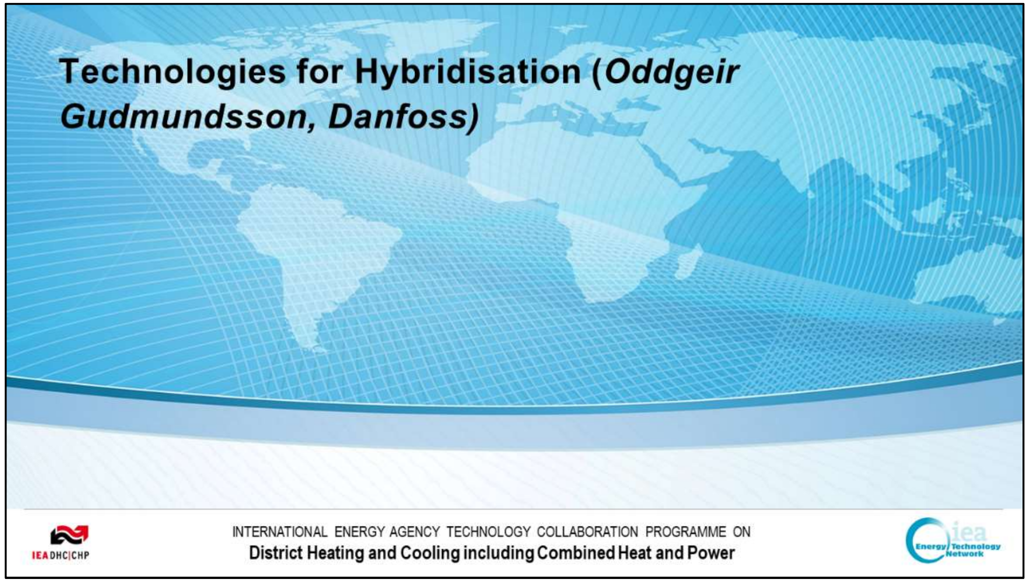
***This classification differs from the 4G DHC networks concept (Lund et. al=)** → the main characteristic of a HEN is the **integration** between the different networks, and not the supply temperature or the time period where the different generations were dominating.

IEA DHC Annex TS3: Schedule and outcomes

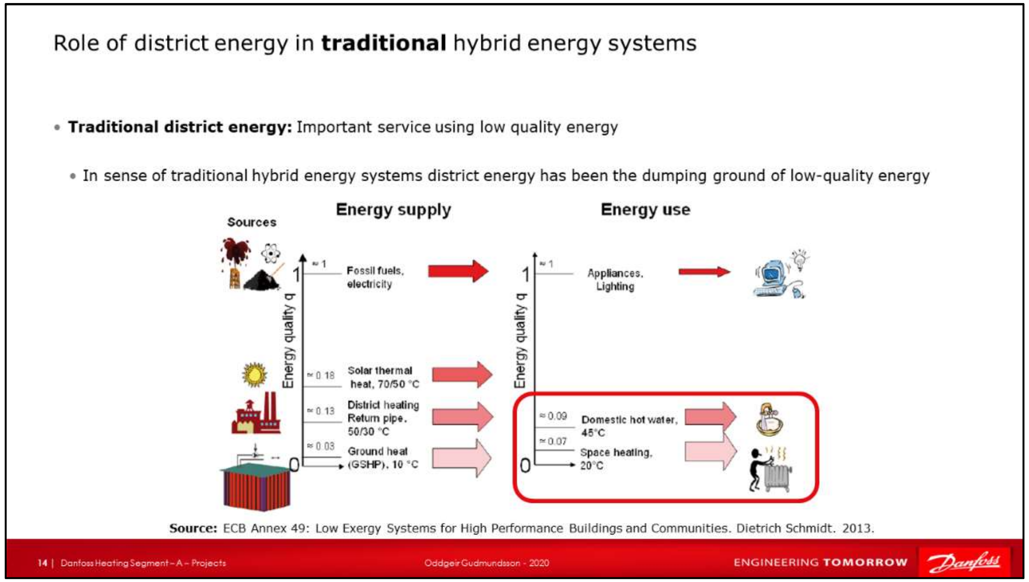
Definition phase	Preparation phase		Working phase					
2017 /Fall	2018 /Spring	2018 /Fall	2019 /Spring	2019 /Fall	2020 /Spring	2020 /Fall	2021 /Spring	2021 /Fall
Austria	Stockholm	Berlin with Industry WS	Stockholm shared WS with ISGAN	France – on invitation by CEA	Online TelCo and public Webinar	Online TelCo and public Webinar	Austria attached to the mission innovation week ?	Denmark – attached to the 4DH / SES conference?

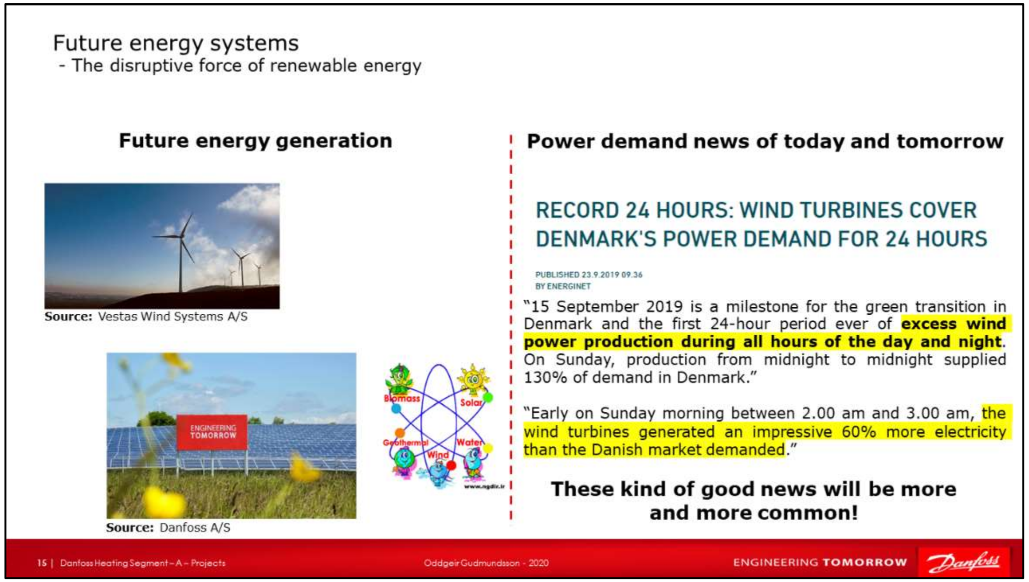
Expected results:

- A **SWOT analyses** of HEN
- An assessment of suitable **technologies** and HEN concepts
- Country reports on national **energy scenarios** (Denmark, Austria ...)
- Collection and assessment of international **case studies**
- A review of existing **methods and tools**
- **Best practice guidelines** and online tutorials for planning, designing and operating HEN
- A report on **exergy as evaluation criteria** for HEN
- Development of new **business models**
- Policy papers and recommendation on **market design and regulations**
- **workshops** with local industries
- **Publications and presentations** on various conferences
- a final **guidebook** summarizing the results
- ...


Technologies for Hybridisation (Oddgeir Gudmundsson, Danfoss)
IEA DHC|CHP
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power
iea Energy Technology Network


ENGINEERING TOMORROW
Danfoss
Energy system coupling technologies
Oddgeir Gudmundsson, Director, Projects


Role of district energy in traditional hybrid energy systems
Traditional district energy: Important service using low quality energy
In sense of traditional hybrid energy systems district energy has been the dumping ground of low-quality energy
Sources
Energy supply
Energy use
Energy quality q
Fossil fuels, electricity
Solar thermal heat, 70/50 °C
District heating Return pipe, 50/30 °C
Ground heat (GSHP), 10 °C
Appliances, Lighting
Domestic hot water, 45°C
Space heating, 20°C
Source: ECB Annex 49: Low Exergy Systems for High Performance Buildings and Communities. Dietrich Schmidt. 2013.
14 | Danfoss Heating Segment – A – Projects
Oddgeir Gudmundsson - 2020
ENGINEERING TOMORROW
Danfoss


Future energy systems
- The disruptive force of renewable energy
Future energy generation
Source: Vestas Wind Systems A/S
Source: Danfoss A/S
Biomass
Solar
Geothermal
Wind
Water
Power demand news of today and tomorrow
RECORD 24 HOURS: WIND TURBINES COVER DENMARK'S POWER DEMAND FOR 24 HOURS
PUBLISHED 23.9.2019 09.36
BY ENERGINET
"15 September 2019 is a milestone for the green transition in Denmark and the first 24-hour period ever of excess wind power production during all hours of the day and night. On Sunday, production from midnight to midnight supplied 130% of demand in Denmark."
"Early on Sunday morning between 2.00 am and 3.00 am, the wind turbines generated an impressive 60% more electricity than the Danish market demanded."
These kind of good news will be more and more common!
15 | Danfoss Heating Segment – A – Projects
Oddgeir Gudmundsson - 2020
ENGINEERING TOMORROW
Danfoss

Technologies to capture and enable maximum usage of excess energy generation

- There are many technologies and solutions available:
  - Batteries
  - District energy systems
  - Heat pumps
  - Thermal storages
  - Load shifting enabling software
  - Power to synthetic fuels
  - Direct electricity to power heaters
  - … and many others

Recap

"15 September 2019 is a milestone for the green transition in Denmark and the **first 24-hour period ever of excess wind power production** during all hours of the day and night. On Sunday, production from midnight to midnight supplied 130% of demand in Denmark."

"Early on Sunday morning between 2.00 am and 3.00 am, **the wind turbines generated an impressive 60% more electricity than the Danish market demanded**."

- Different technologies have different benefits and abilities to capture the excess energy being generated at a given time
- In the scope of hybrid energy systems:
  → We are interested in the excess energy that cannot be cost efficiently stored within the same energy system it was generated

Role of district energy in **future** hybrid energy systems

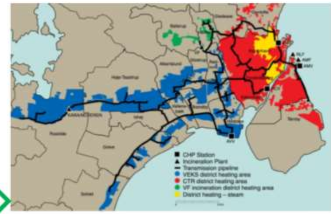
- With decarbonization and focus on energy efficiency district energy is becoming the rising shining star and enabler of cost efficient future renewable based energy systems
  - In combination with thermal storages there is practically no limit on how much excess generated renewable power the systems can absorb
  - It can ramp capacity utilization up/down very fast → Balancing services

Future energy generation

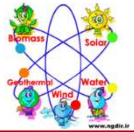

Source: Danfoss A/S


Source: Vestas Wind Systems A/S

Excess


Source: The District Heating System in Greater Copenhagen Area - in a free power market. Varmelast.dk


Source: Aarhus Vand A/S

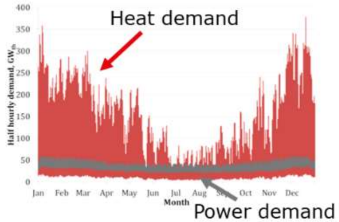


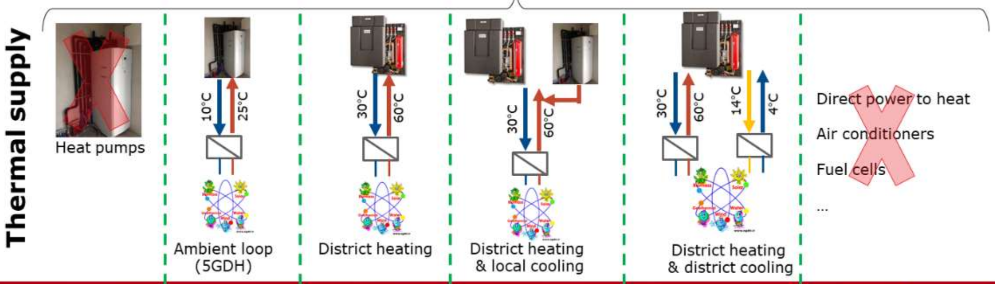

Source: Ramboll A/S

Which thermal supply system?

Thermal demand


This Photo by Unknown Author is licensed under CC BY-SA



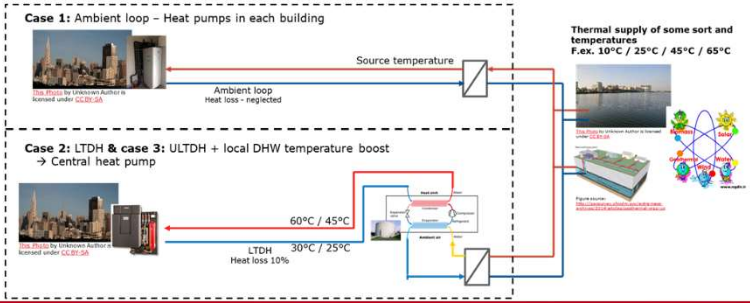


Different thermal supply methods have different benefits and limitations

- Communities need to do a heat planning for the future
  - During heat supply planning solutions should be evaluate on a range of metrics:
  - **Economics**
    - What is the lifecycle cost of the thermal supply?
  - **Energy supply security**
    - What if the future develops differently than we expect?
  - **Flexibility**
    - How flexible is the thermal supply to the expected "fuel" input?
  - **Robustness**
    - Is the supply system able to operate in case of unexpected beating?
  - **Reliability**
    - How frequently does the thermal supply fail to meet the demands?
  - **Resilience**
    - How quickly can the supply system recover from a disruption? (climate related, terror/cyber attacks, …)

District energy is simple as well as complex - Economic example

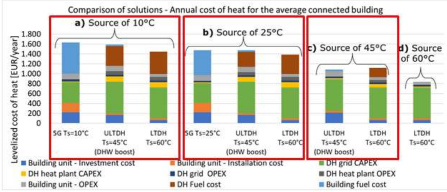
- **District energy is simple:** It distributes heat to buildings or extracts heat from buildings
- **District energy is complex:** It has many stakeholders and has market specific conditions
  - Cost of establishing district energy systems in established district energy countries is "cheap" compared to some new markets



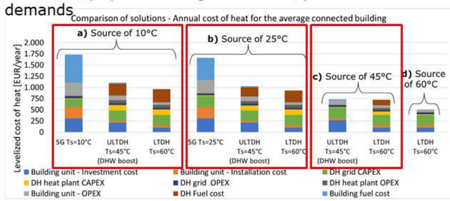
Comparing economics of different solutions for a heat supply in the United Kingdom and Denmark

- The comparison is based on a levelized cost of heating, all main costs inclusive..
  … **Except** the development of the heat source!

United Kingdom
–11,4 MWh/y space heating and 2 MWh/y DHW demands



Denmark
– 15 MWh/y space heating and 2 MWh/y DHW demands



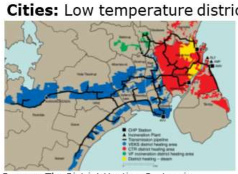
- The conclusion is that knowledge and experience is the king and queen!
  - New markets need to take advantage of the experience acquired in the established markets

Source: Paper to be published in the Smart Energy Systems conference in Aalborg, October 2020.

Different thermal supply methods have different benefits and limitations

- Communities need to do a heat planning for the future
  - During heat supply planning solutions should be evaluate on a range of metrics:
- **Economics**
  - What is the lifecycle cost of the thermal supply?
- **Energy supply security**
  - What if the future develops differently than we expect?
- **Flexibility**
  - How flexible is the thermal supply to the expected "fuel" input?
- **Robustness**
  - Is the supply system able to operate in case of unexpected beating?
- **Reliability**
  - How frequently does the thermal supply fail to meet the demands?
- **Resilience**
  - How quickly can the supply system recover from a disruption? (climate related, terror/cyber attacks, …)

Cities: Low temperature district heating



Source: The District Heating System in Greater Copenhagen Area - in a free power market. Varmelast.dk

Rural areas: Winner for most metrics is:

Heat pumps

Denmark actively takes advantage of district energy to support the future green and sustainable energy system

- The municipality of Aalborg, Denmark, plans to build 1.000.000 m³ thermal storage to enable maximum energy flexibility to:
  - Support renewable power generation,
  - Balance local power plants,
  - Store industrial waste heat and
  - Surplus heat from local waste incineration.
- The thermal storage will provide the ultimate flexibility to the district heating system supplying 98% of Aalborg city building heating demand.

Aalborg får et af verdens største energilagre

Aalborg Forsyning planlægger at bygge verdens største damvarmelager i Aalborg.

Læs også: Ny leverandør af energianlæg høster små og store ordrer på stribe

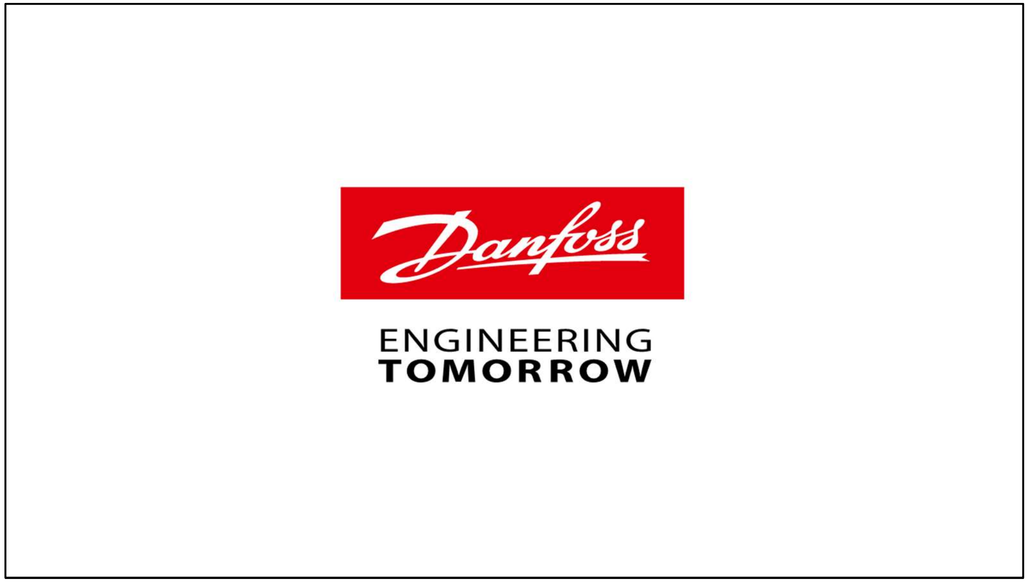
- I Aalborg har vi sat os for at spille en afgørende rolle for den grønne omstilling. Vi ser frem til at kunne optimere vores udnyttelse af de vedvarende energikilder med det nye damvarmelager og give aalborggenserne et endnu grønnere produkt, siger vicedirektør for Aalborg Forsyning, Jesper Høstgaard-Jensen.

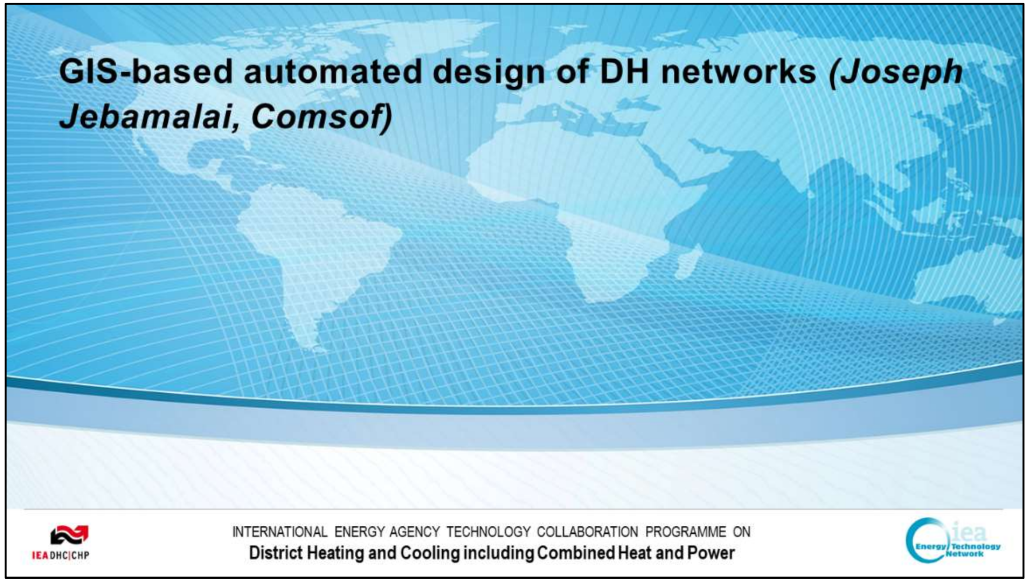
Efter nedlukningen af Nordjyllandsværket skal damvarmelagerne hjælpe med at opsamle overskudsproduktion fra vindmøller og andre vedvarende energikilder.
Visualisering: Rambøll

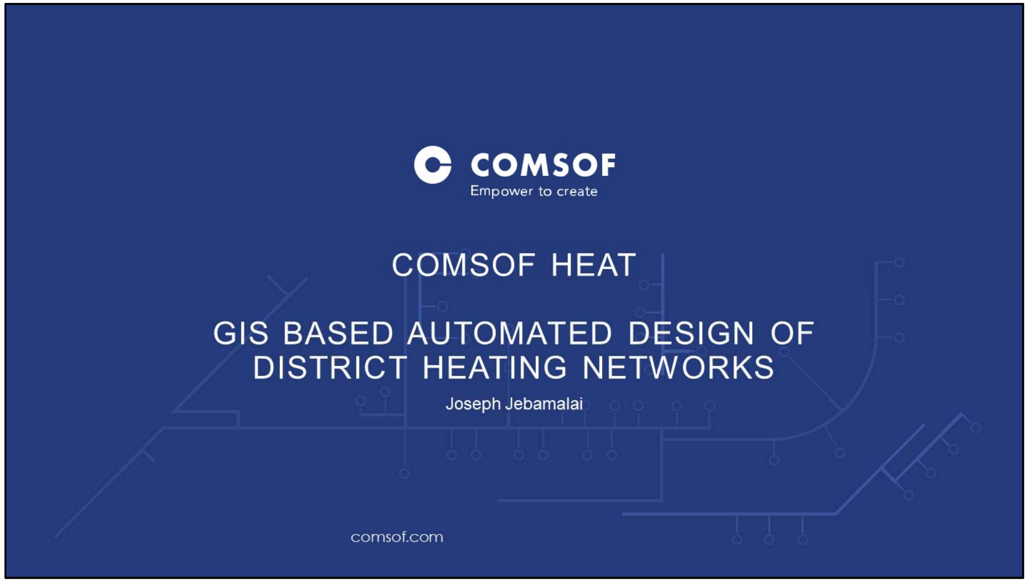
Af Maria Berg Badsbøe Pedersen
3. september 2020 09:04

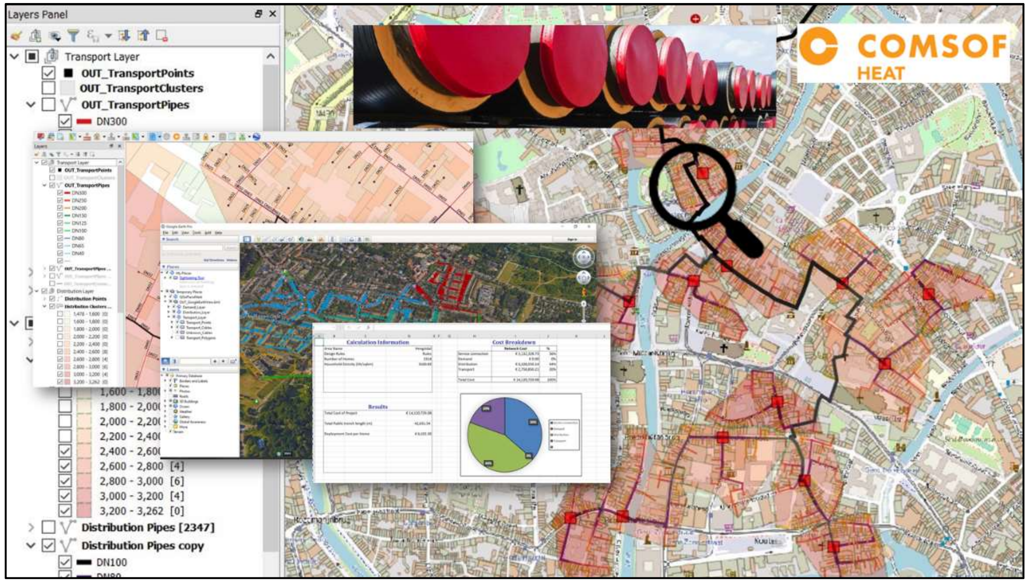
https://www.energy-supply.dk/article/view/737536/aalborg_far_et_af_verdens_storste_energilagre?ref=newsletter&utm_medium=email&utm_source=newsletter&utm_campaign=daily


Thank you for your attention
Contact information:
Dr. Oddgeir Gudmundsson
Director, Projects
og@danfoss.com
Linked in www.linkedin.com/in/oddgeirgudmundsson
24 | Danfoss Heating Segment – A – Projects
Oddgeir Gudmundsson - 2020
ENGINEERING TOMORROW
Danfoss

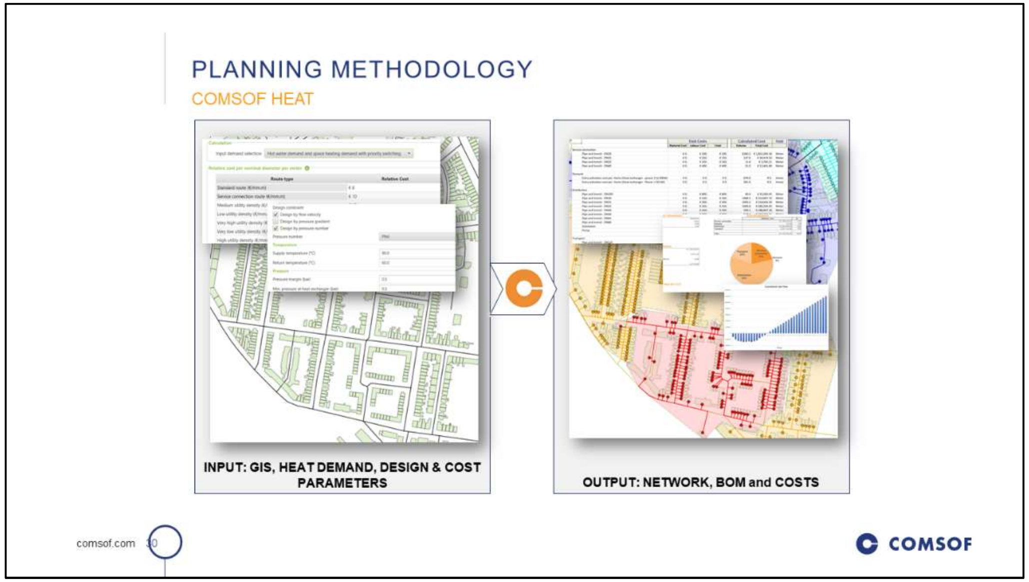

Danfoss
ENGINEERING
TOMORROW

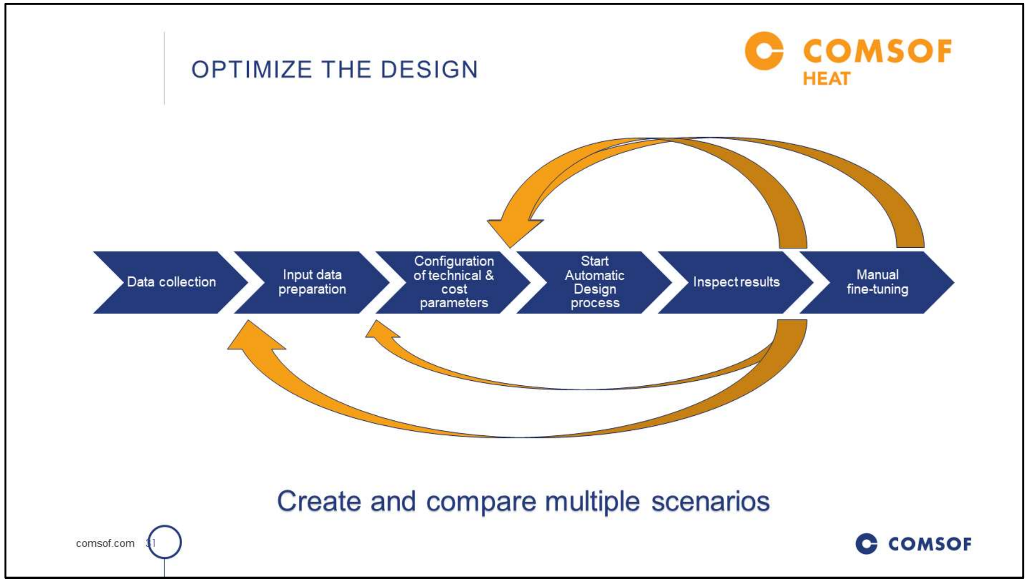

GIS-based automated design of DH networks (Joseph Jebamalai, Comsof)
IEA DHC|CHP
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power
iea Energy Technology Network

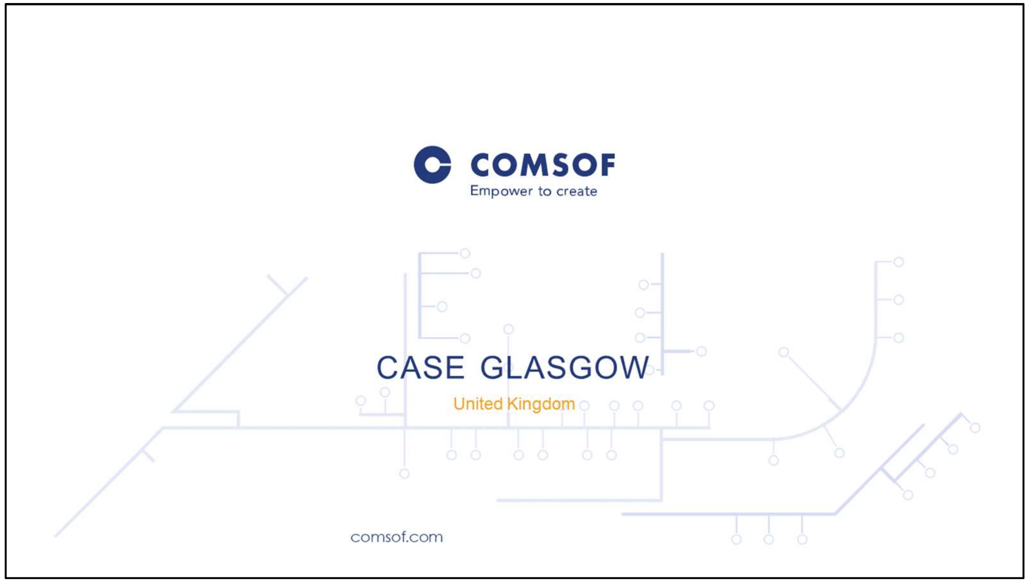

COMSOF
Empower to create
COMSOF HEAT
GIS BASED AUTOMATED DESIGN OF DISTRICT HEATING NETWORKS
Joseph Jebamalai
comsof.com


Layers Panel
Transport Layer
OUT_TransportPoints
OUT_TransportClusters
OUT_TransportPipes
DN300
COMSOF
HEAT
1,800 - 2,000
2,000 - 2,200
2,200 - 2,400
2,400 - 2,600
2,600 - 2,800 [4]
2,800 - 3,000 [6]
3,000 - 3,200 [4]
3,200 - 3,262 [0]
Distribution Pipes [2347]
Distribution Pipes copy
DN100


COMSOF HEAT REFERENCES
ingenium
Nijmegen
GRUNNEGER POWER
fluvius.
hvc.
Royal HaskoningDHV
Enhancing Society Together
Gemeente Rotterdam
KU LEUVEN
FACULTY OF ARCHITECTURE
if
IF Technology Creating energy
WITH COMSOF HEAT YOU CAN HANDLE LARGER PROJECTS. FOR A PROJECT WHERE YOU WOULD NEED THREE MONTHS DESIGN TIME YOU CAN NOW DO THE SAME CALCULATIONS IN A NUMBER OF DAYS, AND WITH MORE DETAIL
rotterdam engineering
WITH THE AUTOMATED GIS-ANALYSIS OF COMSOF HEAT, YOU GET QUICK AND AFFORDABLE INSIGHTS IN NETWORK DESIGN, CAPITAL COST AND MATERIAL NEED. THIS SOFTWARE PROVIDES CONSIDERABLE MORE RELIABLE CAPITAL COST CALCULATIONS THAN MANUAL DESIGNS, FOR ONLY A FRACTION OF THE INVESTED LABOR HOURS
OVER MORGEN
comsof.com
COMSOF


PLANNING METHODOLOGY
COMSOF HEAT
INPUT: GIS, HEAT DEMAND, DESIGN & COST PARAMETERS
OUTPUT: NETWORK, BOM and COSTS
comsof.com
30
COMSOF


OPTIMIZE THE DESIGN
COMSOF HEAT
Data collection
Input data preparation
Configuration of technical & cost parameters
Start Automatic Design process
Inspect results
Manual fine-tuning
Create and compare multiple scenarios
comsof.com
31
COMSOF

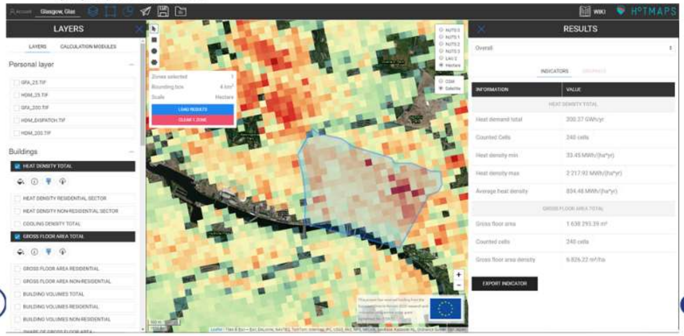

COMSOF
Empower to create
CASE GLASGOW
United Kingdom
comsof.com


GLASGOW PROJECT INFORMATION
District Heating
Project information
Glasgow city centre
Extraction of heat from the river with heat pumps. One or more heat pumps will be used to extract heat from the river and feed the city centre of Glasgow with energy for heating of buildings.
Source locations
comsof.com
33
COMSOF

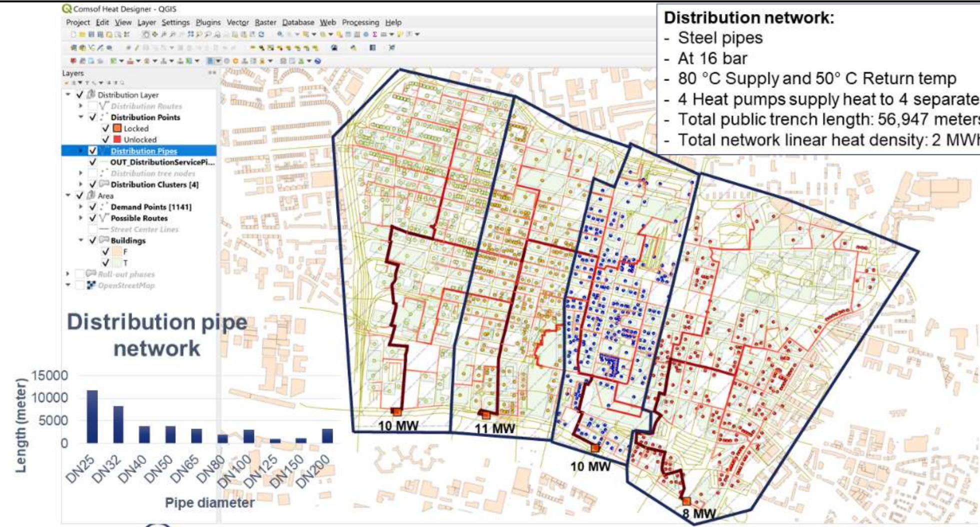
GIS INPUTS AND HEAT DEMAND DATA

Glasgow

- Digitized map of the area
  - In this case from OpenStreet Map data
  - Including street center lines and building polygons
- Heat demand data
  - Heat demand density and gross floor area density has been extracted from the public website (EU Horizon 2020 project) HOTMAPS.EU



comsof.com 34 COMSOF



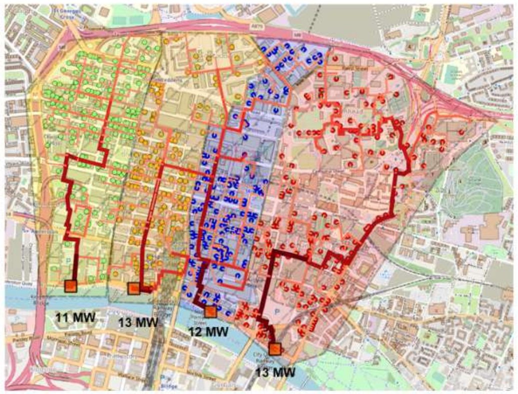
Distribution network:

- Steel pipes
- At 16 bar
- 80 °C Supply and 50° C Return temp
- 4 Heat pumps supply heat to 4 separate clus
- Total public trench length: 56,947 meters
- Total network linear heat density: 2 MWh/m

comsof.com 35 COMSOF

MODIFIED NETWORK DESIGN

Glasgow



comsof.com 36 COMSOF

DEPLOYMENT COST CALCULATION (ASSUMPTIONS)

Glasgow

- Based on sample costs per meter pipe network including
  - Excavation
  - Supply & return pipe
  - Welding & installation costs
  - Refill and repair of top layer
  - Project management overhead
- Heat source cost (Heat pump)
  - 1,600,000 GBP / Megawatt
- Intermediate pump cost – 60,000 GBP / Megawatt
- Heat delivery unit cost

Heat exchangers

Activation Type	Demand Identifier	Lower Bound	Upper Bound	Cost: Material	Cost: Labour
Power		1	50	£2,500.00	£750.00
Power		50	100	£10,000.00	£2,000.00
Power		100	400	£20,000.00	£10,000.00
Power		400	1000	£75,000.00	£150,000.00
Power		1000	∞	£100,000.00	£150,000.00

Activation Type Home Identifier

Tariff

Identifier	Tariff (£/kW)	Connection fee (£/Building)	Monthly fee (£/Home)
<default>	£0.12	£0.00	£15.00

Pipe definitions

Nominal diameter	Cost (£/m) Material cost
DN25	£2,000.00
DN32	£2,000.00
DN40	£2,000.00
DN50	£2,000.00
DN65	£2,000.00
DN80	£2,000.00
DN100	£2,000.00
DN125	£2,000.00
DN150	£2,000.00
DN200	£2,000.00
DN250	£2,000.00
DN300	£2,000.00
DN350	£2,000.00
DN400	£2,000.00
DN450	£2,000.00
DN500	£2,000.00
DN600	£2,000.00
DN700	£2,000.00
DN800	£2,000.00
DN900	£2,000.00
DN1000	£2,000.00

comsof.com 37 COMSOF

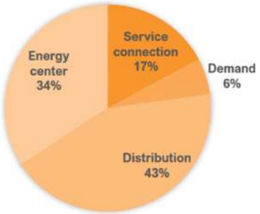
RESULTS – 100% UPTAKE

Glasgow

- Cost breakdown

Results

Total Cost of Project	£252,394,095.39
Total Public trench length (m)	73,674.32
Total Network linear heat density (MWh/m)	1.904
Deployment Cost per Home	£188,213.34



Cost Breakdown

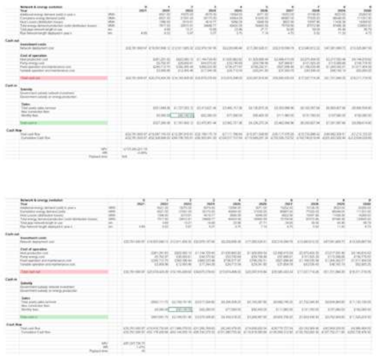
	Network Cost	%
Service connection	£43,419,181.63	17%
Demand	£14,223,250.00	6%
Distribution	£108,498,847.76	43%
Energy center	£86,252,816.00	34%
Total	£252,394,095.39	100%

comsof.com 38 COMSOF

RESULTS WITH 33 GBP AND 15 GBP – COST OF HEAT PRODUCTION

TARIFF – 6p, 8p, 10p, 12p / kWh

33 GBP	NPV	IRR	Payback time
6p	-187,318,676	-3.96	N/A
8p	-137,283,202	-0.49	N/A
10p	-87,247,727	1.47	43
12p	-37,212,252	3	32
15 GBP	**NPV**	**IRR**	**Payback time**
6p	-134,327,755	-0.35	N/A
8p	-84,292,280	1.57	42
10p	-34,256,805	3.08	32
12p	15,778,670	4.4	26



comsof.com 39 COMSOF

COMSOF
Empower to create

CASE KORTRIJK

Multiple sources

comsof.com

CASE STUDY - INPUTS

Selected 2328 buildings and heat source – Kortrijk, Belgium

BUILDING INPUTS:
- Open source street level gas consumption data
  - Mapped street level to building level using building area ratio
- Building types are categorized as
  - Residential
  - Commercial
  - Industrial
- Load factors → Estimation of peak demand

HEAT SOURCE:
- IMOG, waste incineration plant
  - 2 km from the network
  - Incinerate 65,000 tons of municipal waste per year
- Heat pumps → 3 units
- Gas boiler
- Combined heat and power (CHP) plant

Case study area

comsof.com 41 COMSOF

CASE STUDY - INPUTS

Selected 2328 buildings and heat source – Kortrijk, Belgium

HEAT SOURCE ATTRIBUTES:

Source type	Capacity (MW)	Investment cost (€/MW)	Energy production cost (€/MWh)	CO2 released (t per MWh)
Waste incineration	13	-	6	0.6
Heat pump	6	600,000	50	0.075
CHP	2	-	14	0.42
Gas boiler	4	150,000	42	0.5

comsof.com 2 COMSOF

CASE STUDY – NETWORK

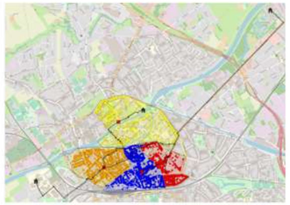
2 - layer network and intermediate results

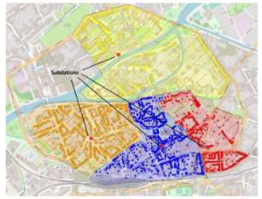
2 – LAYER NETWORK:

- Transport network → Source to substations
    - Multiple source design method
    - 80/50 temperature level
- Distribution network → Substation to buildings
    - Branched network design method
    - 70/40 temperature level
- Network sizing
- Cost estimation

INTERMEDIATE RESULTS:

- Clusters with substation locations
- Simultaneous demand of each substation

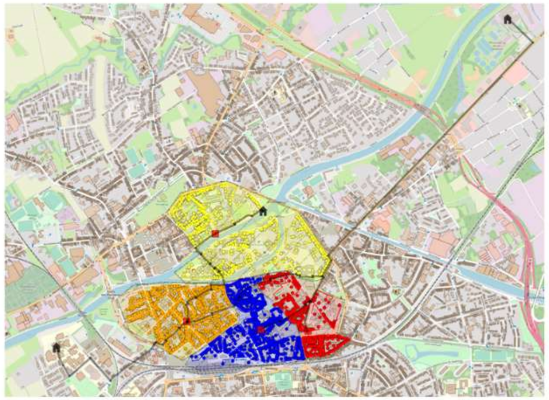




comsof.com 3 COMSOF

SCENARIOS – OPTIMAL SOLUTION

3 sources selected



comsof.com 4 COMSOF

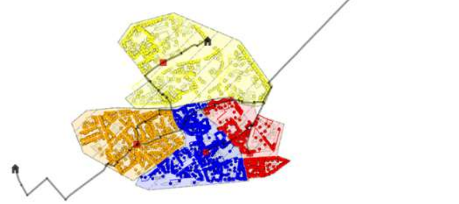
DESIGN SCENARIO – SOURCE SELECTION

Supply is greater than demand

GHENT UNIVERSITY

Source selection:

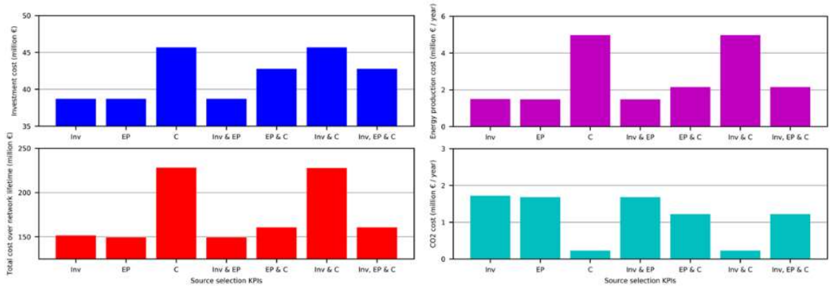
- Investment cost
- Energy production cost
- CO2 cost
- Combinations



comsof.com 5 COMSOF

SCENARIOS
Source selection

GHENT UNIVERSITY

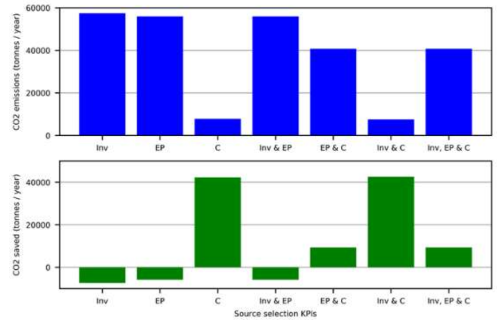


comsof.com 6

COMSOF

SCENARIOS
Source selection

GHENT UNIVERSITY



comsof.com 7

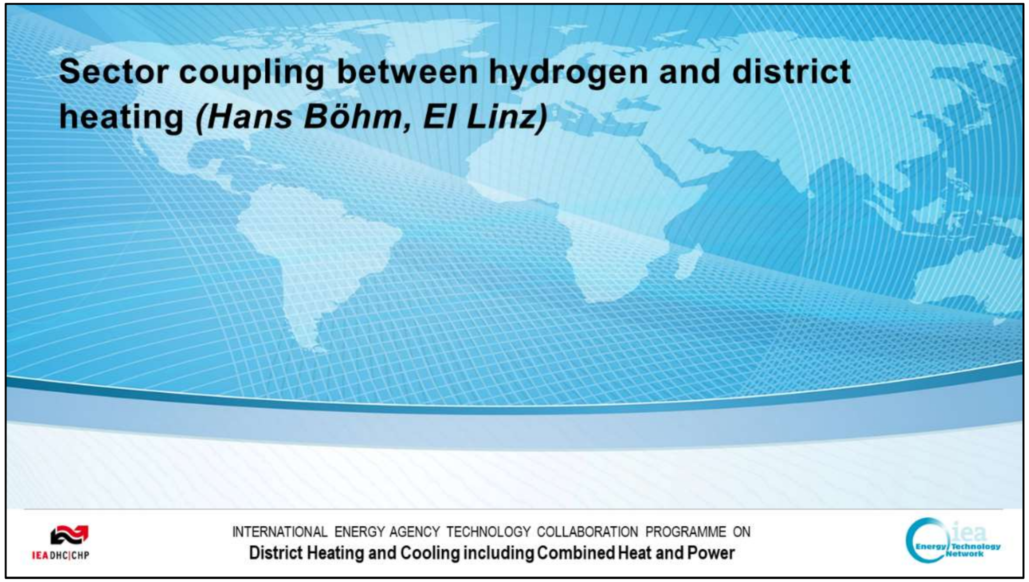
COMSOF

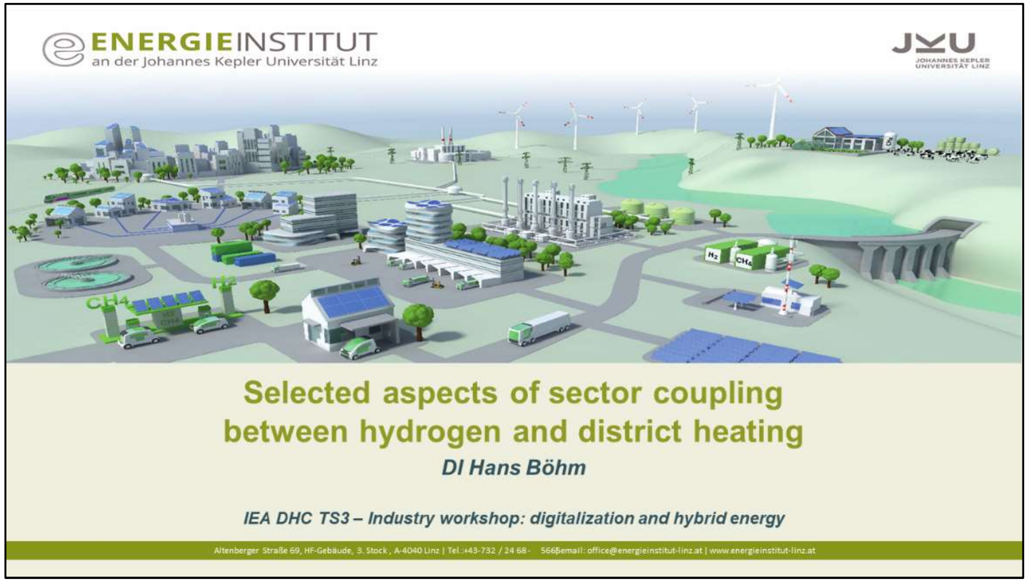
CONTACT

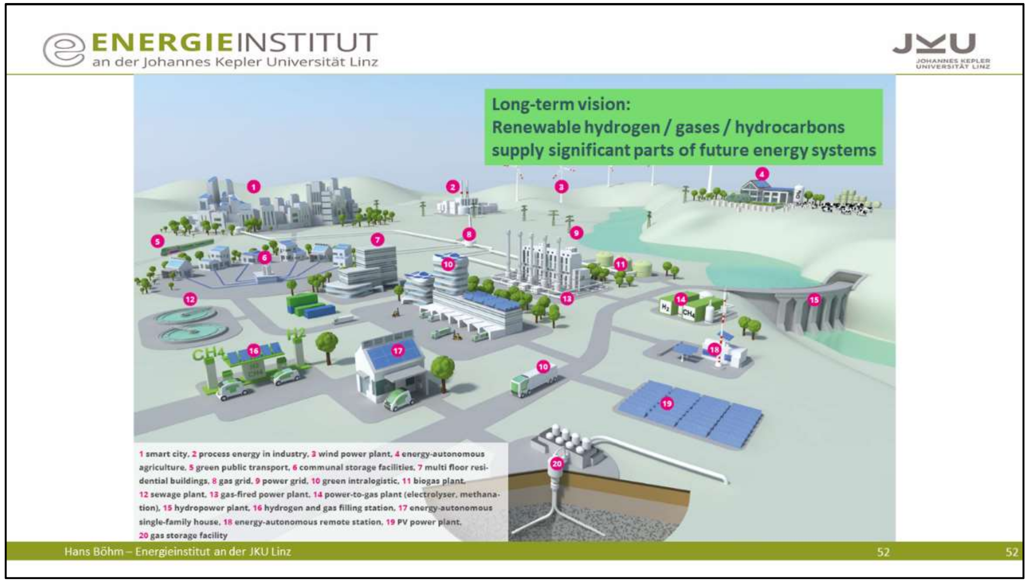
- Kurt Marlein
  - Product Manager
  - kurt.marlein@comsof.com
  - +32 9 275 31 00
  - +32 473 53 83 45
- Joseph Jebamalai
  - Innovation Engineer
  - joseph.jebamalai@comsof.com
  - +32 9 275 31 00
- www.comsof.com
- sales@comsof.com

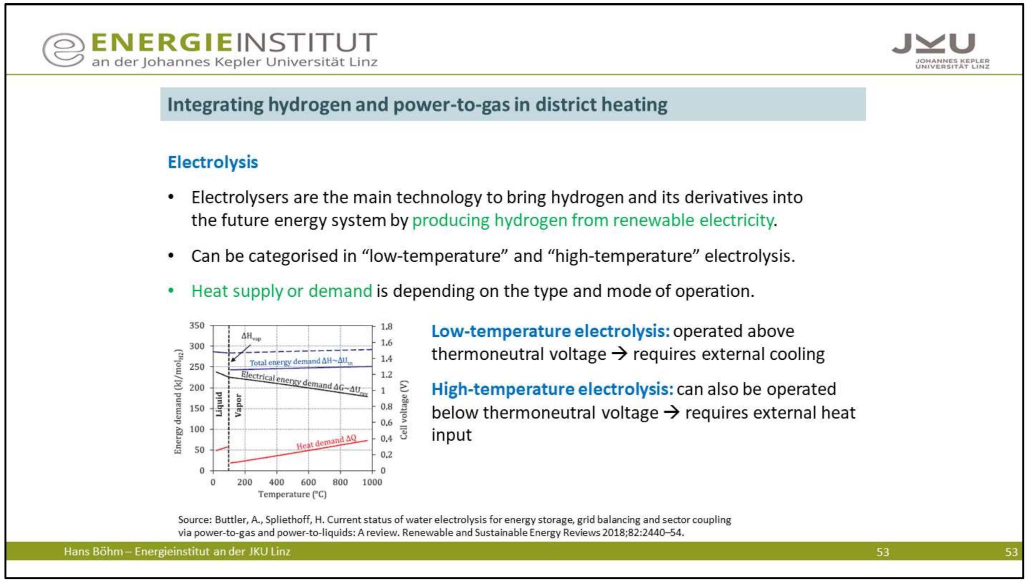
comsof.com 8

COMSOF


Sector coupling between hydrogen and district heating (Hans Böhm, EI Linz)
IEA DHC|CHP
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power
iea Energy Technology Network


ENERGIEINSTITUT
an der Johannes Kepler Universität Linz
JKU
CH4
H2
Selected aspects of sector coupling between hydrogen and district heating
DI Hans Böhm
IEA DHC TS3 – Industry workshop: digitalization and hybrid energy


ENERGIEINSTITUT
an der Johannes Kepler Universität Linz
JKU
Long-term vision:
Renewable hydrogen / gases / hydrocarbons supply significant parts of future energy systems
1 smart city, 2 process energy in industry, 3 wind power plant, 4 energy-autonomous agriculture, 5 green public transport, 6 communal storage facilities, 7 multi floor residential buildings, 8 gas grid, 9 power grid, 10 green intralogistic, 11 biogas plant, 12 sewage plant, 13 gas-fired power plant, 14 power-to-gas plant (electrolyser, methanation), 15 hydropower plant, 16 hydrogen and gas filling station, 17 energy-autonomous single-family house, 18 energy-autonomous remote station, 19 PV power plant, 20 gas storage facility
Hans Böhm – Energieinstitut an der JKU Linz
52
52


ENERGIEINSTITUT
an der Johannes Kepler Universität Linz
JKU
Integrating hydrogen and power-to-gas in district heating
Electrolysis
• Electrolysers are the main technology to bring hydrogen and its derivatives into the future energy system by producing hydrogen from renewable electricity.
• Can be categorised in “low-temperature” and “high-temperature” electrolysis.
• Heat supply or demand is depending on the type and mode of operation.
Energy demand (kJ/mol H2)
Cell voltage (V)
Temperature (°C)
Liquid
Vapor
ΔHvap
Total energy demand ΔH~ΔUtn
Electrical energy demand ΔG~ΔUrev
Heat demand ΔQ
Low-temperature electrolysis: operated above thermoneutral voltage → requires external cooling
High-temperature electrolysis: can also be operated below thermoneutral voltage → requires external heat input
Source: Buttler, A., Spliethoff, H. Current status of water electrolysis for energy storage, grid balancing and sector coupling via power-to-gas and power-to-liquids: A review. Renewable and Sustainable Energy Reviews 2018;82:2440–54.
Hans Böhm – Energieinstitut an der JKU Linz
53
53

ENERGIEINSTITUT an der Johannes Kepler Universität Linz — JKU JOHANNES KEPLER UNIVERSITÄT LINZ

Integrating hydrogen and power-to-gas in district heating

Electrolysis – SoA and technology options

Electrolysis cell type	Operating temperature	Typical stack size	Electric efficiency (LHV)	Advantages	Disadvantages
Polymer Electrolyte Membrane (PEMEC)	50(20)-80°C	<1 MW	50-60%	• Short start-up (cold: minutes, warm: seconds) • High load flexibility (0-100%)	• Pt-grade catalysts • Sensitivity to impurities
Alkaline (AEC)	60(30)-90°C	<5 MW	50-60%	• High lifetime • Low efficiency degradation	• Electrolyte management
Solid Oxide (SOEC)	500-900°C	<100 kW	75-90%	• High efficiency • High load flexibility • Reversibility	• High degradation / short lifetimes (pre-commercial) • Long start-up (cold start)

- **LT-electrolysers** encourage a usage in **spatially close applications** and/or where temperature level is of secondary importance (e.g. swimming pools or hospitals)
- Heat intense industries are expected to use **HT-electrolysis with thermal integration** for on-site hydrogen production for better efficiency → this could lead to **increased heat demands in future district heating grids**.
- **Downstream synthesis** processes can provide additional **waste heat at elevated** temperatures for further utilization (e.g. methanation @ 200-300°C)

Source: Energieinstitut an der JKU Linz

Hans Böhm – Energieinstitut an der JKU Linz 54 54

ENERGIEINSTITUT an der Johannes Kepler Universität Linz — JKU JOHANNES KEPLER UNIVERSITÄT LINZ

Integrating hydrogen and power-to-gas in district heating

Fuel Cells – SoA and technology options

Fuel cell type	Operating temperature	Typical stack size	Electric efficiency (LHV)	Applications	Advantages	Challenges
Polymer Electrolyte Membrane (PEMFC)	<120°C	<100 kW	60% (direct H_2)	• Backup power • Portable power • Distributed generation • Transportation	• Reduced corrosion • Low temperature • Quick start-up and load following	• Expensive catalysts • Sensitive to fuel impurities
Alkaline (AFC)	<100°C	<100 kW	60%	• Military • Space • Backup power • Transportation	• Lower cost components • Low temperature • Quick start-up	• Sensitive to CO_2 • Electrolyte management / conductivity
Phosphoric Acid (PAFC)	**150–200°C**	<500 kW	40%	• Distributed generation	• **Suitable for CHP** • Increased tolerance to fuel impurities	• Expensive catalysts • Long start-up time • Sulfur sensitivity
Molten Carbonate (MCFC)	**600–700°C**	<3 MW	50%	• Electric utility • Distributed generation	• High efficiency • Fuel flexibility • **Suitable for CHP**	• High temperature corrosion and lifetime • Long start-up time • Low power density
Solid Oxide (SOFC)	**500–1,000°C**	<2 MW	60%	• Auxiliary power • Electric utility • Distributed generation	• High efficiency • Fuel flexibility • Solid electrolyte • **Suitable for CHP**	• High temperature corrosion and lifetime • Long start-up time

Source: based on Lindorfer, J., et al. (2020). Fuel Cells: Energy Conversion Technology. In: Future Energy (Third Edition), Letcher, T. (Ed.), Elsevier, 2020

Hans Böhm – Energieinstitut an der JKU Linz 55 55

ENERGIEINSTITUT an der Johannes Kepler Universität Linz — JKU JOHANNES KEPLER UNIVERSITÄT LINZ

Gas infrastructure is still required in a sustainable energy system
from an Austrian perspective

- National **renewable electricity potentials do not cover the Austrian consumption** – neither profile- nor balance-related.
- The trade-off of electricity demand and supply primarily requires short- (days) and **long-term (seasonal) storage** capacities.

→ For seasonal storage **hydrogen (and derivatives) are essential**

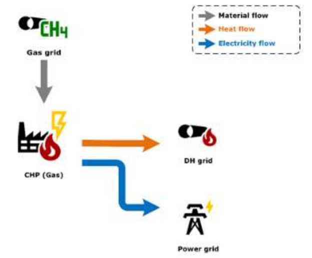
- In the future sustainable energy system today's gas infrastructure still supplies …
  - **Renewable gas CHP** (as backup)
  - Industrial consumers (energy carrier & feedstock)
  - Other consumers (e.g. heavy-duty transport, etc.)

National potentials for renewable power are insufficient to cover demands. Thus, the focus has to be on primary energy efficiency, which requires the **operation of CHP plants**.

Hans Böhm – Energieinstitut an der JKU Linz 56 56

ENERGIEINSTITUT an der Johannes Kepler Universität Linz — JKU JOHANNES KEPLER UNIVERSITÄT LINZ

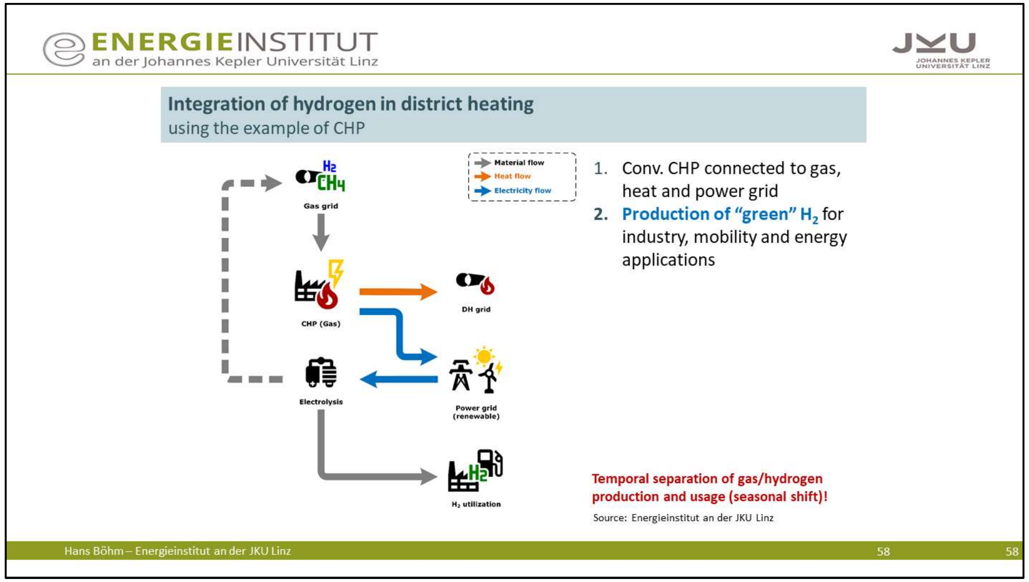
Integration of hydrogen in district heating
using the example of CHP

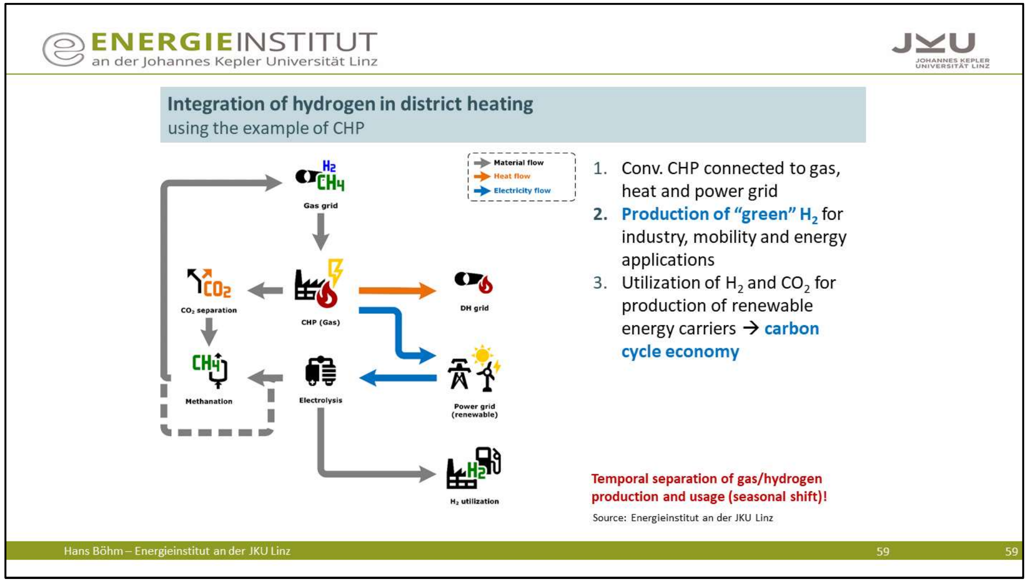


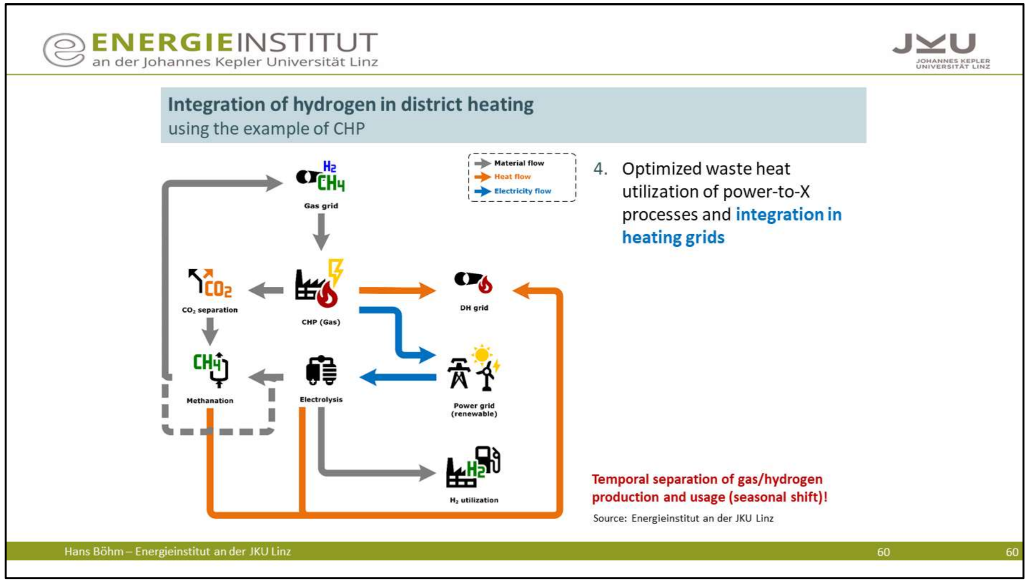
1. Conv. CHP connected to gas, heat and power grid

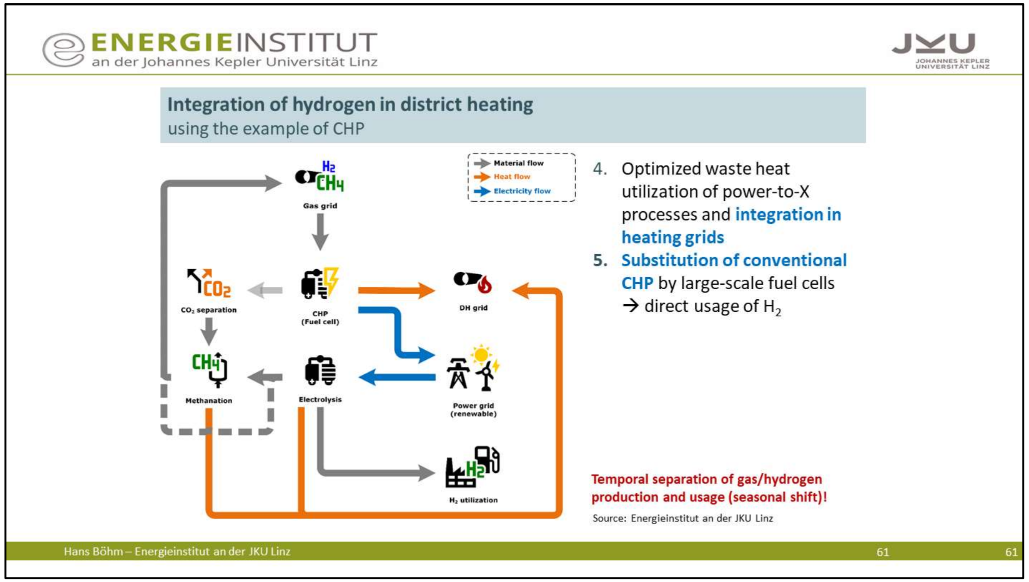
Source: Energieinstitut an der JKU Linz

Hans Böhm – Energieinstitut an der JKU Linz 57 57


ENERGIEINSTITUT
an der Johannes Kepler Universität Linz
JKU
Integration of hydrogen in district heating
using the example of CHP
Material flow
Heat flow
Electricity flow
Gas grid
CHP (Gas)
DH grid
Electrolysis
Power grid (renewable)
H2 utilization
1. Conv. CHP connected to gas, heat and power grid
2. Production of "green" H2 for industry, mobility and energy applications
Temporal separation of gas/hydrogen production and usage (seasonal shift)!
Source: Energieinstitut an der JKU Linz
Hans Böhm – Energieinstitut an der JKU Linz
58
58

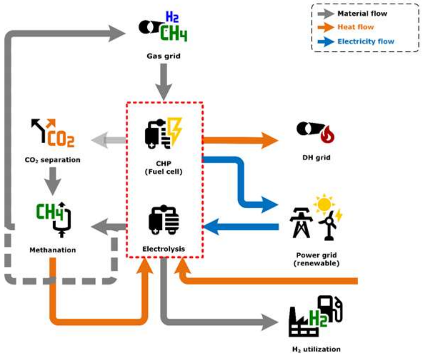

ENERGIEINSTITUT
an der Johannes Kepler Universität Linz
JKU
Integration of hydrogen in district heating
using the example of CHP
Material flow
Heat flow
Electricity flow
Gas grid
CO2 separation
CHP (Gas)
DH grid
Methanation
Electrolysis
Power grid (renewable)
H2 utilization
1. Conv. CHP connected to gas, heat and power grid
2. Production of "green" H2 for industry, mobility and energy applications
3. Utilization of H2 and CO2 for production of renewable energy carriers → carbon cycle economy
Temporal separation of gas/hydrogen production and usage (seasonal shift)!
Source: Energieinstitut an der JKU Linz
Hans Böhm – Energieinstitut an der JKU Linz
59
59


ENERGIEINSTITUT
an der Johannes Kepler Universität Linz
JKU
Integration of hydrogen in district heating
using the example of CHP
Material flow
Heat flow
Electricity flow
Gas grid
CO2 separation
CHP (Gas)
DH grid
Methanation
Electrolysis
Power grid (renewable)
H2 utilization
4. Optimized waste heat utilization of power-to-X processes and integration in heating grids
Temporal separation of gas/hydrogen production and usage (seasonal shift)!
Source: Energieinstitut an der JKU Linz
Hans Böhm – Energieinstitut an der JKU Linz
60
60


ENERGIEINSTITUT
an der Johannes Kepler Universität Linz
JKU
Integration of hydrogen in district heating
using the example of CHP
Material flow
Heat flow
Electricity flow
Gas grid
CO2 separation
CHP (Fuel cell)
DH grid
Methanation
Electrolysis
Power grid (renewable)
H2 utilization
4. Optimized waste heat utilization of power-to-X processes and integration in heating grids
5. Substitution of conventional CHP by large-scale fuel cells → direct usage of H2
Temporal separation of gas/hydrogen production and usage (seasonal shift)!
Source: Energieinstitut an der JKU Linz
Hans Böhm – Energieinstitut an der JKU Linz
61
61

ENERGIEINSTITUT an der Johannes Kepler Universität Linz — JKU

Integration of hydrogen in district heating
using the example of CHP



4. Optimized waste heat utilization of power-to-X processes and **integration in heating grids**
5. **Substitution of conventional CHP** by large-scale fuel cells → direct usage of H_2
6. Implementing **reversible fuel cells** (rSOFC) → **optimizing** operating hours and **plant costs**

Temporal separation of gas/hydrogen production and usage (seasonal shift)!

Source: Energieinstitut an der JKU Linz

Hans Böhm – Energieinstitut an der JKU Linz 62 62

ENERGIEINSTITUT an der Johannes Kepler Universität Linz — JKU

Options for direct integration of power-to-gas applications in heating grids

1. Alkaline and PEM electrolysers provide a **waste heat potential of about 10-25%** of their nominal capacity at temperatures of **60-80 °C.**
2. **Downstream synthesis** processes provide additional sources of heat at elevated temperatures, e.g. catalytic methanation **@ 250-300 °C** in the range of 15% of the processed gas.
3. Operating temperatures of **HT-electrolysis are in the range of 500-1,000 °C** and can be a **heat source or drain** depending on the mode of operation.
4. **Fuel cells** can be (and are already) used as micro-CHP for decentralized **electricity and heat supply**. Future large-scale implementations could substitute conventional CHP plants in **H_2-/SNG-based energy systems.**

Hans Böhm – Energieinstitut an der JKU Linz 63 63

ENERGIEINSTITUT an der Johannes Kepler Universität Linz — JKU

DI Hans Böhm
Researcher – Energy Technologies
Energieinstitut an der Johannes Kepler Universität Linz
Altenberger Straße 69
4040 Linz, AUSTRIA
Tel: +43 723 2468 5665
e-mail: boehm@energieinstitut-linz.at

Thanks for your attention!

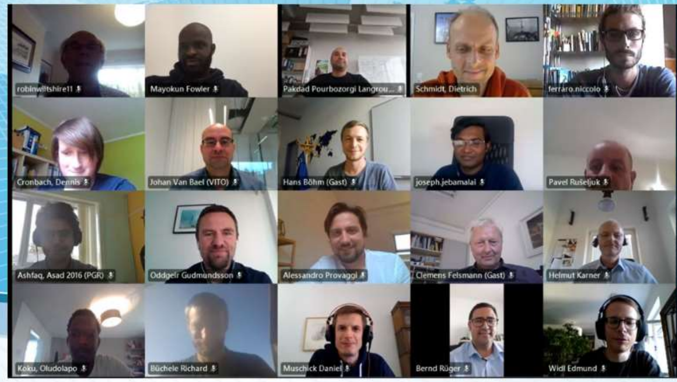
Altenberger Straße 69, HF-Gebäude, 3. Stock , A-4040 Linz | Tel.:+43-732 / 24 68 - 5656email: office@energieinstitut-linz.at | www.energieinstitut-linz.at

Q&A to all presenters

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

Group photo

+ many others without webcam (in total about 50 participants)



INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power

Summary and next steps

- We will make the **recording of the webinar** available on the IEA DHC YouTube channel https://www.youtube.com/channel/UCuYcqLjJi8thrUJCjzLBaow and send out the **presentation slides**
- If you want to **join the IEA DHC Annex TS3 or TS4**, please contact
  - Ralf-Roman Schmidt, ralf-roman.schmidt@ait.ac.at (leader TS3)
  - Dietrich Schmidt, dietrich.schmidt@iee.fraunhofer.de (leader TS4)
  - AND: contact your national IEA DHC representative for funding opportunities https://www.iea-dhc.org/home/

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power 67

Thank you for your attention!

Webinar Digitalization for optimizing integrated district heating systems - Block III

9. September 2020

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

Fraunhofer IEE

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY TOMORROW TODAY

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
District Heating and Cooling including Combined Heat and Power