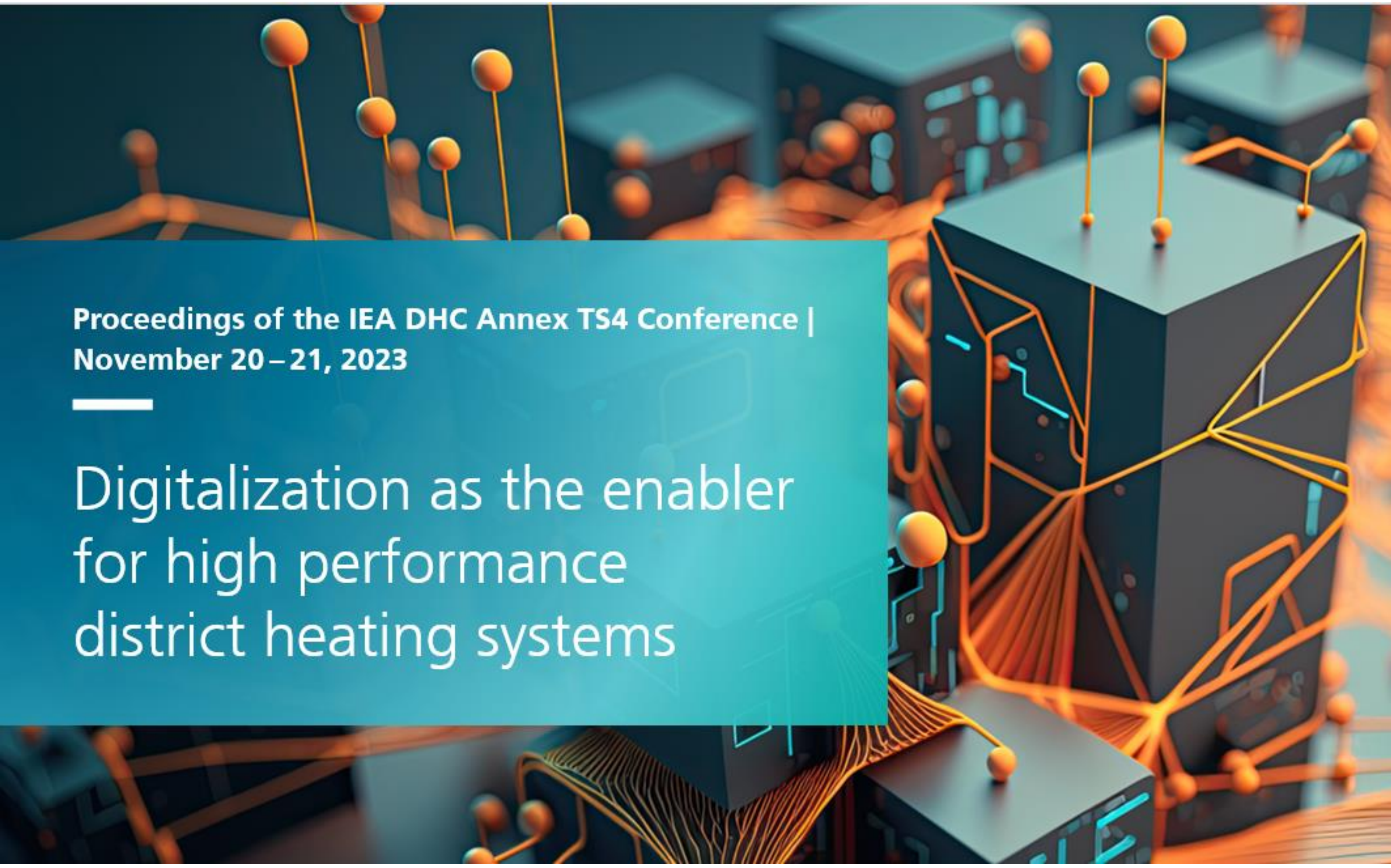


Proceedings of the IEA DHC Annex TS4 Conference | November 20 – 21, 2023

Digitalization as the enabler for high performance district heating systems

Hosted by:
Fraunhofer Cluster for Integrated Energy Systems (CINES), Germany

Fraunhofer
CINES

Organised by:
Fraunhofer Institute for Energy Economics and Energy System Technology, Germany

Fraunhofer
IEE

Digitalization as the Enabler for High Performance District Heating Systems

Digital technologies are expected to improve the efficiency and system integration of additional renewable sources, as well as making the entire energy system reliable, smarter, and more efficient. Future digital applications may allow district energy systems to fully optimize the operation of their plant and network assets while realizing immediate and feasible decarbonization of urban heat supply: With data to optimize district heating systems and new business opportunities.

This conference offered information on cutting-edge technologies and solutions around digitalization measures in district heating supply systems and created a forum for participants from business, research institutions, and politics. A small industry exhibition allowed exchange in these topics as well as products and technology. Thus, the conference provided an opportunity for an open interdisciplinary conversation on how to address the upcoming challenges of the digital energy transition

The presenters brought a wide range of expertise in digitalization solutions with a specific focus on the design and management of district heating systems. They additionally gave insight into the development status of new digital business processes.

This event completed the Annex TS4 project, "Digitalization of District Heating and Cooling: Optimised Operation and Maintenance of District Heating and Cooling Systems via Digital Process Management", which was carried out within the framework of the International Energy Agency's District Heating and Cooling Program. It is organized in close collaboration with the Fraunhofer Cluster for Integrated Energy Systems (CINES).

Index

The conference was held in seven sessions:

Contact:

Task Manager / Conference Chair:
Dietrich Schmidt - dietrich.schmidt@iee.fraunhofer.de

Session I - Opening

Technology Collaboration Programme
by iea

DIGITALISATION AS A KEY TECHNOLOGY FOR OPTIMISATION OF DHC

Digitalisation as the Enabler for High Performance District Heating Systems

20 November 2023

Dr. Robin Wiltshire

Chair, IEA DHC TCP

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

What is the IEA District Heating & Cooling Technology Collaboration Programme?

Global international research programme on DHC technology focusing on reducing cost and improving performance

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

IEA DHC TCP member countries

Established in 1983, current members are: Austria, Belgium, Canada, China, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Korea, Netherlands, Norway, Sweden, UK, USA

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

Work Plan 2021-6: Principal Research Themes

- Improving the business case for DHC including the integration of prosumers
- Decarbonisation and temperature reduction in DH networks
- Integration of renewable energy sources into existing DHC systems
- Hybrid energy networks
- Digitalisation – systematic optimisation of DHC in the era of big data
- Improving district heating infrastructure.

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

The research: Cost and Task Share projects

5

- Research projects proceed in two ways: '**cost share**' and '**task share**'
- IEA DHC has carried out cost share projects since 1983, and task share projects since 2011
- **Cost share** projects: chosen by competitive bidding and funded by IEA-DHC
- **Task share** projects: arising from suggestions by member country organisations - participants identify their own funding
- Reports for all completed projects are freely available at www.iea-dhc.org

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

Importance of digitalisation to DHC

6

- Deployment of digitalisation (hardware, software, and controls) has the potential to be a fundamental game-changer leading to the emergence of new business models.
- Potential improvements can be made to all aspects of DHC systems from planning to operation, improving efficiency, economy, and environmental performance.
- Digital platforms can promote user engagement, and digital techniques can potentially enable future consumers to become prosumers.
- A further important element is cybersecurity.

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

Optimising DHC networks: the role of digitalisation

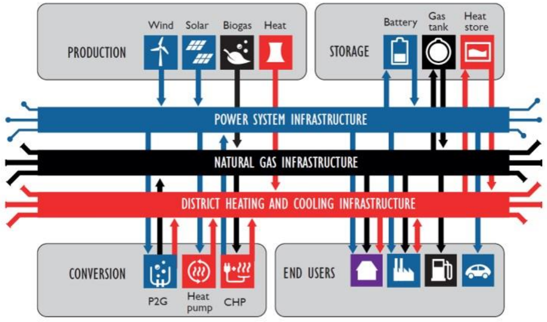
7

- Digital techniques can be deployed to optimise overall heat distribution and integration of new technologies and multiple heat sources.
- Monitoring can be carried out down to individual component level, enabling fault detection of problems that otherwise would not be found.
- Fault diagnosis and continuous commissioning helps to secure low-temperature operation. This is crucial for the transition towards renewables-based DHC networks.
- In this way, thermal grids can evolve towards smart grids, integrating multiple heat sources and enabling the circular economy.

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

Hybrid Energy Networks *(excerpt from report)*

8



Example of a Hybrid Energy Network with some possible technologies and connections (source: Fraunhofer IEE)

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

Benefits of belonging to IEA District Heating & Cooling TCP

- Access to state-of-the-art international research
- Global reach leads to deeper perspectives on technology implementation and market development
- All projects benefit from input from researchers from multiple countries
- Help to define future research priorities and shape the research programme
- Bid for future cost share projects; participate in task share projects
- Networking opportunities with experts from different countries
- Cooperation with other TCPs and Euroheat & Power and International District Energy Association.

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

Benefits of taking part in projects

- Direct benefit of receiving funding for successful **cost share** bids; successful bids are 100% funded
- For **task share** participation: contribute your own research effort – and receive the additional benefit of matching research efforts from other participants
- Both cost and task share final reports are widely read across the current membership countries and beyond – a great shop window!
- International perspectives enrich project outcomes
- Opportunity to build up international networking
- Under the auspices of the IEA, project outcomes come to the notice of ministerial representatives on IEA committees.

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

At the website…

- **Full reports** for detailed information about completed projects
- **Summary reports** for a quick synopsis of project outcomes
- **Webinars** on various project topics
- **Key guide to information by topic**
- **Programme brochure**
- **Links to major external sources of DHC information**

www.iea-dhc.org

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

Technology Collaboration Programme
by iea

Thank you for listening!

For more about the IEA DHC TCP:

www.iea-dhc.org

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IEA-DHC@agfw.de

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

Federal Ministry for Economic Affairs and Climate Action

Welcoming,
8th German Energy Research Programme

Tobias Heffels
Division IIB5, Energy research – project funding and market building; key technologies for the energy transition

Launch of the 8th Energy Research Programme for applied energy research – Research missions for the energy transition

Federal Ministry for Economic Affairs and Climate Action

https://www.bmwk.de/Redaktion/DE/Dossier/energieforschung-und-innovation.html

1

Five missions to focus energy research on accelerating the energy transition and towards the German climate policy goals

⇒ Mission Energy System
⇒ Mission Wärmewende
(Transformation of the heating sector)
⇒ Mission Stromwende
(Transformation of the electrical system)
⇒ Mission Hydrogen
⇒ Mission Transfer

Federal Ministry for Economic Affairs and Climate Action

2

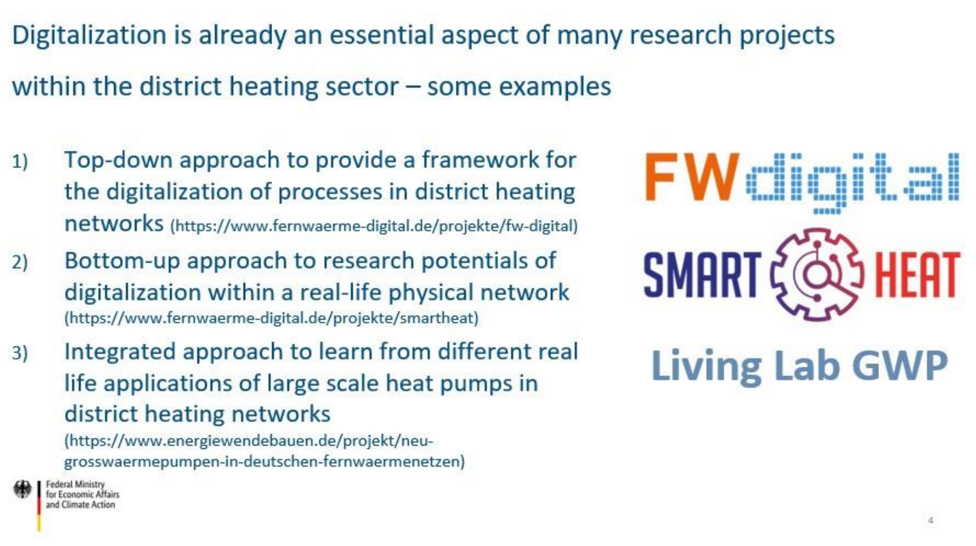
Mission Wärmewende – Accelerating the transition to climate-neutral and efficient heating and cooling

Objectives

1) Climate-neutral and sustainable heating and cooling for buildings
2) De-fossilize heating and cooling supply in industry
3) Robust infrastructure for efficient distribution and storage of heat
4) Exploitation of flexibility within the heating and cooling sector

Federal Ministry for Economic Affairs and Climate Action

3


Digitalization is already an essential aspect of many research projects within the district heating sector – some examples
1) Top-down approach to provide a framework for the digitalization of processes in district heating networks (https://www.fernwaerme-digital.de/projekte/fw-digital)
2) Bottom-up approach to research potentials of digitalization within a real-life physical network (https://www.fernwaerme-digital.de/projekte/smartheat)
3) Integrated approach to learn from different real life applications of large scale heat pumps in district heating networks (https://www.energiewendebauen.de/projekt/neu-grosswaermepumpen-in-deutschen-fernwaermenetzen)
FWdigital
SMART HEAT
Living Lab GWP
Federal Ministry for Economic Affairs and Climate Action
4


Federal Ministry for Economic Affairs and Climate Action


IEA DHC Annex TS4 Conference | November 20 – 21, 2023
Introduction to the Conference Themes
Dietrich Schmidt
Fraunhofer
CINES
IEA DHC


Our future Energy system will be digital!


IEA DHC Annex TS4
Digitalization of District Heating and Cooling:
Optimized Operation and Maintenance of District Heating and Cooling Systems via Digital Process Management


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

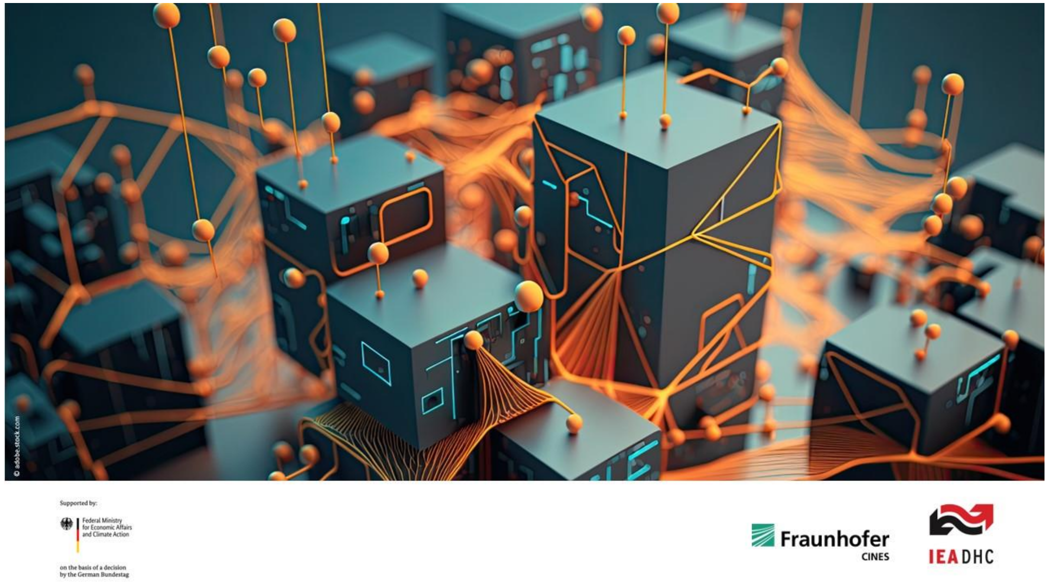

Digitalization of the
demand side


Digitalization to Link the Entire
Supply Chain
– System Perspective


Digitalization of
Energy Infrastructure


Business Models
– Unlocking the Value
of Digitalization


Technology Collaboration Programme
by iea
Annex TS4 | Digitalisation of district heating
FINAL REPORT
Guidebook for the Digitalisation of District Heating: Transforming Heat Networks for a Sustainable Future
Published via the German Heat and Power Association AGFW
Some facts:
13 chapters
32 authors and 3 guest authors
IEA DHC
INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING


Fraunhofer
CINES
IEA DHC

Smart Thermal Networks in the European Union

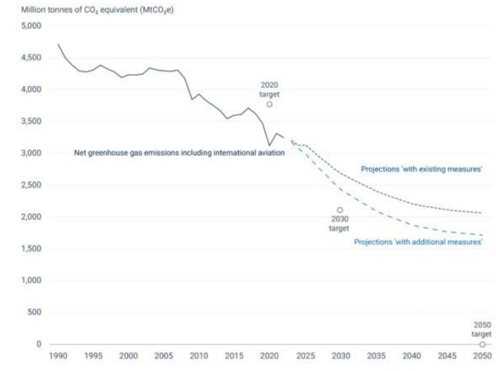
Digitalization as the Enabler for High Performance District Heating Systems

Jonathan Volt
JRC C.7 - Energy Transition Insights for Policy

Total net greenhouse gas emission trends and projections in Europe

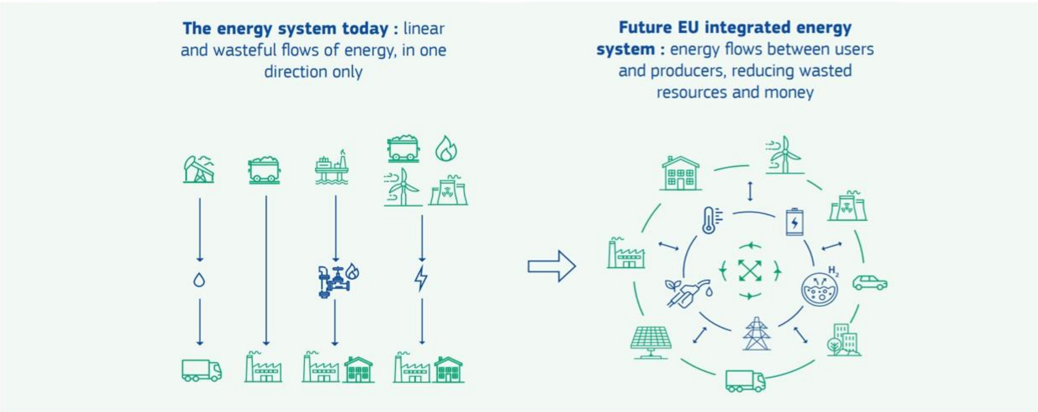
EU intensifies efforts for faster emission reductions:

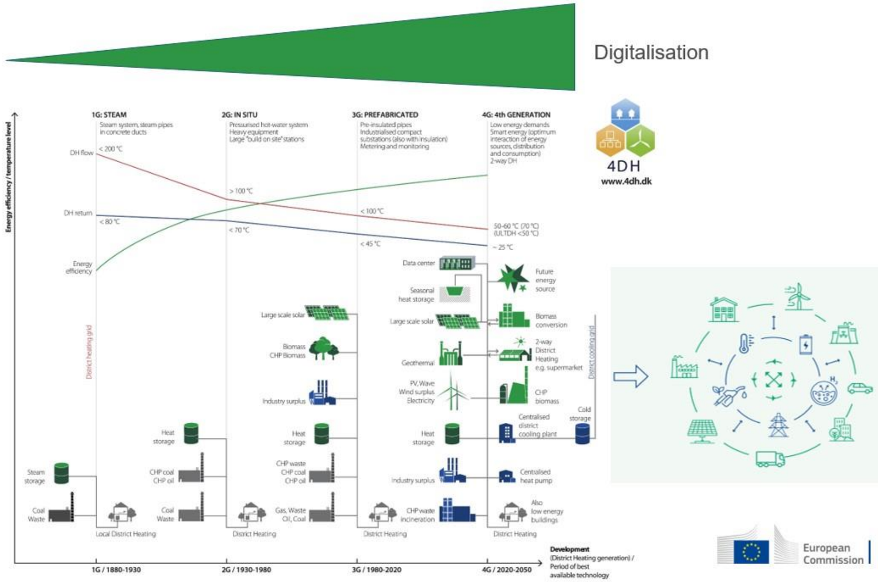
- Commitment to reduce emissions by at least 55% by 2030
- New binding target for share of RES at 42.5% by 2030
- Binding efficiency target of at least 11.7% compared to the expected FEC in 2030
- Actions to reduce dependency on Russian gas
- Renovation Wave, Heat Pump Action Plan, ETS overhaul



Source: EEA, 2023

From linear to integrated energy systems





Source: Lund et al. (2021) Perspectives on fourth and fifth generation district heating

Smart Thermal Network?

Smart thermal networks refer to efficient heating infrastructures that distribute heating and cooling to multiple facilities within a district or city. They are characterized by **operating at lower temperatures** than conventional thermal networks and possessing a **higher complexity** with numerous supply and demand points. Smart thermal networks **utilise intelligent technologies** and strategies to maximize energy efficiency, reduce emissions, and optimize thermal distribution. Furthermore, they are **typically integrated into the wider energy system**, enabling them to provide valuable balancing services to power grids.

European Commission

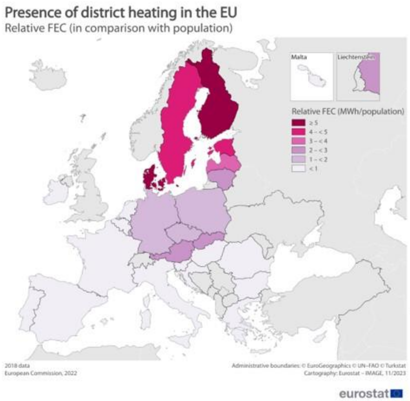
New models and new challenges

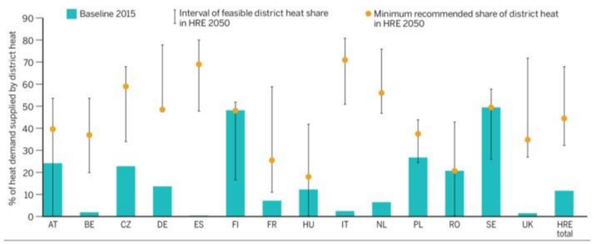
Source: European Commission (2022) District Heating and Cooling in the European Union. Overview of Markets and Regulatory Frameworks under the Revised Renewable Energy Directive

Traditional DHC model (70s-90s)	New models
Long term concessions linking large scale production, supply and grid management within a unique contract	**Mid term concessions + service contracts**, often separating production contracts and supply from grid operation
Vertical integration, **no transparency on embedded costs**	Full **transparency on the value chain** at various levels
Centralised production, often coal or gas based, with or without CHP, unchallenged during the contract	**Decentralised production**, constantly reshaped with respect to environmental targets and cost effectiveness
Grid as a closed, **"one way" system**	Grid as enabler to **energy exchanges**
Mandatory connection, regardless of efficiency of alternative supply proposals	Conditional connection, can be challenged by efficient standalone solutions
Supply driven development	**Demand driven** development
Low consumer information, no cooperative dialogue to stakeholders	**Customer/stakeholder information as enabler to the model**

European Commission

Overlooked potential (?)





Source: Paardekooper et al. 2018, Heat Roadmap Europe, in RAP, 2023.

European Commission

Smart thermal networks: a strategic element in EU's climate work

EU Energy System Integration Strategy
- Strategy laying the foundation for the decarbonised European energy system of the future

Renewable Energy Directive
- Target of 42.5% of energy consumed comes from renewables (Art. 3)
- RES and waste heat targets for district heating and cooling (Art. 24)
- Requirement to inform consumers about RES in DHC (Art. 24)

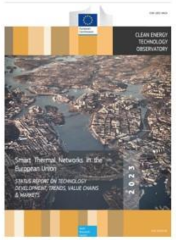
Energy Efficiency Directive
- Definition of efficient district heating and cooling (Art. 26)
- Local heat and cooling plans (Art. 25)
- Comprehensive assessment (Art. 25)

Energy Performance of Buildings Directive
- Zero emission buildings (Art. 2)
- National building renovation plans (Art. 3)
- Renovation passports (art. 10)

Other
- EU ETS and ETS 2
- Target of 100 climate neutral cities
- Energy communities
- Positive Energy Districts

European Commission

Trends



- Digitalisation and the increased use of smart meters and sensors in the networks have dramatically increased the amount of data available, and this can be used for advance planning and operational optimisation.
- System integration represents a great opportunity for the EU's power and heating and cooling sectors. Networks with multiple thermal generation plants can offer great flexibility to the wider energy system, especially if coupled with thermal energy storages.
- The role of thermal networks has shifted from simply ensuring sufficient supply to optimising the whole system, from supply point to end-users.
- New role for utilities and new potential business models.

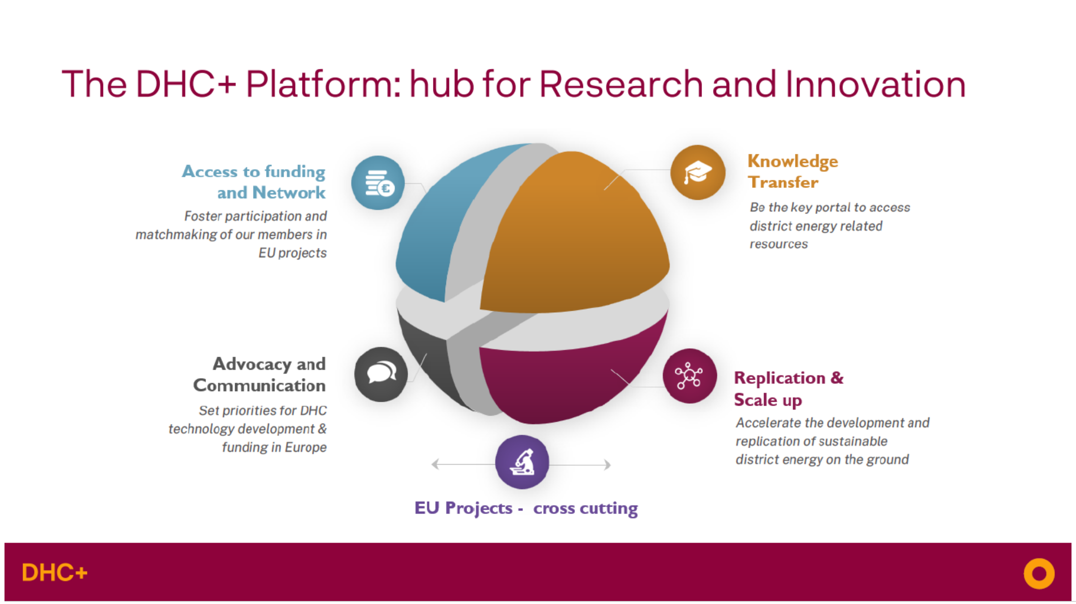
Clean Energy Technology Observatory

- The Clean Energy Technology Observatory (CETO) is a project to monitor EU research and innovation activities on clean energy technologies needed for the delivery of the European Green Deal.
- The 2023 Competitiveness Progress Report on clean energy technologies
- Strategic Energy Technology (SET) Plan

https://setis.ec.europa.eu/publications/clean-energy-technology-observatory-ceto/ceto-reports-2023_en

Thank you

Session II - Challenges of Digitalization in District Heating



Presentation 5:
The Role of Digitalization for District Heating and Cooling Performance Upgrade: an Industry Perspective

Activity timeline

DigiWG activities since 2022

Revamp WG	Survey Design	Survey Launch	Survey analysis	Results discussion	Report draft	Report final	Public Launch	Social media Campaign	SES Conf. Copenhagen	Webinar w/ Utilities	IEADHC Conf. Berlin
3/22	5/22	6/22	9/22	12/22 - 2/23	3/23	4/23	5/23	7-9/23	12/9/23	19/9/23	20-21/11/23

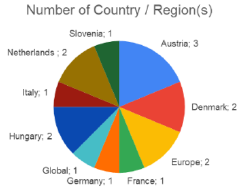
DHC+

DHC+ Digital Heat Survey

- 2 parallel surveys focused on Digital Solutions supply and demand were launched

Supply side

- Target: (digital) solution providers or inhouse developed tools
- Aim: understand what solutions are available / maturity / areas of investment

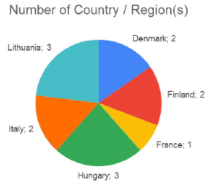


16 contributions

- 10 Digital solution providers
- 2 Research centres

Demand side

- Target: DHC utilities at large
- Aim: verify uptake of digital tools and solutions by operators / identify upcoming challenges



13 contributions

- 60% are public and private DH utilities
- Large, medium and small systems

DHC+

DHC+ Digital Heat Survey: key findings

Supply side

- Significant number (and quality) of market-ready innovative solutions and approaches
- Strong commitment to make an impact, based on growing data availability
- Good coverage of the value chain*, margins for more integration
- Communication on impacts may improve

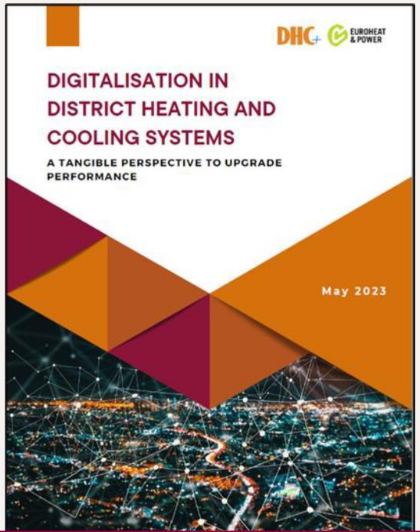
Demand side

- Small number of respondents is a clear sign that issue is not on top of the agenda (and/or there may be an "ownership" issue)
- Complexity is increasing and there is good awareness of untapped potential, but "pain level" still low
- Struggle to perceive real impacts (cost-benefit balance) of digital heat

- There seems to be a gap between demand and supply of Digital Solutions

DHC+

The report on Digitalisation in DHC Systems



Available on the Knowledge Hub

DHC+

Presentation 5:
The Role of Digitalization for District Heating and Cooling Performance Upgrade: an Industry Perspective

The report on Digitalisation in DHC Systems

Bridging the gap between theory and practice to untap the potential of Digitalisation

1. Introduction: What is the state of Digital Heat and its role and potential?
2. Long-term vision: What is the ongoing transition, its importance and complexity?
3. Value chain perspective: Reaching the buildings and end-user
4. The age of GDPR: Focus on customers' data
5. The pathway to digitalisation: Assess your status and define the next steps
6. Digitalisation in practice: Stories, impacts and lessons from a utility perspective

DHC+

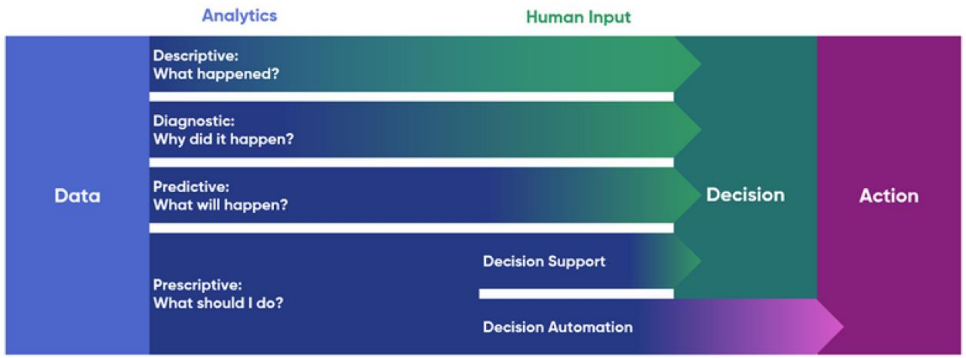
The report on Digitalisation in DHC Systems

Key messages

- DHC is one of the key solutions to enable the decarbonisation of the energy system. Yet, DHC systems must encompass an increasing level of **complexity** due to a growing mix of technologies, sources and sector coupling.
- Complexity can be managed with available and rapidly developing digital solutions that can **leverage on data** to achieve **effective design and efficient operations.**
- Maximum performance is achieved when the **value chain** is considered as a whole, including buildings and customers (where there is lots of untapped potential)
- We must **act now**! Good news is: **high returns on investment** can be achieved also when data and analytics maturity level is still low.

DHC+

The roadmap for digital uptake



© Gartner: data analytics maturity map

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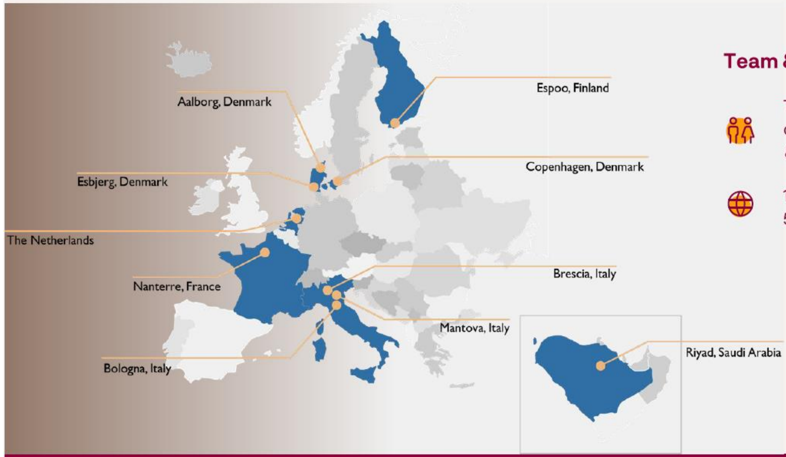
Digitalisation in DHC Systems: the Utilities perspective



Team & Content

Task Force with authors and contributors from 11 members, & DHC+ Secretariat

11 case studies from 5+1 countries

DHC+

Presentation 5:
The Role of Digitalization for District Heating and Cooling Performance Upgrade: an Industry Perspective

The report on Digitalisation in DHC Systems

Release at the #EHPCongress23

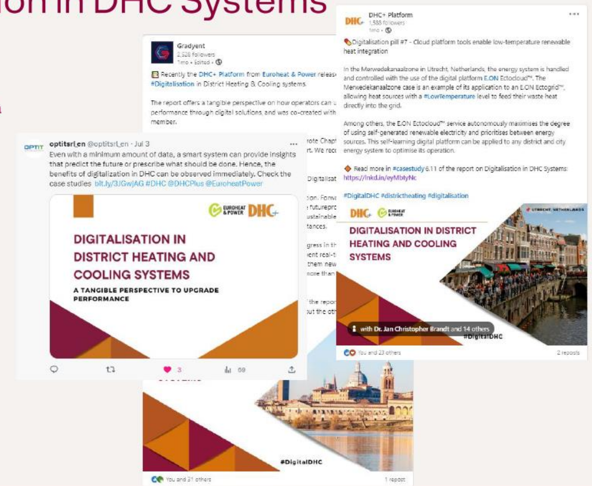
- Public launch during the previous DHC+ Assembly
- Dedicated Session with authors

DHC+

The report on Digitalisation in DHC Systems

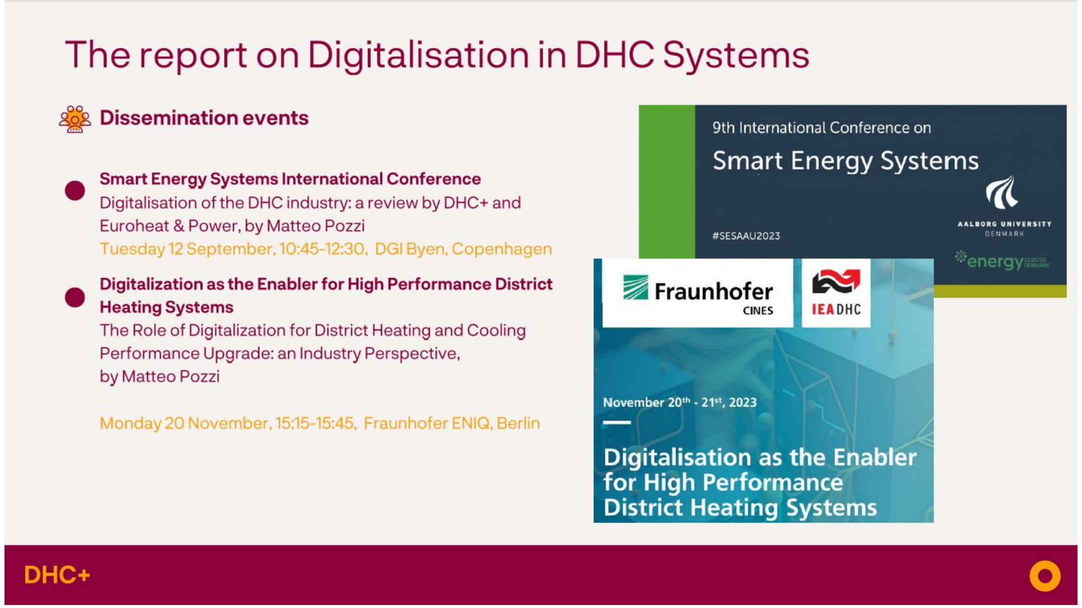
Dissemination and promotion

- #Digitalisation pill 💊 campaign on social media
  More than 10K impressions & 250 reactions
- Dissemination by DHC+ members
- More than 1000 views



DHC+

Presentation 5:
The Role of Digitalization for District Heating and Cooling Performance Upgrade: an Industry Perspective



Presentation 5:
The Role of Digitalization for District Heating and Cooling Performance Upgrade: an Industry Perspective


Next steps
Next activities of the Digitalisation Working Group
We will meet shortly to set the goals for 2024
Explore further dissemination opportunities
We intend to continue our action to promote Digitalisation as Enabler for High Performance District Heating Systems. Contributions and ideas are welcome!
DHC+


Thank you!
John Kapetanakis
Project Officer
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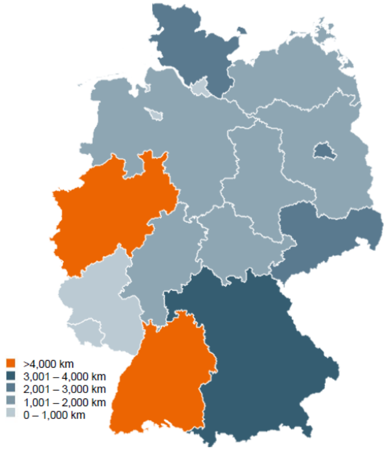
@DHCPlus
@EuroheatPower
DHC+ Platform
Euroheat & Power
euroheat.org

AGFW ABOUT US - WHO WE ARE AND WHAT WE DO

- AGFW is an independent, impartial German association promoting energy efficiency, (district) heating, cooling and CHP – Combined Heat and Power – at national and international levels
- AGFW comprises more than **670** regional und municipal energy suppliers, consultants, experts manufacturing companies including component and system manufacturers, assembling companies and testing institutes within Germany and Europe
- AGFW represents 95% of the heat load connected to German district heating systems – the largest scale in Western Europe
- AGFW with more than five decades of expertise in the district heating sector, covers the entire process chain of efficient district heating, district cooling and CHP

www.agfw.de Seite 2

AGFW FACTS AND FIGURES – DISTRICT ENERGY IN GERMANY



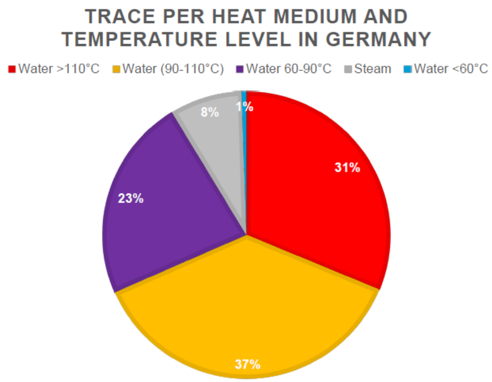
Source: Dashboard AGFW Hauptbericht [6]

- **The district heating production per year in Germany is approximately 58.779 GWh and we have a growing DH grid length of 31.252 km**
- **DH has a market share of 14 % of the German heating market – this means round about 1,25 million buildings**
- **The district heating customers are: 46% private homes, 36% public buildings, commercial and trade sector and 18% industry**
- **Closed to 86% of District Heating is generated in high efficient cogeneration (CHP) plants - partly with renewables and waste incineration already**

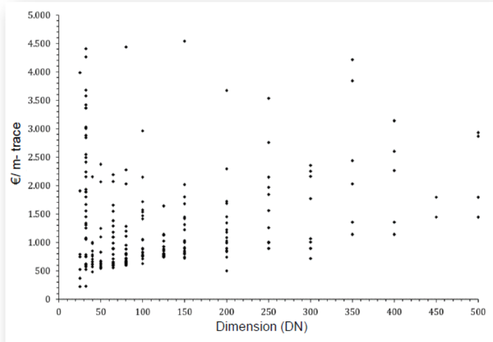
www.agfw.de Seite

AGFW FACTS AND FIGURES – DISTRICT ENERGY IN GERMANY

German DH Systems have a wide range of variants and charcteristics



Source: Dashboard AGFW Hauptbericht [6] (Database 2020)



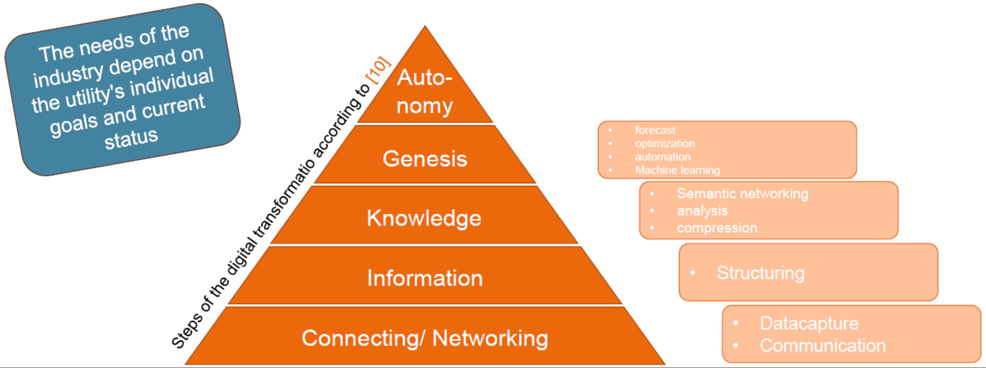
Laying costs for pre insulated pipes (DIN EN 253, series 1) under paved surfaces (excluding VAT)
Source: AGFW 2021 [7]

www.agfw.de Seite

Presentation 6:
Industry Needs for Practical Implementation
of Digitalization Processes

Digitalisation as digital transformation [9]

» Aim: Increase productivity
» Generate knowledge by linking relevant information and gradually condense, expand and use it through innovative data processing methods



www.agfw.de Seite 5

Framework: Legal boundary conditions

www.agfw.de Seite 6

Legal boundary conditions

Is there a digitalisation need in DH?

» **So far there is no directive or law that forces digital tools to operate a DH grid**
» **But since 10/ 2021 there is the FFVAV [1]**
  - National implementation of the European Renewable Energy Directive (EU 2018/2001)
  - National implementation of Energy Efficiency Directive (EU 2018/2002)
  - Scope of application: A company that supplies a customer with district heating or district cooling
» **Some relevant aspects**
  - Metering equipment installed from 10/ 2021 must be remotely readable
  - All metering equipment must be remotely readable at least until 12/2026
  - Remotely readable → it can be read without access to the individual "units of use"
  - DH supply company must provide
    - Billing (at least once a year)
    - Monthly consumption and billing information (no invoice)
    - comprehensive information on the energy quality of its heating or cooling product as well as other information regulated in detail (§ 5 FFVAV).

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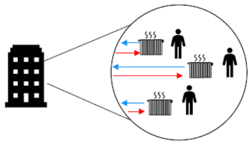
Legal boundary conditions

FFVAV

» To fulfill the FFVAV the DH utility needs to read remotely the heat consumption once a month for every customer
» The utility company must ensure compliance with data protection and data security requirements when processing billing information, including consumption information. (§4 (5))

HeizkostenV



» The "Heating Costs Ordinance" (HeizkostenV) is also affected by the implementation of the European legal requirements on consumption, billing and information obligations.
» The "HeizkostenV" manages the distribution of the total heat consumption of a building heated by a central heating system to the individual usage units or users.
» **§ 6b Permissibility and scope of data processing**
  - The collection, storage and use of data from remotely readable equipment for the purpose of metering may only be carried out […] insofar as this is necessary to fulfill the consumption-based cost allocation and for billing […]

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AGFW **Legal boundary conditions**

Open Questions?

- Are we allowed to use additional data gathered with the FFVAV infrastructure (more frequently collected, return & supply temperatures, etc.)
- Are heat meter data personal data? → EU GDPR?
- Is there a minimum number of households "behind a substation" to avoid personal data?
- Could we adapt the requirement of data usage in general at new contracts?
- Could we change the technical connection conditions (TAB) that are a linked part of the DH contract.
- How to find the best way to ask customers for permission to use substation data for optimisation purposes?
- Whom we need to ask for permission, if the house owner is the DH customer and not the residents?
- Is it useful to use pseudonymized data with no location information of the substation?
- What's next?
  - NIS 2
  - EU Data Act
- …

Tomorrow:
Legal Requirements for Data Protection and Cybersecurity in the Digitalization of District Heating and Cooling
Carsten von Gneisenau, Stiftung Umweltenergierecht, Germany

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AGFW

Get the benefits

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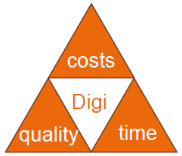
AGFW **Get the benefits**

Possible benefits of digitalisation are



- **Reduction of costs**
  - optimised grid operation modes reducing heat losses and electricity demand for pumps
  - optimised heat generation reducing primary energy demand
  - etc.
- **Improving the quality**
  - faster detection of leakages could avoid major damage at the DH grid (Security of supply)
  - detection of poorly performing substation (avoid supply outages)
  - etc.
- **Reduce the time effort**
  - internal management of customer alarms (optimised staff deployment)
  - automated heat meter data collection and billing process (no manual meter reading, less manual processes)
  - etc.

Source: State of Green[3]

Source: DHC+ [2]

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AGFW **ILSE**

- „Intelligent Learning Systems in Energy Networks (ILSE)"
- **Funding code:** 03EN3033B
- **Project period:** 01.04.2021 – 31.03.2024
- **Supported by:** Supported by: Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag
- **Project partner** AGFW; stadtwerke rosenheim; Technische Hochschule Rosenheim Fakultät Informatik; INEV ENERGIE. INNOVATION. EFFIZIENZ.

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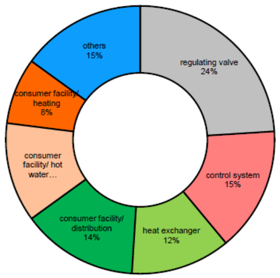
AGFW Get the benefits

Possible benefits of digitalisation are

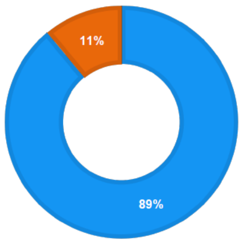
- not always realised by being discovered!
- example detection of substation errors

AFFECTED COMPONENTS



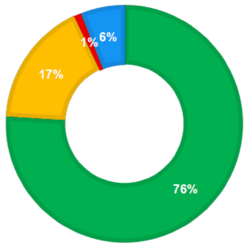
Source: Müller, Binder et Schmidt 2021 [4]

RESPONSIBILITY „ERROR CORRECTION“



Source: Müller, Binder et Schmidt 2021 [4]

EFFORT “ERROR CORRECTION”



Source: Müller, Binder et Schmidt 2021 [4]

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Other Topics

AGFW N5GEH - DigiHEAT

fernwärme digital

- „Digitalised heat and power plant for a more efficient urban district heating supply “
- **Funding code:** 03EN3065 A
- **Project period:** 01.11.2022 – 31.10.2025 (36 month)
- **Supported by:**

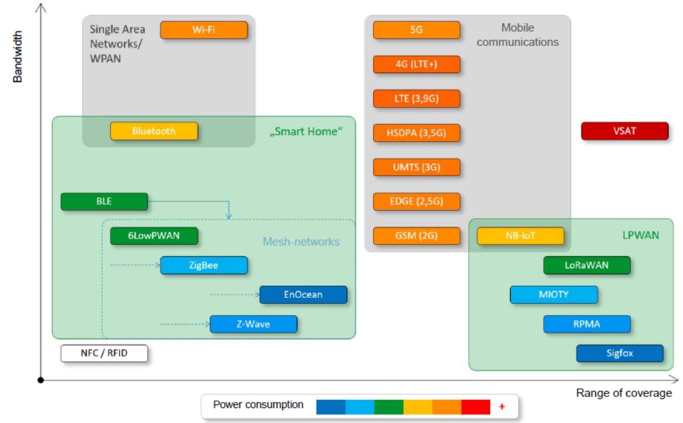
Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

- **Project partner**

AGFW, stadtwerke hanau, Stadtwerke Gießen SWG, STADTWERKE MARBURG, Danfoss, Fraunhofer IEE, Technische Universität Berlin

AGFW Data transfer technology

Choosing the best technology



Multiple options for different usecases

- **Energy consumption**
- **Building penetration**
- **Data transmission rate**

- **Market availability**
- **Manufacturer/ Provider**
- **Security/ Approval**

Presentation 6:
Industry Needs for Practical Implementation
of Digitalization Processes

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Transferability and Comarability

Direct transfer of BPE is sometimes challenging

- examples with very different starting points
- No standards for the comparability of software solutions
- Multiple software tools with different ideas and approaches
- No uniform definition of buzzwords (eg. Digital Twin)

Source: Screenshot of https://www.fernwaerme-digital.de/software-tools [8]

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Conclusion

www.agfw.de Page 18

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Industry Needs for Practical Implementation of Digitalization Processes

Conclusion

- Individual strategy and vision
- Clear and sustainable legal framework conditions
- Further practical examples of various district heating systems with detailed information on initial situations, costs and ROI
- Clear picture of expected added value technically and economically
- Information and support for detailed (technical) topics
- Experience Exchange with other Utilities

IEA DHC

fachtage fernwärme 17.-18.04.2024 KONGRESSPALAIS KASSEL

fernwärme digital

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Industry Needs for Practical Implementation of Digitalization Processes

Research activities and communication

SAM-FW
- Sustainable Asset Management District Heating: Sustainability assessment of heating networks for increasing the service life and efficiency in operation;

N5GEH-DigiHeat
- Digitalised heat and power plant for a more efficient urban district heating supply

N5GEH-DIGiHAST
- Digitization of heat transfer in house stations and network nodes

ILSE
- Intelligent Learning Systems in Energy Networks (ILSE)

FW-Digital
- Digitalisation of technology and business processes in heat supply systems

SAM-FW DIGIHEAT DIG iHAST ILSE FWdigital

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Sources

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Sources

[1]	Verordnung über die Verbrauchserfassung und Abrechnung bei der Versorgung mit Fernwärme oder Fernkälte (Fernwärme- oder Fernkälte-Verbrauchserfassungs- und -Abrechnungsverordnung - FFVAV) Ausfertigungsdatum: 28.09.2021
[2]	Digitalisation in District Heating and Cooling Systems – DHC+ May 2023 https://www.euroheat.org/dhc/knowledge-hub/dhc-report-on-digitalisation-in-dhc-systems
[3]	Digitalisation of the Danish District Heating Sector, State of Green, June 2023, https://www.euroheat.org/static/0c206794-6738-47fb-80ed739b50656bb2/Danish-Case-Catalogue-2023.pdf
[4]	Müller, Andreas; Binder, Jakob; Schmidt, Ralf-Roman (2021): Zukunftsfähige Fernwärmenetze durch niedrige Netztemperaturen. In: EuroHeat&Power (6/2021), S. 50–55.
[5]	Directive (EU) 2022/2555 of the European Parliament and of the Council of 14 December 2022 on measures for a high common level of cybersecurity across the Union, amending Regulation (EU) No 910/2014 and Directive (EU) 2018/1972, and repealing Directive (EU) 2016/1148 (NIS 2 Directive) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022L2555&qid=1700140471057
[6]	Dashboard AGFW Hauptbericht, „Zahlen aus amtlicher Statistik 2020" https://experience.arcgis.com/experience/82acf304f20046c3983ad82d3ef9aeae/
[7]	AGFW | Der Energieeffizienzverband für Wärme, Kälte und KWK e. V (Hg.) - Praxishilfe Fernwärmeleitungsbau – Verlegesysteme und Kosten 2021
[8]	Plattform Fernwärme Digital www.fernwaerme-digital.de
[9]	AGFW | Der Energieeffizienzverband für Wärme, Kälte und KWK e.V. (Hrsg.): Sonderheft der AGFW Heftreihe Forschung und Entwicklung. AGFW-Orientierungshilfe zur Digitalisierung in der Fernwärmebranche. Frankfurt am Main: AGFW-Projektgesellschaft für Rationalisierung, Information und Standardisierung mbH 2019
[10]	Prüß, H., Zopff, C. u. Richter, S.: Digitalisierung als Mittel zur Prozessexzellenz in der Fernwärme – Teil 1. EuroHeat&Power 47 (2018)

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Presentation 6:
Industry Needs for Practical Implementation
of Digitalization Processes

AGFW Legal boundary conditions

Is there a digitalisation need in DH?

» Overview of most relevant FFVAV Information obligation

Type	Content	FFVAV
Relevant billing information	Consumption and prices of the billing period	§ 5 (1) No. 1
	Taxes, duties or customs duties	§ 5 (1) No. 2 c)
Classification of the current consumption	Comparison with the customer's previous year's consumption	§ 5 (1) No. 3
	Comparison with an average customers consumption	§ 5 (1) No. 6
Energetic quality	Proportion of energy sources and heat generation technologies used in the overall energy mix	§ 5 (1) No. 2 a)
	Proportion of renewable energies used in the overall energy mix	§ 5 (3)
	Greenhouse gas emission	§ 5 (1) No. 2 b)
	Primary energy factor	§ 5 (3)

AGFW AGFW Research & Development topics

AGFW THE AGFW R&D TEAM

R&D Team in Frankfurt

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CEO AGFW-Projekt GmbH

Dipl.-Ing. Stefan Hay

Kibriye Sercan-Çalışmaz M.Sc.

Sebastian Grimm M.Sc.

Heike Kratzert

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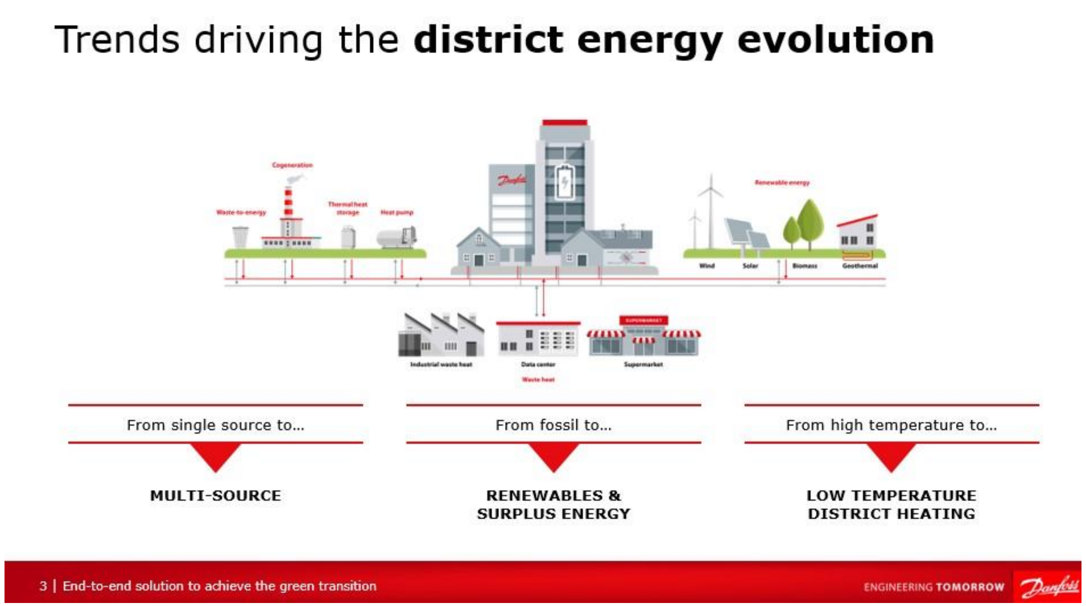
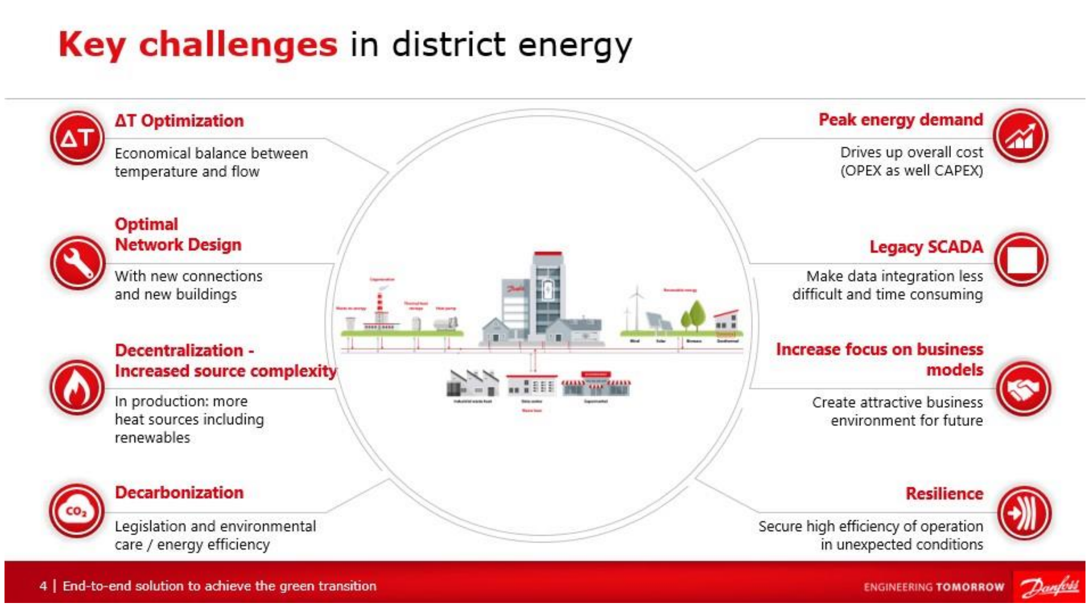
Dr. Andrej Jentsch
Münster, NRW

Dr. Bernd Wagner
Regensburg, BY

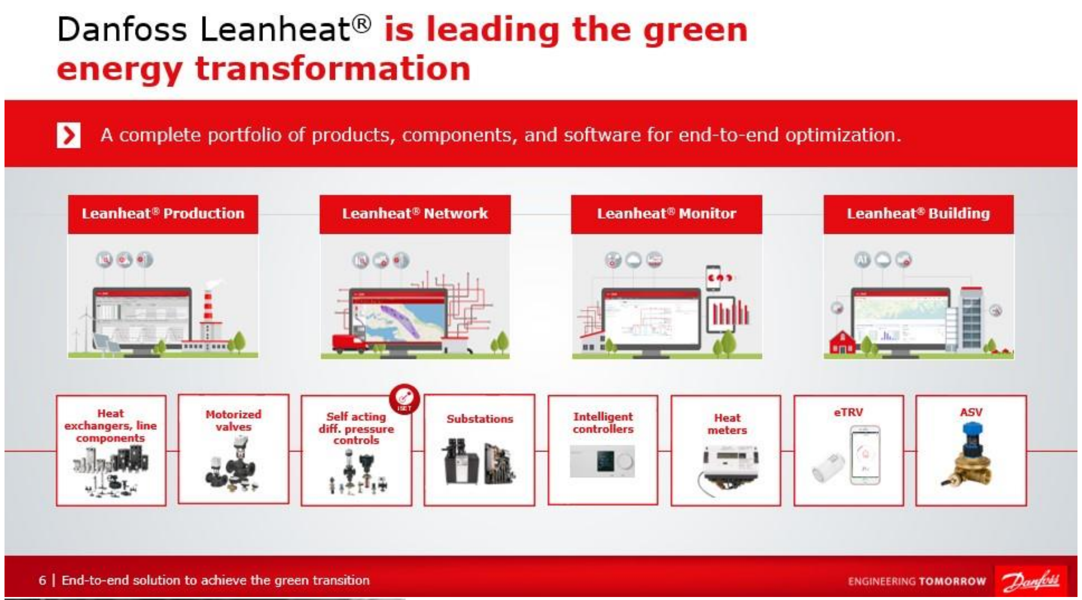
Session III – Digitalization of the Demand Side





Presentation 7:
End-to-End Heat Supply System
Optimization via Leanheat Software


Danfoss Leanheat®
Leanheat® Production (LHP)
Leanheat® Network (LHN)
Leanheat® Monitor (LHM)
Leanheat® Building (LHB)
PRODUCTION & DISTRIBUTION
PRIMARY SIDE
DEMAND
SECONDARY SIDE
5 | End-to-end solution to achieve the green transition
ENGINEERING TOMORROW


Danfoss Leanheat® is leading the green energy transformation
A complete portfolio of products, components, and software for end-to-end optimization.
Leanheat® Production
Leanheat® Network
Leanheat® Monitor
Leanheat® Building
Heat exchangers, line components
Motorized valves
Self acting diff. pressure controls
Substations
Intelligent controllers
Heat meters
eTRV
ASV
6 | End-to-end solution to achieve the green transition
ENGINEERING TOMORROW

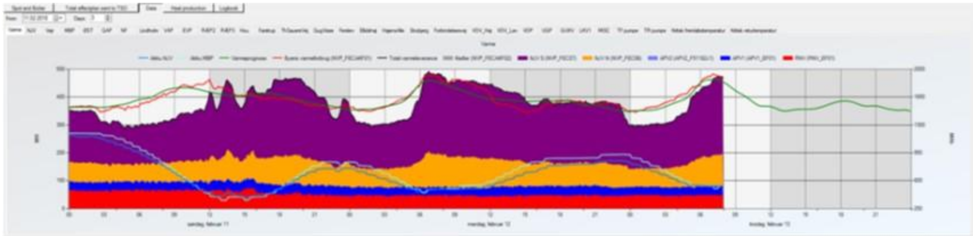

Leanheat
Production
7 | End-to-end solution to achieve the green transition
ENGINEERING TOMORROW

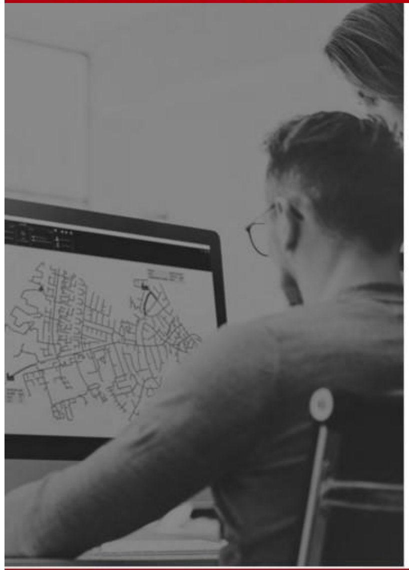

Leanheat® Production
Leverage data to maximize energy efficiency.
Leanheat® Production is an advanced software tool for forecasting, planning, and optimizing district energy production and distribution. The future-proof software helps adjust, reduce, and optimize energy consumption.
• Load forecasting predicts exact in-network heat consumption
• Production optimization saves between 1 – 3% on fuel costs annually
• Temperature optimization reduces heat loss by 5 – 10%
• Low ROI between 0-5 – 2 years
Predictive maintenance
Improved reliability, uptime, service life
8 | End-to-end solution to achieve the green transition
ENGINEERING TOMORROW

Leanheat® Production
Achieve more with optimization and planning

Leanheat® Production **supports the operation staff in the daily operation to:**

Reduce loss in the district energy network	Suggest the most **economical operating schedule**	Collect all the **relevant data**	Achieve **time savings** in daily operations	Ensure the best possible **price on energy** during security of supply	**Develop** and maintain **the skills** of operating staff





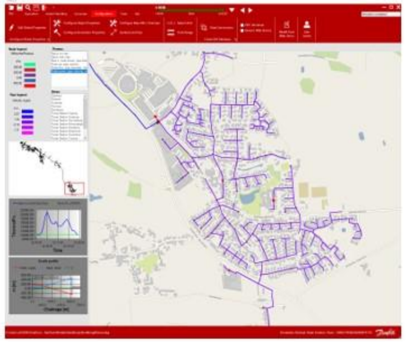
Leanheat® Network
Plan, visualize, and optimize a sustainable network operation

Leanheat® Network is a thermo-hydraulic modeling tool developed specifically for use in district energy systems to support the planning, design, and operational processes.

- Network design to **build and maintain models**
- **Simulate** hydraulic and thermal conditions in district heating network
- **Optimize** network supply temperatures and pressure conditions
- **Predict** and interpret future consumptions on your network using AI

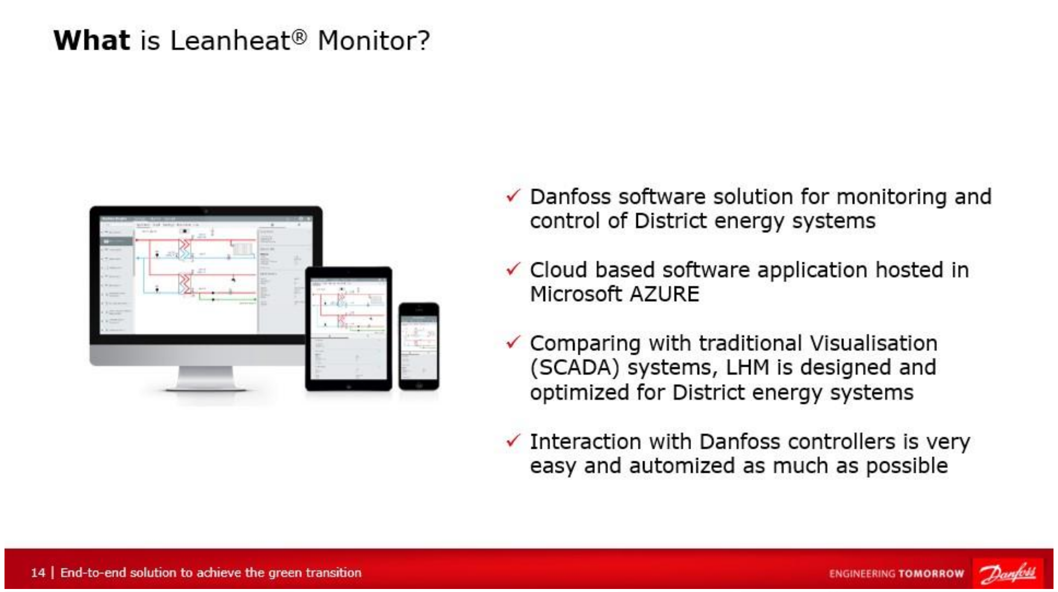
Leanheat® Network
Achieve improved and sustainable network operation

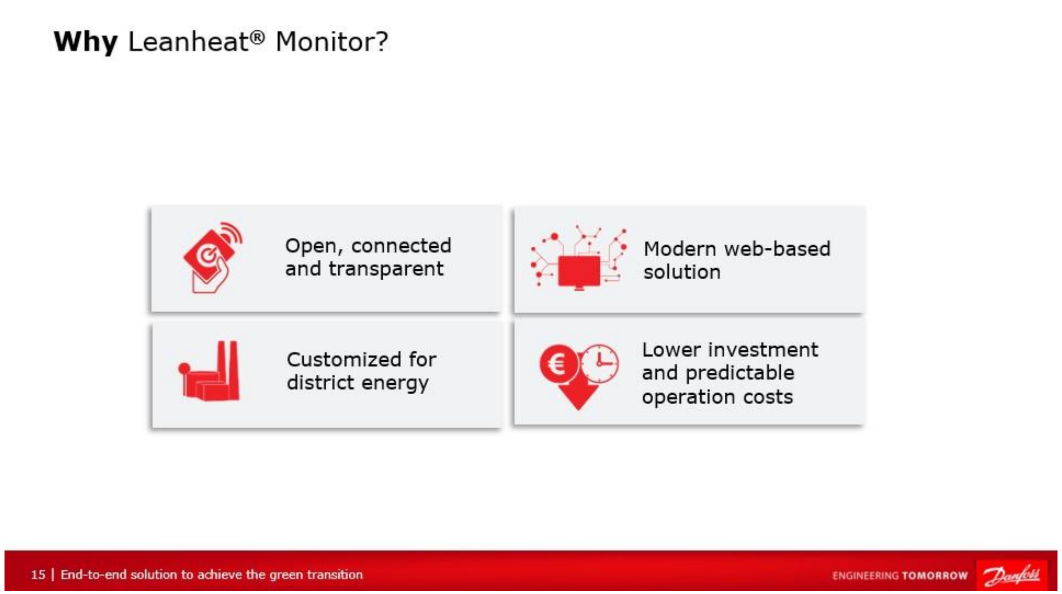
Leanheat® Network as an online support tool



Calculate **optimal hydraulic parameters** and apply them	Overview of the **temperature, flow** and **pressure** at any point in the network	Overview of **the composition of production sources** at any point in the network
Simulation of future conditions based on weather prognosis	**What-if analysis** for daily operating challenges and critical events	Planning of interventions with **effective execution** and **quality of services**

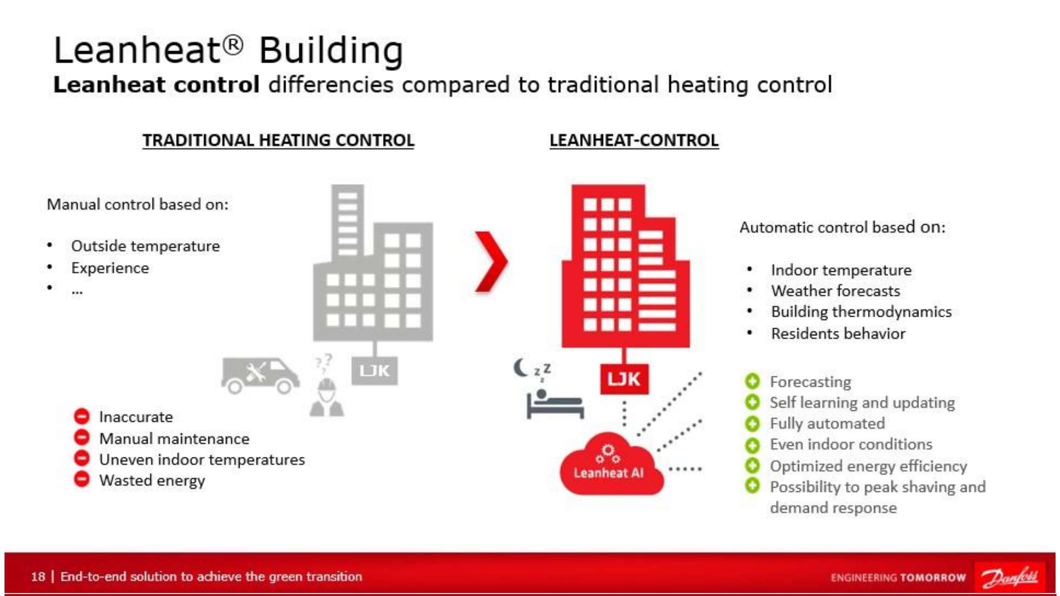

Leanheat Monitor
13 | End-to-end solution to achieve the green transition
ENGINEERING TOMORROW
Danfoss


What is Leanheat® Monitor?
✓ Danfoss software solution for monitoring and control of District energy systems
✓ Cloud based software application hosted in Microsoft AZURE
✓ Comparing with traditional Visualisation (SCADA) systems, LHM is designed and optimized for District energy systems
✓ Interaction with Danfoss controllers is very easy and automized as much as possible
14 | End-to-end solution to achieve the green transition
ENGINEERING TOMORROW
Danfoss


Why Leanheat® Monitor?
Open, connected and transparent
Modern web-based solution
Customized for district energy
Lower investment and predictable operation costs
15 | End-to-end solution to achieve the green transition
ENGINEERING TOMORROW
Danfoss


Leanheat Building
16 | End-to-end solution to achieve the green transition
ENGINEERING TOMORROW
Danfoss


Leanheat® Building
AI-optimized heating control
and maintenance.
Leanheat® Building is a cloud-based AI solution using IoT technology to enable smart heating control and maintenance in buildings. Leveraging sensor data to optimally control the HVAC system, power usage is reduced by 10 – 30% without compromising comfort.
• Peak load optimization
• Energy optimization
• Maintain comfortable indoor climate
• Mechanical maintenance savings
• Scalable solution
17 | End-to-end solution to achieve the green transition
ENGINEERING TOMORROW Danfoss


Leanheat® Building
Leanheat control differencies compared to traditional heating control
TRADITIONAL HEATING CONTROL
LEANHEAT-CONTROL
Manual control based on:
• Outside temperature
• Experience
• ...
LJK
Inaccurate
Manual maintenance
Uneven indoor temperatures
Wasted energy
Automatic control based on:
• Indoor temperature
• Weather forecasts
• Building thermodynamics
• Residents behavior
LJK
Leanheat AI
Forecasting
Self learning and updating
Fully automated
Even indoor conditions
Optimized energy efficiency
Possibility to peak shaving and demand response
18 | End-to-end solution to achieve the green transition
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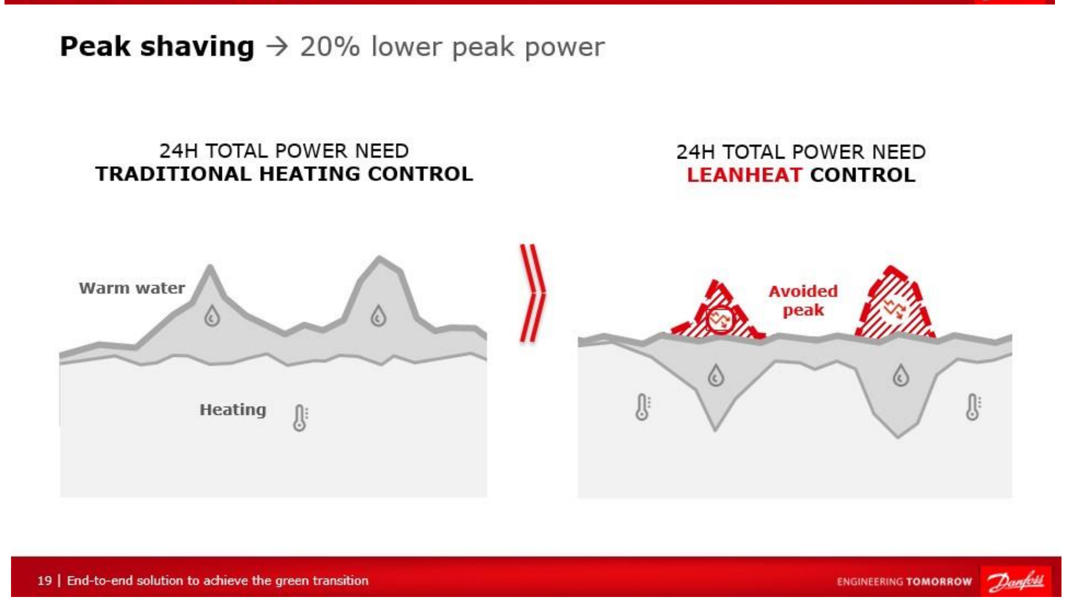
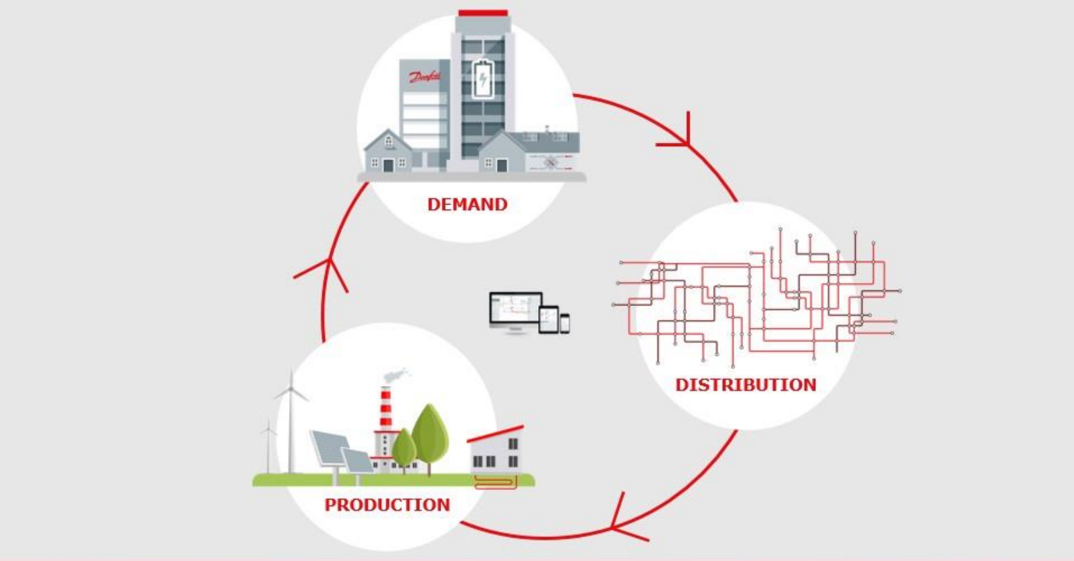
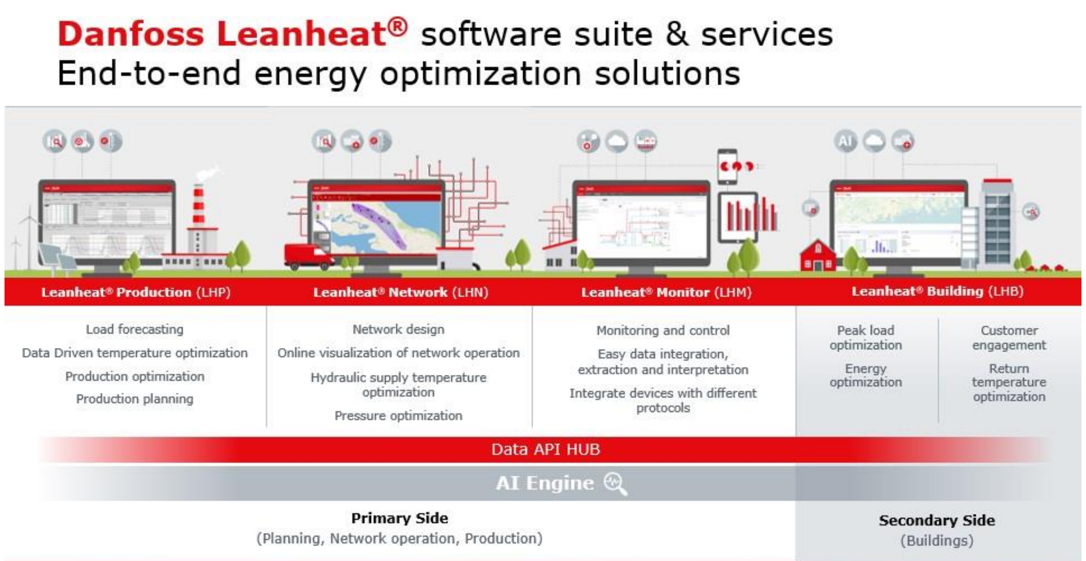

Peak shaving → 20% lower peak power
24H TOTAL POWER NEED
TRADITIONAL HEATING CONTROL
Warm water
Heating
24H TOTAL POWER NEED
LEANHEAT CONTROL
Avoided peak
19 | End-to-end solution to achieve the green transition
ENGINEERING TOMORROW Danfoss


ENGINEERING TOMORROW Danfoss
Conclusions



21 | End-to-end solution to achieve the green transition ENGINEERING TOMORROW



22 | End-to-end solution to achieve the green transition ENGINEERING TOMORROW

Thank you for your attention

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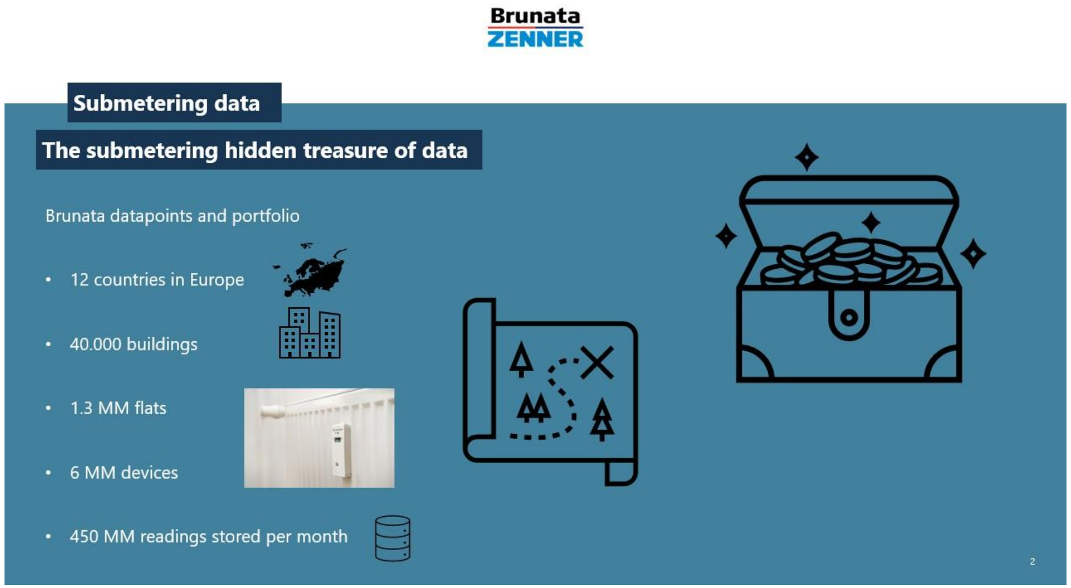
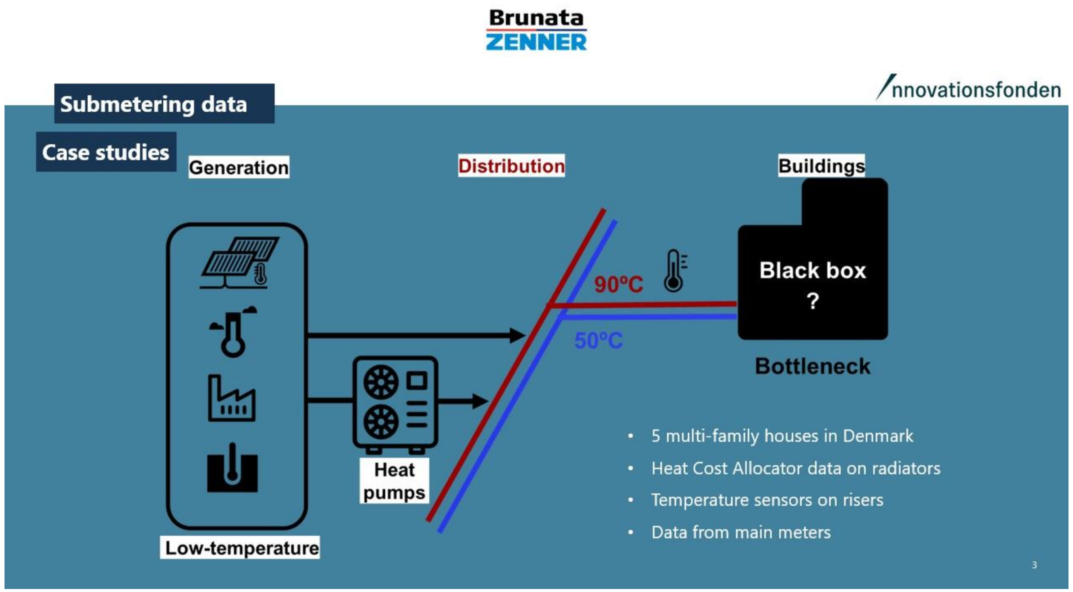
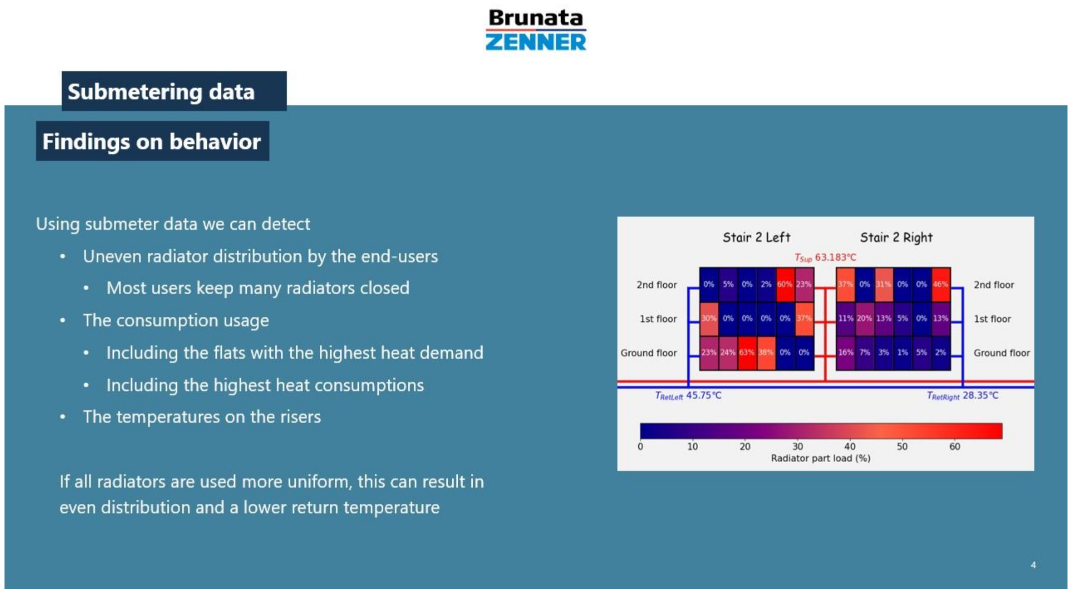
23 | End-to-end solution to achieve the green transition ENGINEERING TOMORROW

ENGINEERING
TOMORROW







Presentation 8:
Energy Meters and Submeters Data for Innovative Control and Operation of Heating Systems in Buildings

Brunata ZENNER

Submetering data

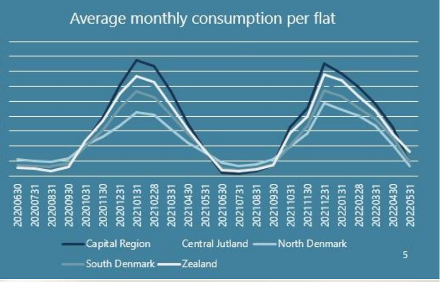
can contribute to healthy DHS from the demand side

Advantages

- Help behavioral change to save energy and costs
- Pinpoint inefficient use of radiators
  - Radiators are the most used heat elements in space heating systems in Europe
- Analyze faulty radiators, potentially causing high return temperatures
- Increasing attractiveness for future investments

Challenges

- Not engaged end-users limit the implementation of low-temperature operation in multi-story buildings
- Thermal comfort and financial energy savings are the main drivers for end-users
- Behavioral change might be slower than technical change



5

Brunata ZENNER

Submetering data

Why use submeter data to contribute to lowering return temperatures

The incentive

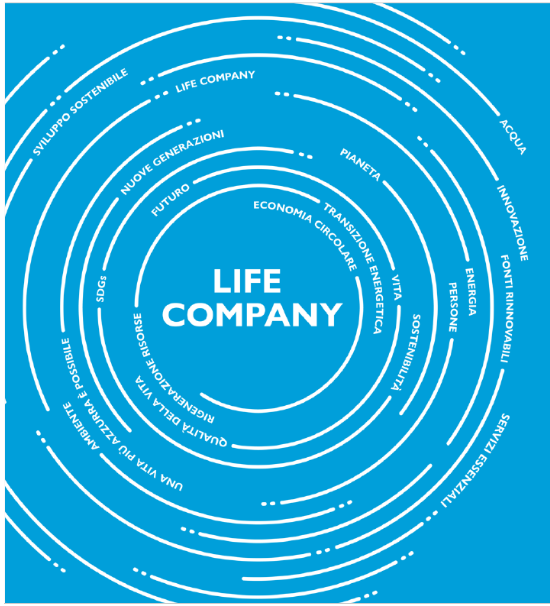
- We can use what we have
  - None to very little additional investment required
- High frequency readings from reliable data sources with complete datasets (including historic data)
- Due to legislations, most multi-family houses (must) have heating and hot water meters with remote readings
- We can contribute to the lowering of return temperatures without full renovations of the building

Business potential for submetering

- Informative services for building owners and end-user to pinpoint restrictive behavior that leads to poor distribution of heating energy
- Provide insights of the building properties with big-data sets
- Help heating system operators identify errors and malfunctions in the radiator systems

6

Presentation 8:
Energy Meters and Submeters Data for Innovative Control and Operation of Heating Systems in Buildings



A2A Calore e Servizi

District Heating Management

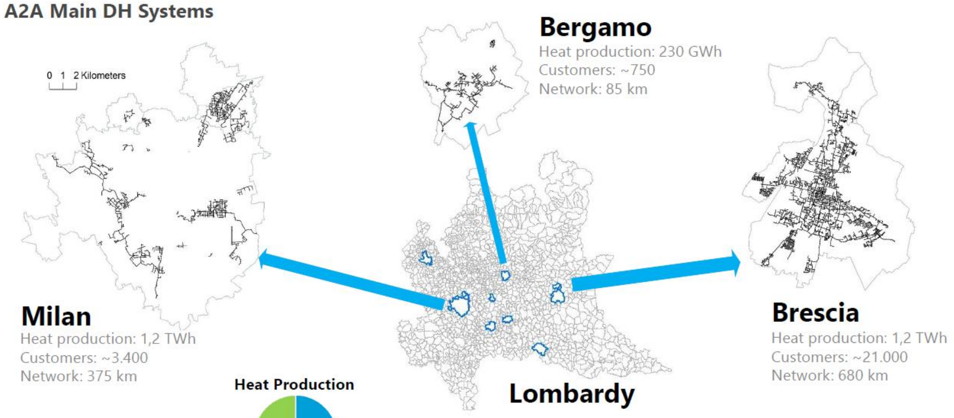
Digitalization – The (Present) Future

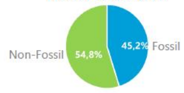
20th November, 2023

a2a LIFE COMPANY

A2A DISTRICT HEATING SYSTEMS

A2A Main DH Systems





In total, more than 1,100 km of underground pipes installed

A2A Calore e Servizi

a2a LIFE COMPANY

2

«TEMPO» PROJECT - TEMPERATURE OPTIMISATION FOR LOW TEMPERATURE DISTRICT HEATING ACROSS EUROPE

TEMPO

Objectives: demonstrate the applicability of low temperature district heating through different solution packages including:

- technological innovations on the network and building side,
- consumers' empowerment enabled by digital solutions,
- and innovative business models for EU replication.

Duration: October 2017 – March 2022

Funding frame: EU H2020 EE-04-2016-2017: New heating and cooling solutions using low grade sources of thermal energy, GA 768936

Web-site: www.tempo-dhc.eu

A2A Calore e Servizi

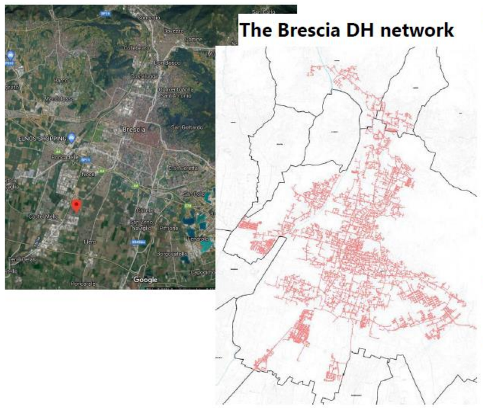
a2a LIFE COMPANY

3

BRESCIA DEMO SITE (1)

TEMPO

DH System Main Characteristics



- The largest DH system in Italy:
  - ~1.1 TWh/a, peak 670 MW
  - 61% waste-to-energy CHP; 27% gas CHP; 10% gas boiler, 2% waste heat
  - ~70% of town demand, >21,000 customers
- Supply temp. up to **130 °C** in winter, **80÷90 °C** in summer; Return temperature: ~ **60 °C**
- **High interest in temp. reduction, at least in low-density branches;**
- Bottlenecks on the building side: heat demand, heating system, CTRL, connection size, customer behavior

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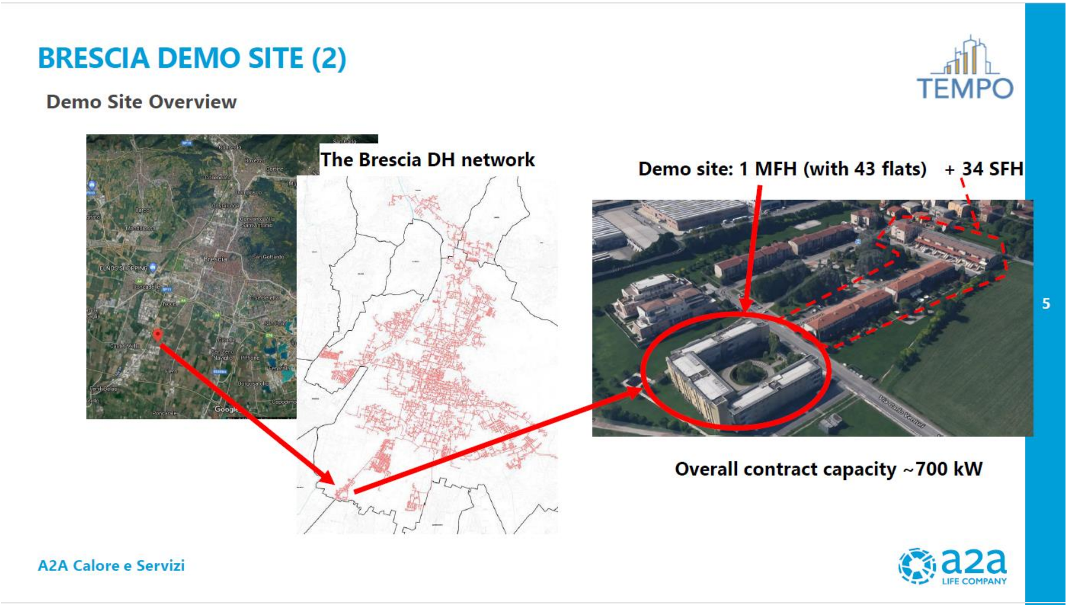
BRESCIA DEMO SITE (2)
Demo Site Overview
TEMPO
The Brescia DH network
Demo site: 1 MFH (with 43 flats) + 34 SFH
Overall contract capacity ~700 kW
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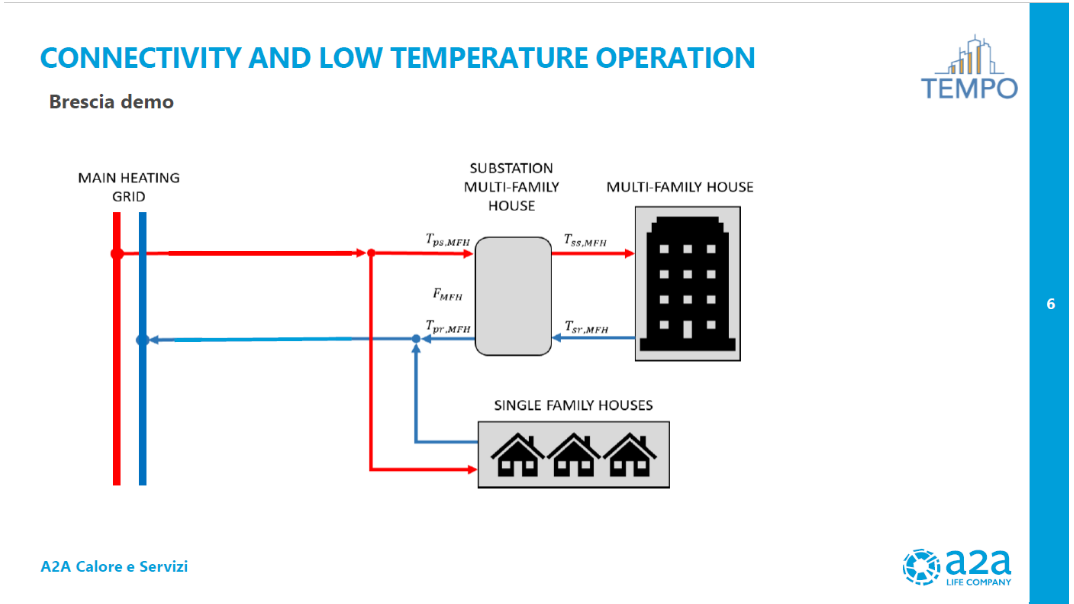
CONNECTIVITY AND LOW TEMPERATURE OPERATION
Brescia demo
TEMPO
MAIN HEATING GRID
SUBSTATION MULTI-FAMILY HOUSE
MULTI-FAMILY HOUSE
$T_{ps,MFH}$
$T_{ss,MFH}$
F_{MFH}
$T_{pr,MFH}$
$T_{sr,MFH}$
SINGLE FAMILY HOUSES
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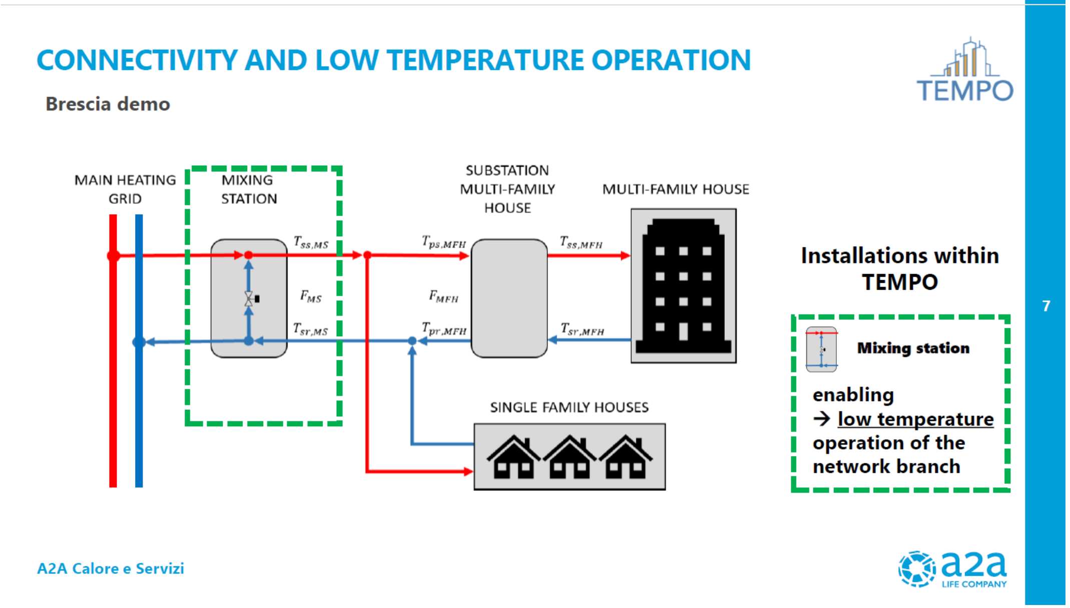
CONNECTIVITY AND LOW TEMPERATURE OPERATION
Brescia demo
TEMPO
MAIN HEATING GRID
MIXING STATION
SUBSTATION MULTI-FAMILY HOUSE
MULTI-FAMILY HOUSE
$T_{ss,MS}$
F_{MS}
$T_{sr,MS}$
$T_{ps,MFH}$
$T_{ss,MFH}$
F_{MFH}
$T_{pr,MFH}$
$T_{sr,MFH}$
SINGLE FAMILY HOUSES
Installations within TEMPO
Mixing station
enabling
→ low temperature operation of the network branch
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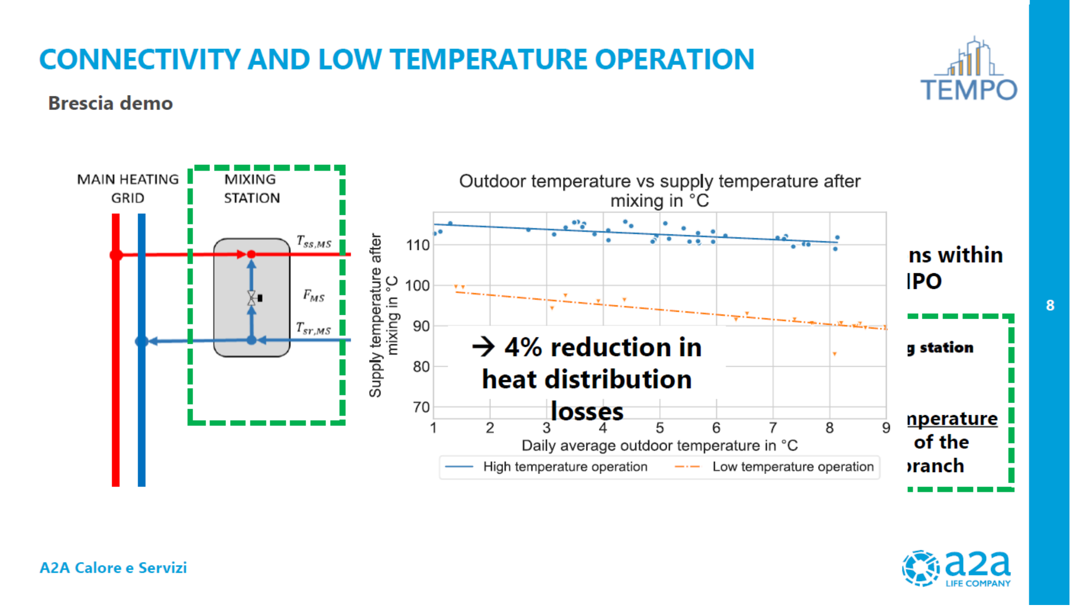
CONNECTIVITY AND LOW TEMPERATURE OPERATION
Brescia demo
TEMPO
MAIN HEATING GRID
MIXING STATION
$T_{ss,MS}$
F_{MS}
$T_{sr,MS}$
Outdoor temperature vs supply temperature after mixing in °C
Supply temperature after mixing in °C
110
100
90
80
70
1
2
3
4
5
6
7
8
9
Daily average outdoor temperature in °C
High temperature operation
Low temperature operation
→ 4% reduction in heat distribution losses
ns within
IPO
g station
nperature
of the
ranch
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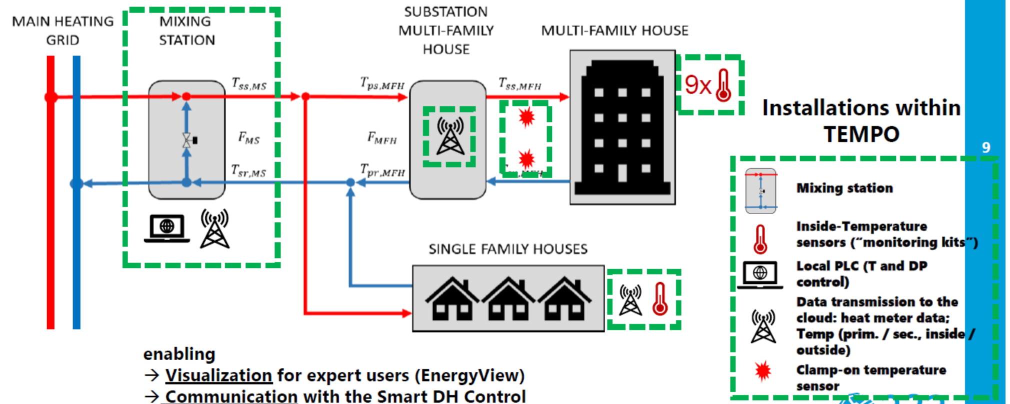
CONNECTIVITY AND LOW TEMPERATURE OPERATION

TEMPO

Brescia demo



enabling
→ Visualization for expert users (EnergyView)
→ Communication with the Smart DH Control
→ Demand side management by faking outdoor temp.

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SMART DH NETWORK CONTROLLER

TEMPO

Brescia demo

Directly controls the network supply temperature at the mixing station

Application: **PEAK LOAD REDUCTION** using the energy flexibility of the DH network

Makes use of the thermal mass of the buildings

Application: **RETURN TEMPERATURE REDUCTION**

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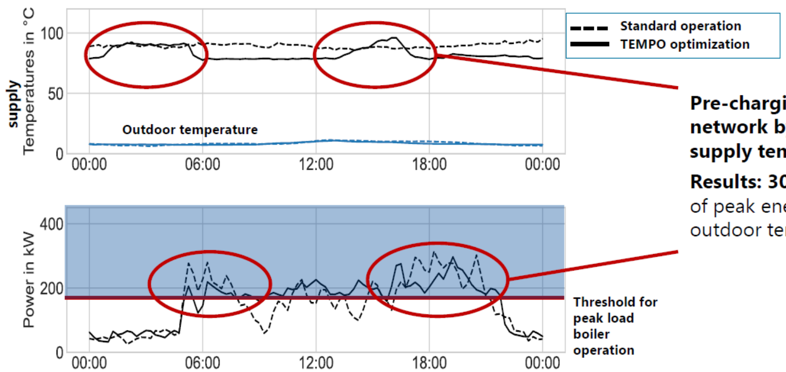
PEAK LOAD REDUCTION

TEMPO

Brescia demo



Pre-charging of the DH network by increasing supply temperatures

Results: 30 to 50% reduction of peak energy (at higher outdoor temperatures)

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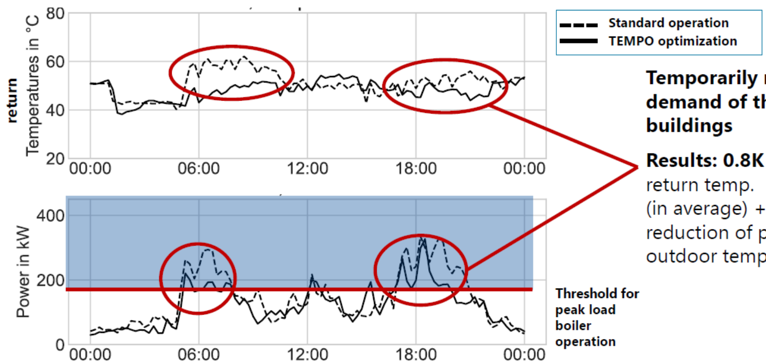
RETURN TEMPERATURE REDUCTION

TEMPO

Brescia demo



Temporarily reducing the heat demand of the connected buildings

Results: 0.8K reduction of daily return temp.
(in average) + **60% to 70%** reduction of peak energy (at higher outdoor temp.)

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CHALLENGES AND LESSONS LEARNED

Non-technical:

- Every **involvement and communication towards the customer** is sensitive and needs to be planned carefully
- Involvement of final customers is **not certain**
- **Contractual terms** as well as responsibilities / ownership must be carefully evaluated when proposing activities on customers side (in Brescia the customers are the owner of the substations)

Technical:

- The **implementation of ICT and monitoring equipment** need to be carefully planned to ensure full connectivity and interoperability
- **The building side heating systems:**
  - can be very complex (e.g. interdependency between different variables) thus limiting the possible impact of the innovations
  - can be very building specific and details are often unknown, leading to difficulties in implementation of the innovations;
  - can limit the building flexibility due to bad design

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CUSTOMER DDM (DISTRICT DEMAND MANAGEMENT) PROJECT

Data platform development	Customer characterisation chart	Historic data retrieve	KPI definition
Merging data from different platforms	Tecnichal and economical parameters comparison	Power domand profile and climate data	Customers evaluation and peak shaving.

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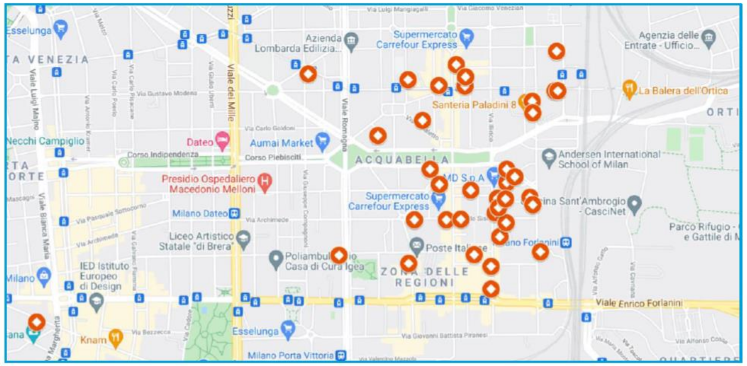
CUSTOMERS INVOLVED

39 buildings in Milan



- **20 buildings** with active **day/night tariff**
- **Just one maintenance technician + 2 building managers** involved
- Customers subtended to **12 concentrators** (replaced)
- **+ 40 regulation device** updated
- **Indoor sensors** in 7 apartment block

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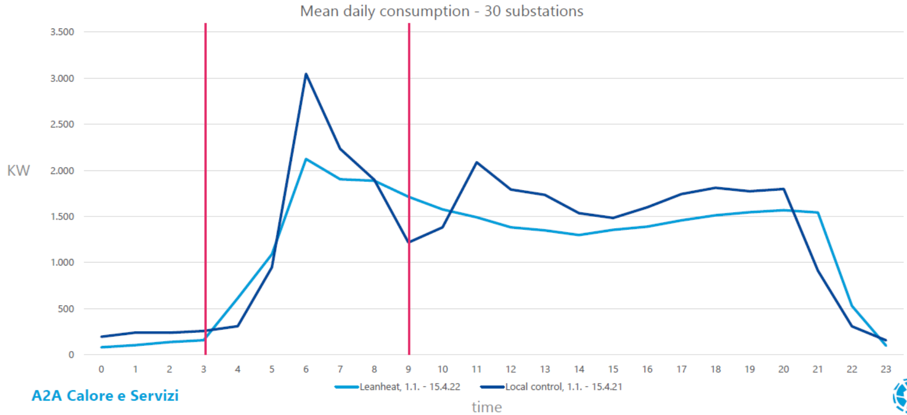
IMPACT EVALUATION ON TOTAL ENERGY DEMAND

Energy consumption reduced by **16%** compared with previous year



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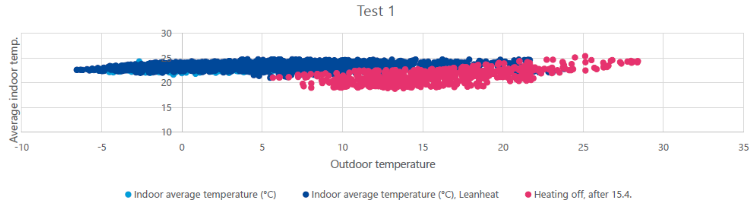
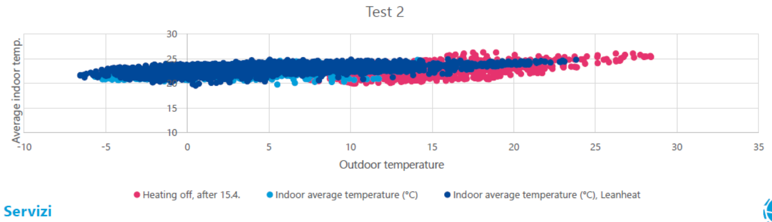
INDOOR COMFORT EVALUATION

No significant indoor temperature changes





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FINAL RESULTS - OVERVIEW

# 32	# 7	- 30%	- 19%
Buildings completely controlled via DDM	**Building equipped with indoor sensors** to evaluate confort within the project timeline	**Peak load mean reduction** recorded in 4 months in 32 buildings	**Mean energy saving** compared to previous year in a 4 months period

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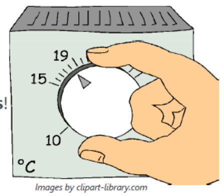
DHC DIGITALISATION

Challenges and Opportunity

- Driving forces:
  - market/customers
  - policy/regulations
- What is needed?
  - Action at building level
  - Probably/possibly new rules
  - New business models to enable/facilitate sector market interrelation

➢ DHC fully enable energy sharing at a local (city) level

But… don't forget the **role of energy users**!



Images by clipart-library.com

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QUESTIONS OR COMMENTS?

Alessandro Capretti
Head of District Heating Network Planning and Design
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www.a2acaloreservizi.eu

THANK YOU

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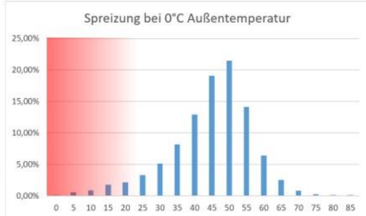
Session IV – Digitalization to Link the Entire Supply Chain

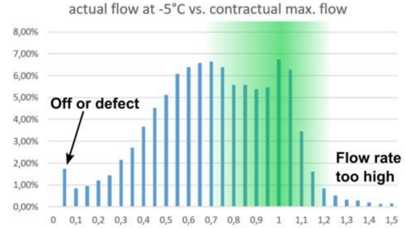
SAM DIGITAL

TYPICAL NUMBERS FOR HEATING NETWORKS

- 5% ob substations have a very small spread in primary loop (in winter – more in summer)
- 12% of consumers go over contractual flow rates
- Inlet temperatures in network (primary loop) typically 10-15K over required minimum
- Inlet temperature in building typically 4K above minmally needed temperature

→ **Optimiziation potentials**





APPROACH

Optimization on several scales

1. Secondary loop and primary return flow
2. Primary inlet flow

Why this split? Experiments show

- Primary inlet temperature influences flow rate, but not primary return flow temperature
- 1K reduction of secondary inlet temperature typically causes a reduction of primary return flow temperature by 0,8K (while not undersupplying)

→ Concept of separation goes straight through consumer

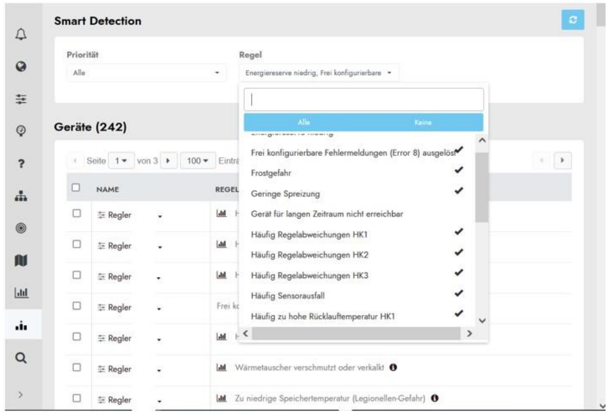
Image source: https://www.flaticon.com/de/kostenlose-icons/wohn; https://www.flaticon.com/de/kostenlose-icons/kraftwerk

SMART DETECTION

Smart Detection

- Automatically highlight problematic substations
- Automatic priorization
- Repair recommendation

→ 30-80% fewer service trips

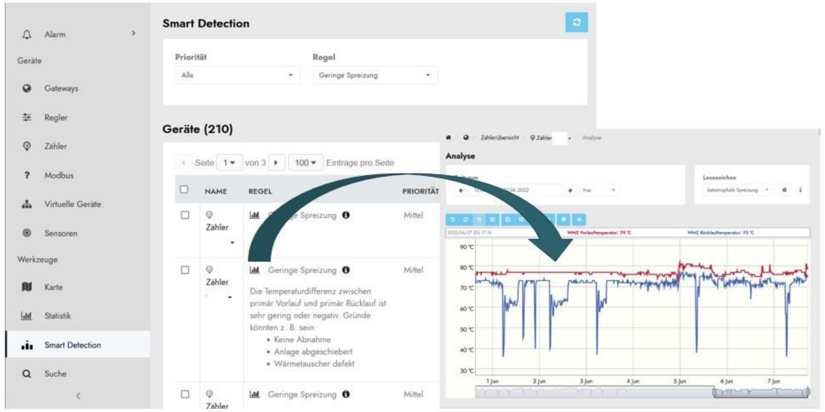


SMART DETECTION

Jump to problematic data sequences

One substation can cost 100.000€/year unnecessary network pump power

5% worst substations are 60% pump power in summer and 20% in winter



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NETWORK OPTIMIZATION: REDUCE RETURN FLOW TEMPERATURE

Detect outliers and errors → Smart Detection

Solutions in house

1. **AI-based predictive** setpoint-reduction secondary loop (also available as **digital twin**) → Smart Temp
2. Support for hardware issues in substations → Smart Detection
3. Hard limiting the return flow temperature in controller (55xx)

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SMART TEMP

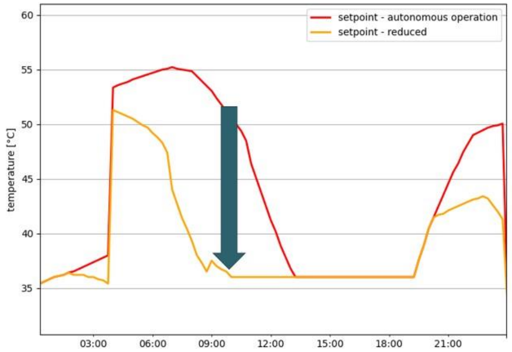
Reduce secondary inlet temperature

→ AI based load prediction using weatherforecast, time, date etc

→ Reduce inlet temperature → reduce return temperaterature, flow rate, unwanted heat losses etc

→ Digital twin: test mode in simulation surroundings

No additional sensors needed



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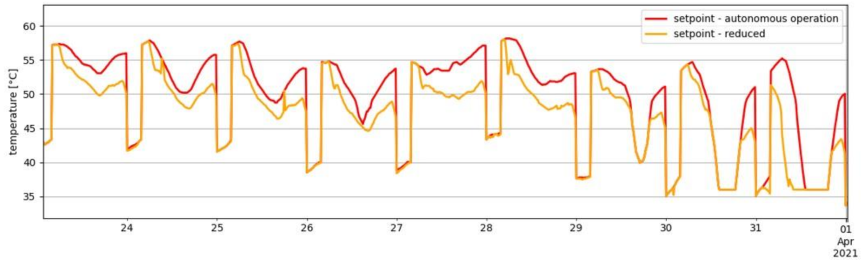
SMART TEMP

Significantly reduce heat loss and pump power

- 10% more spread means 27% less pump power



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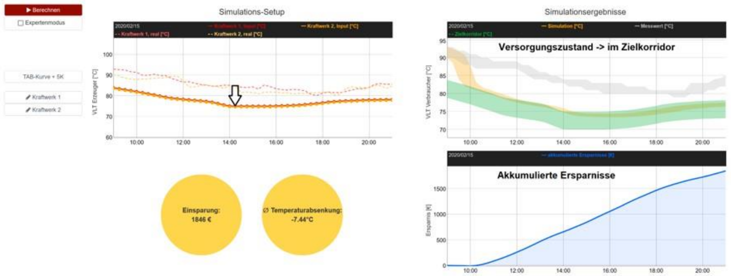
NETWORK OPTIMIZATION: SUPPLY

Network optimization based on data

- **AI-based prediction**
- **Optimizing** balance heat losses and pump power
- **Digital twin**: different future szenarios can be tested without influencing the real system
- Optimization based on inlet data and metering data

Typically networks are 10K-15K too warm
→ proven heatloss >12%



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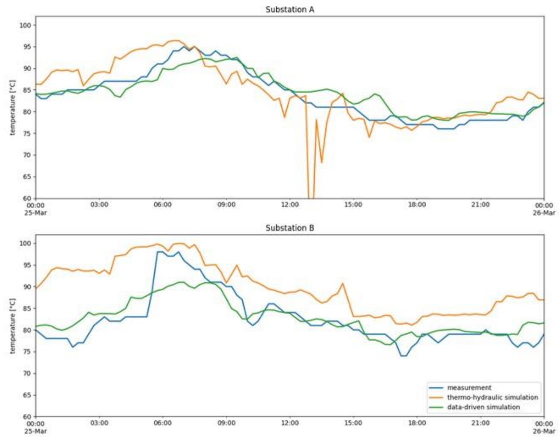
LASTVORHERSAGE EINZELSTATIONEN

AI based load prediction and learned properties of network

→ No thermoydraulic model required

→ 5-30% better than thermohydraulic network models (because these often have inaccurate input)

Using meta-data (contract value, building type etc) , replacement load models can be used.



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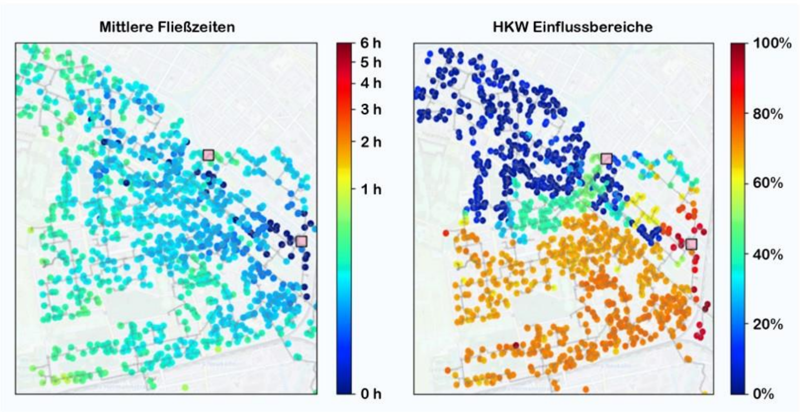
STAGGERING NIGHT SETBACK

Runtime in the network
→ End of the night setback strategic staggering

Used data:

- Meter and feed point data (historical)



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FINAL NOTES

Contact

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www.samsongroup.com

This presentation included results from funded research
ML4Heat: FKZ 03ET1668, runtime 7/2019 – 12/12/2022, funded through BMWK
SimKI-Mop: FKZ 03EN3074A-C, runtime: 6/2023 - 5/2027, funded through BMWK

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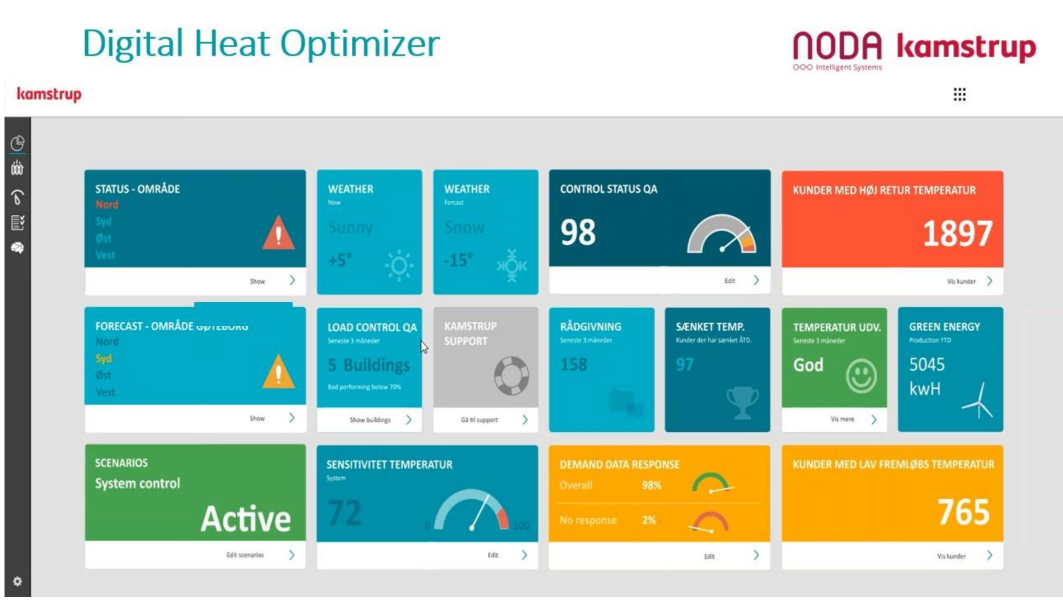
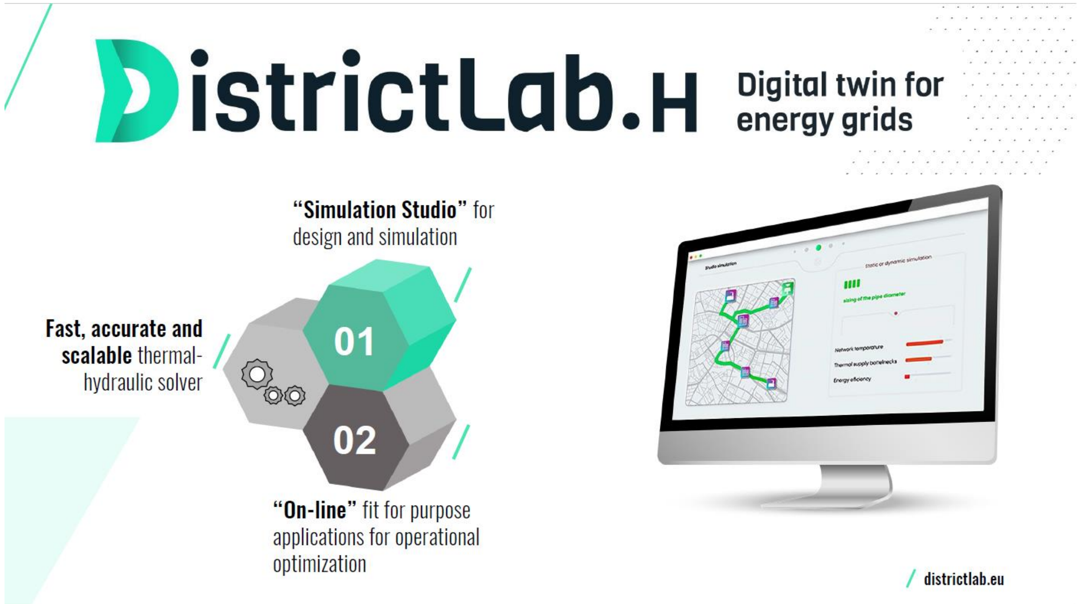
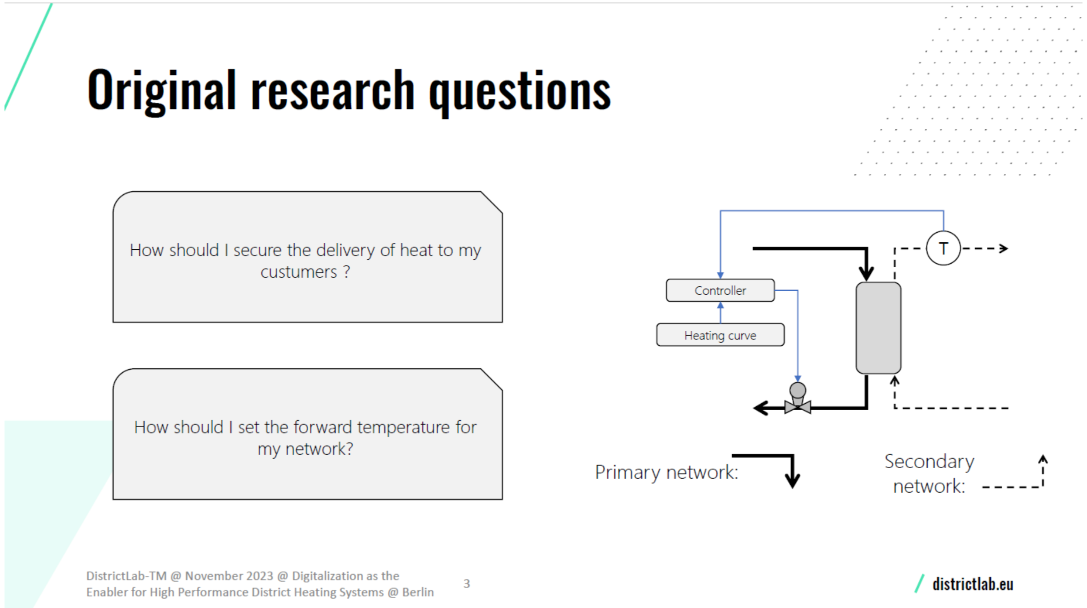
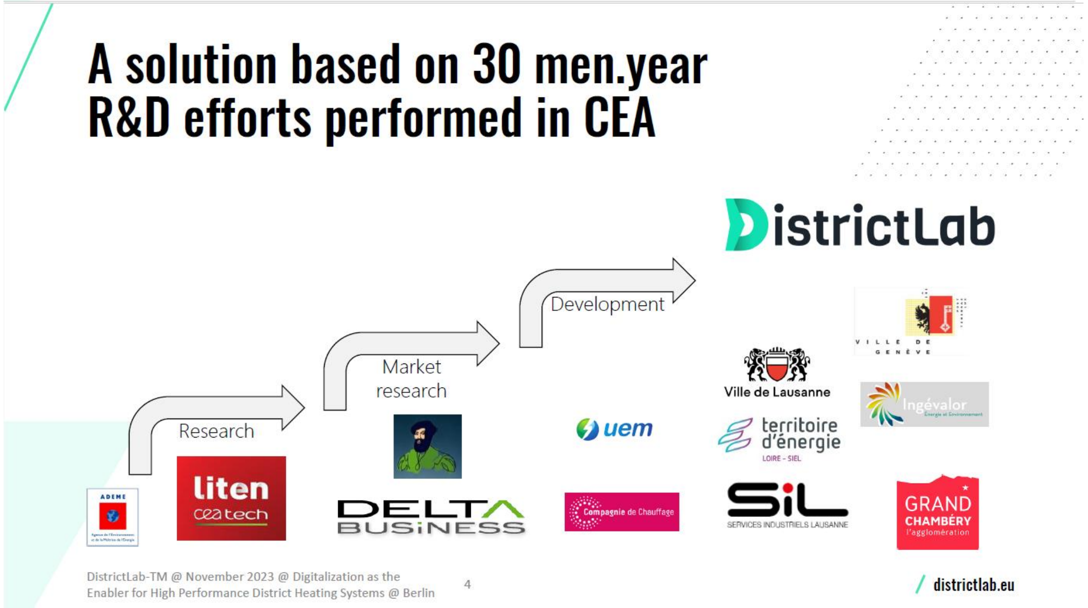
Presentation 11:
The Glue of AI Solutions and the Energy Sector


Digital Heat Optimizer
NODA
kamstrup
kamstrup
STATUS - OMRÅDE
Nord
Syd
Øst
Vest
WEATHER
Sunny
+5°
WEATHER
Snow
-15°
CONTROL STATUS QA
98
KUNDER MED HØJ RETUR TEMPERATUR
1897
FORECAST - OMRÅDE
LOAD CONTROL QA
5 Buildings
KAMSTRUP SUPPORT
RÅDGIVNING
158
SÆNKET TEMP.
97
TEMPERATUR UDV.
God
GREEN ENERGY
5045 kwH
SCENARIOS
System control
Active
SENSITIVITET TEMPERATUR
72
DEMAND DATA RESPONSE
Overall 98%
No response 2%
KUNDER MED LAV FREMLØBS TEMPERATUR
765


ACCELERATING TRANSITION
noda.se
christian.Johansson@noda.se | CSO

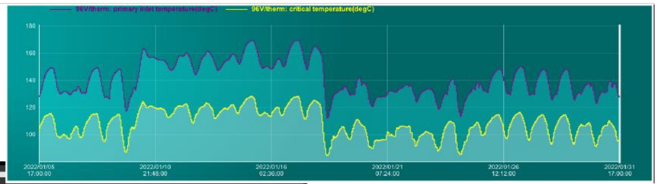




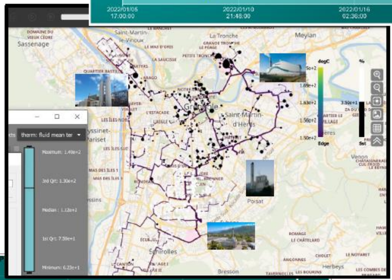


Presentation 12:
DistrictLab-H: a new Tool to Optimize the Design and Operation of District Heating and Cooling Networks

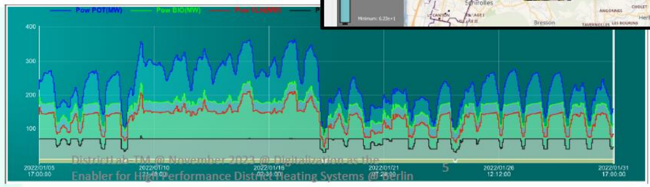
A SINGLE TOOL FOR THE PRODUCTION, DISTRIBUTION AND CONSUMPTION DOMAINS



CONSUMPTION



DISTRIBUTION



PRODUCTION

districtlab.eu

The strengths of our solution

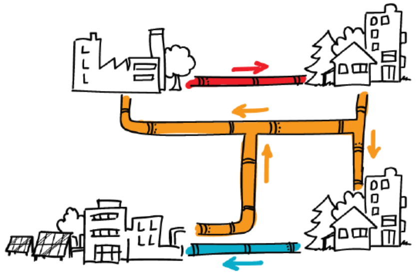
- Fast to set-up & productive
  - Minimized set-up time based on an efficient model builder
  - Represents in a single tool the production, the distribution and the consumption domains
- Scalable & Versatile
  - From MegaWatt to GigaWatt
  - Covers all main kinds of network architectures
- Numerically efficient and accurate
  - Analyses complex systems on a laptop within seconds
  - Thermodynamic consistency of results is 100 % guaranteed

DistrictLab-TM @ November 2023 @ Digitalization as the Enabler for High Performance District Heating Systems @ Berlin 6

districtlab.eu

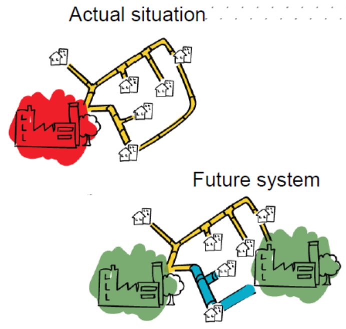
Assessing an innovative 3-tubes project

- The concept was proposed by the CADOuest company (https://cadouest.ch/)
- The concept was studied by the SIL company (https://www.lausanne.ch/vie-pratique/energies-et-eau/services-industriels.html), relying on the DistrictLab-H software
- Goals: produce and distribute 11 GWh of low temperature & renewable heat



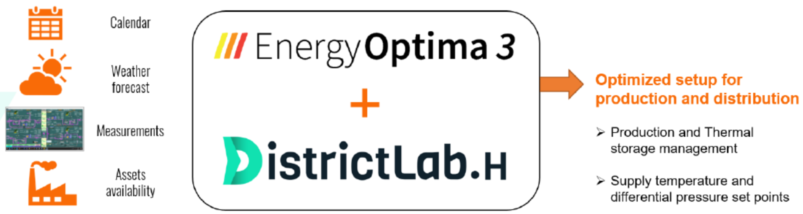
Network resizing to lower operational temperature

- Current temperature level: 145 degC
- Target temperature level: 110 degC
- Which piping element should be resized and when?



Real-time operational optimization

- Implemented on the Grenoble District Heating network (https://www.compagniedechauffage.fr/)
- The “Energy Optima 3” software was provided by the Energy Opticon company (https://en.energyopticon.com/)



Summary

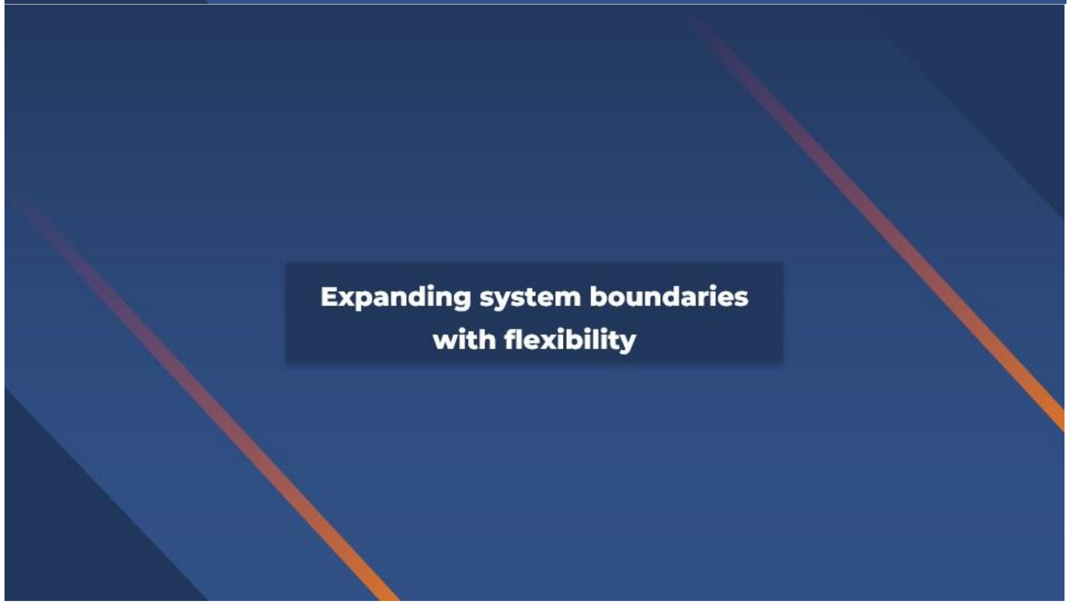
- 30 men.year of R&D conducted to derive efficient methodologies for the design and operation of efficient district heating and cooling systems
- This content is now implemented in the DistrictLab-H software, market by the https://www.districtlab.eu/ company
- Current work focuses on the extension of DistrictLab towards 5th generation DHC

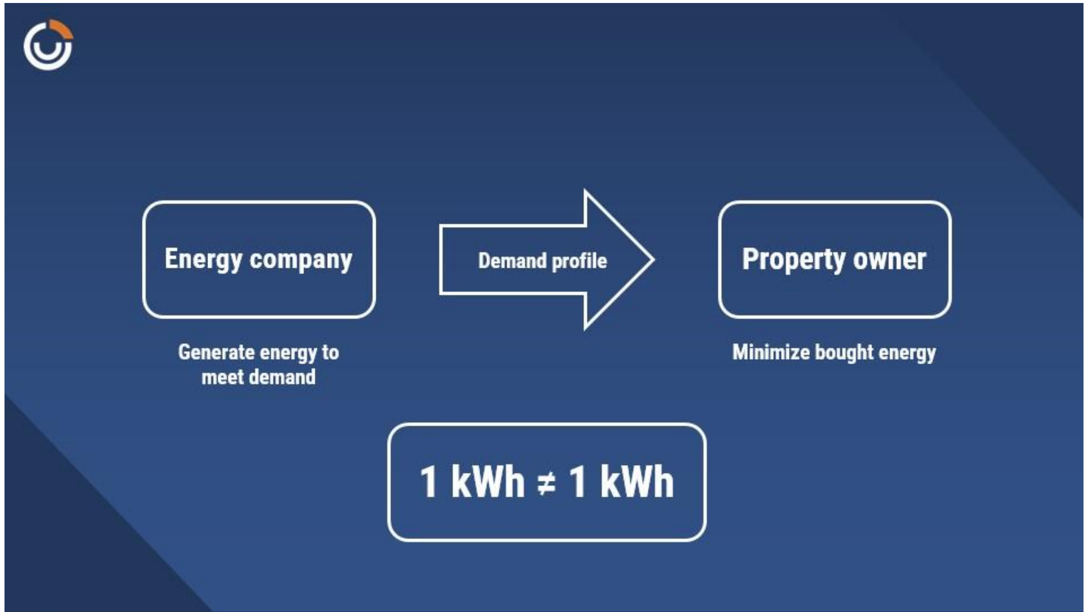
Dr. Axel BECKER
Business developer in Germany
axel.becker@districtlab.eu

Presentation 12:
DistrictLab-H: a new Tool to Optimize the Design and Operation of District Heating and Cooling Networks

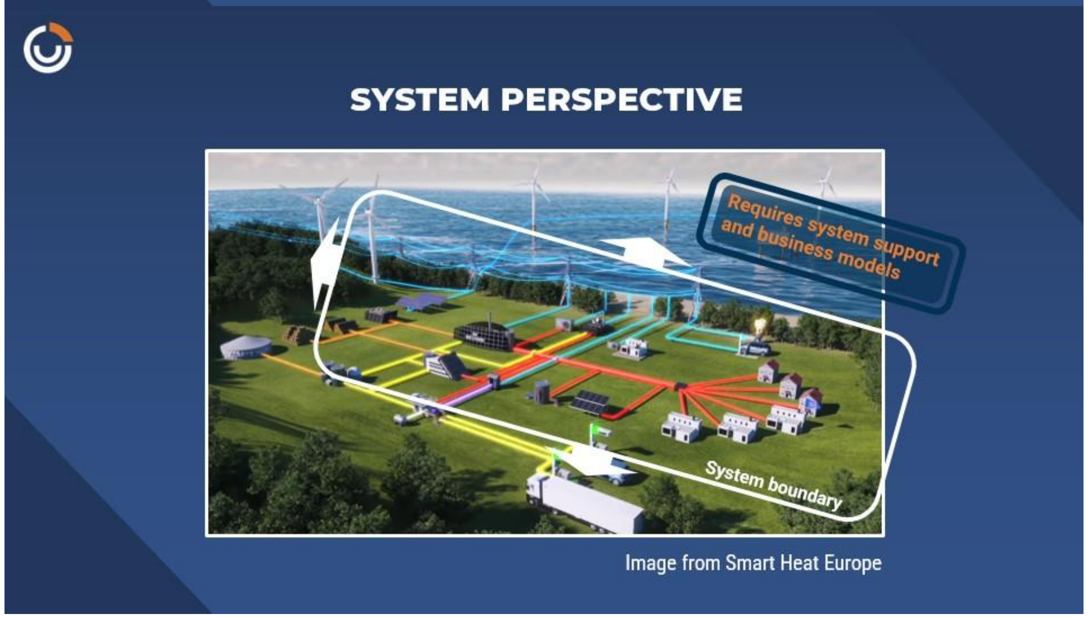

BRING EVERYONE
THE POSSIBILITY
OF SUSTAINABLE
THERMAL COMFORT
DistrictLab
/ districtlab.eu
11

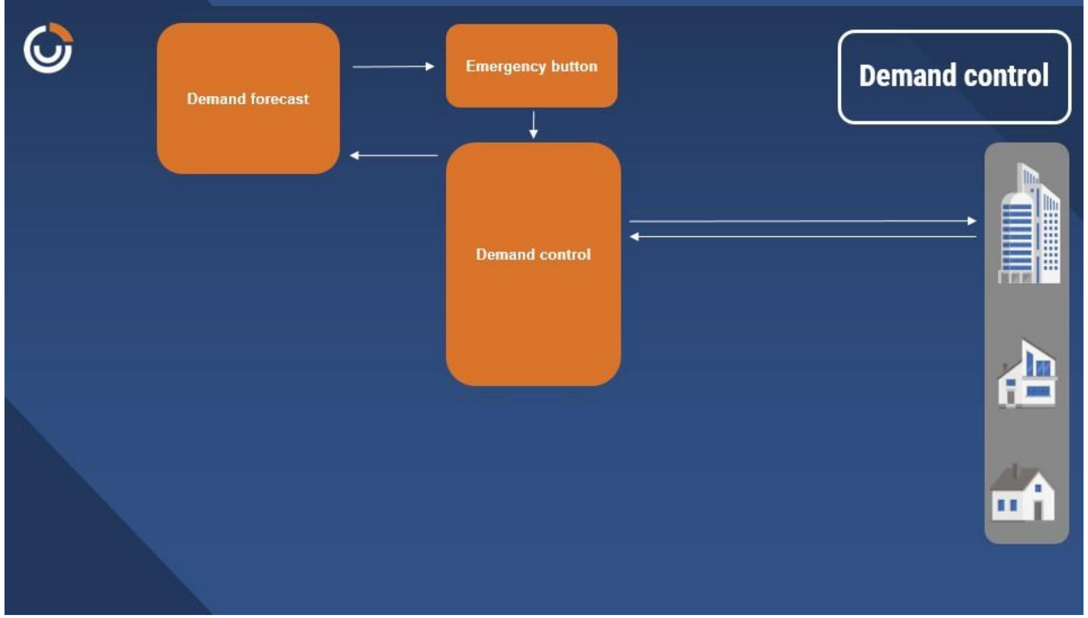
Session V - Digitalization of Energy Infrastructure

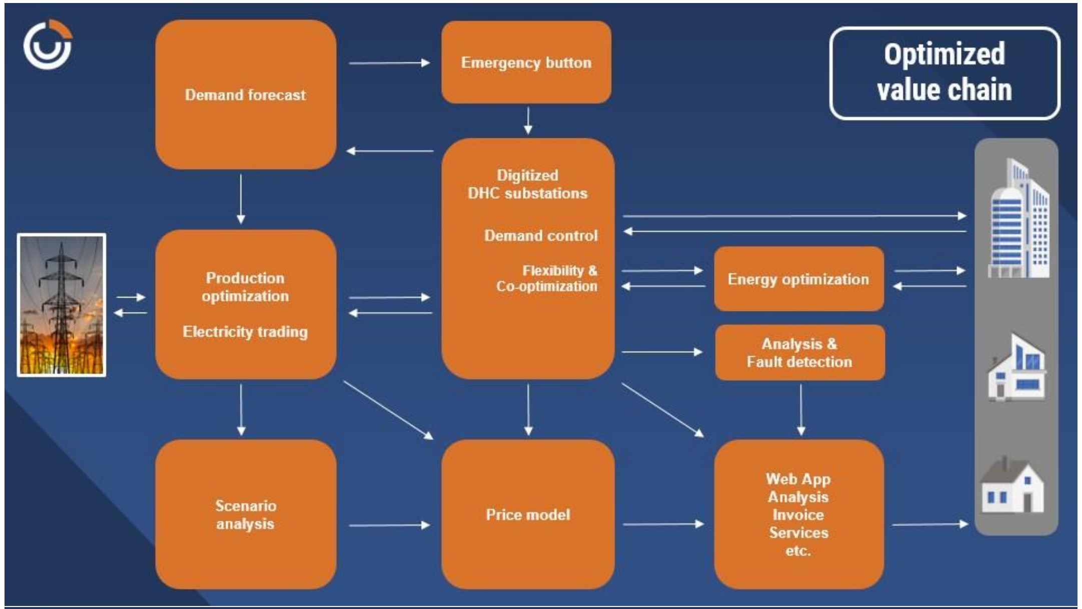


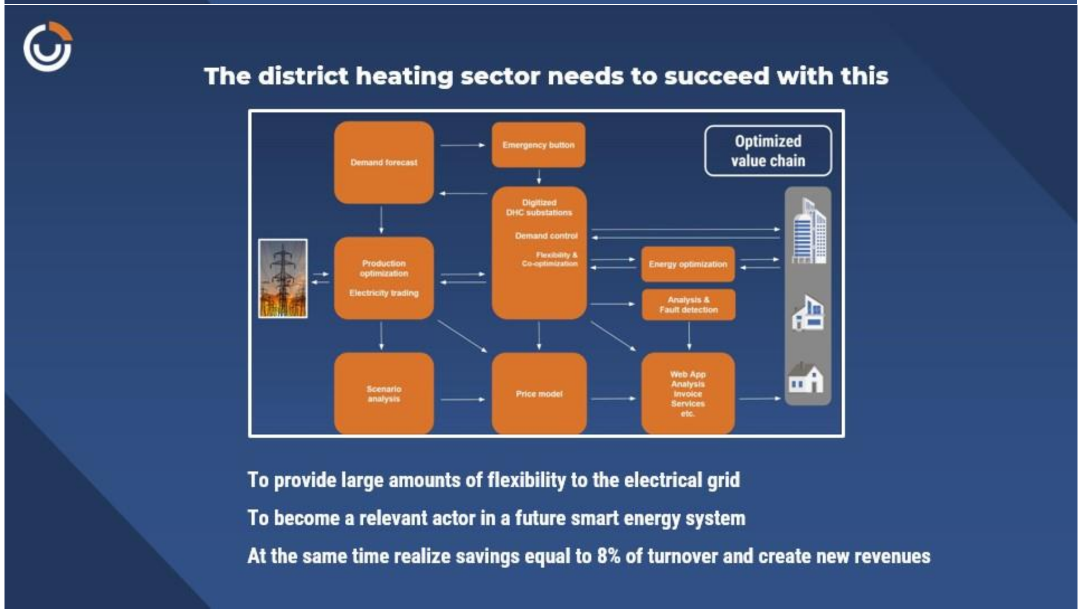

Energy company
Demand profile
Property owner
Generate energy to meet demand
Minimize bought energy
1 kWh ≠ 1 kWh


THE TRADITIONAL TARGET
System boundries
Image from Smart Heat Europe


SYSTEM PERSPECTIVE
Requires system support and business models
System boundary
Image from Smart Heat Europe


Demand forecast
Emergency button
Demand control
Demand control





Presentation 13:
Expanding System Boundaries with Flexibility


THANKS
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+46 76 010 35 45
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Digitalisation as the Enabler for High Performance DHS, 21.11.2023, Ines Lindmeier
WIEN ENERGIE
DIE ENERGIE VON WIEN
Advantages of Using Digital Twins for the Operation of District Heating Systems
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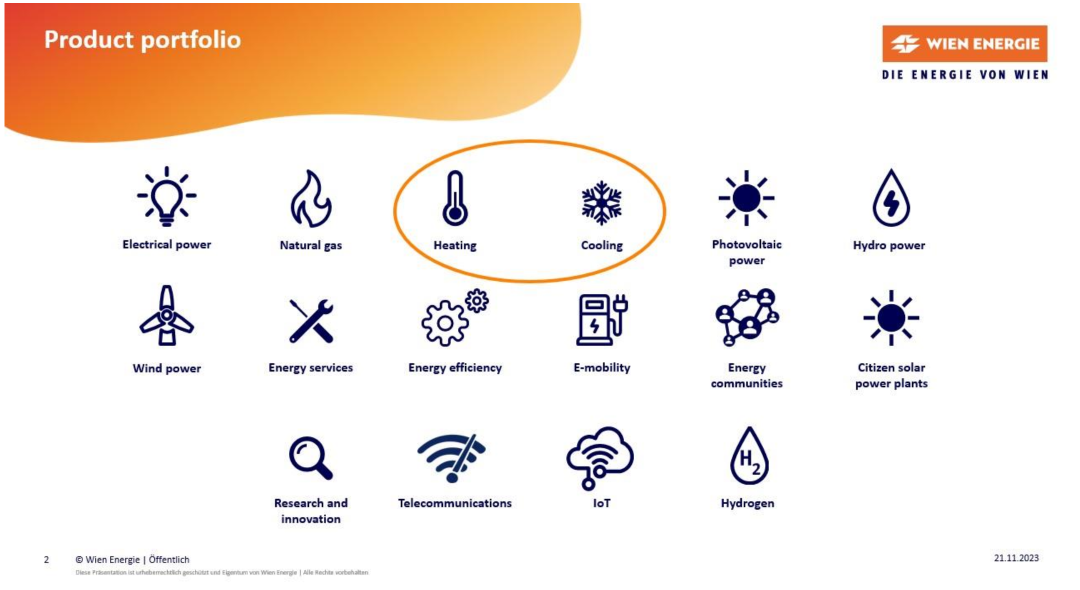
Product portfolio
WIEN ENERGIE
DIE ENERGIE VON WIEN
Electrical power
Natural gas
Heating
Cooling
Photovoltaic power
Hydro power
Wind power
Energy services
Energy efficiency
E-mobility
Energy communities
Citizen solar power plants
Research and innovation
Telecommunications
IoT
Hydrogen
2
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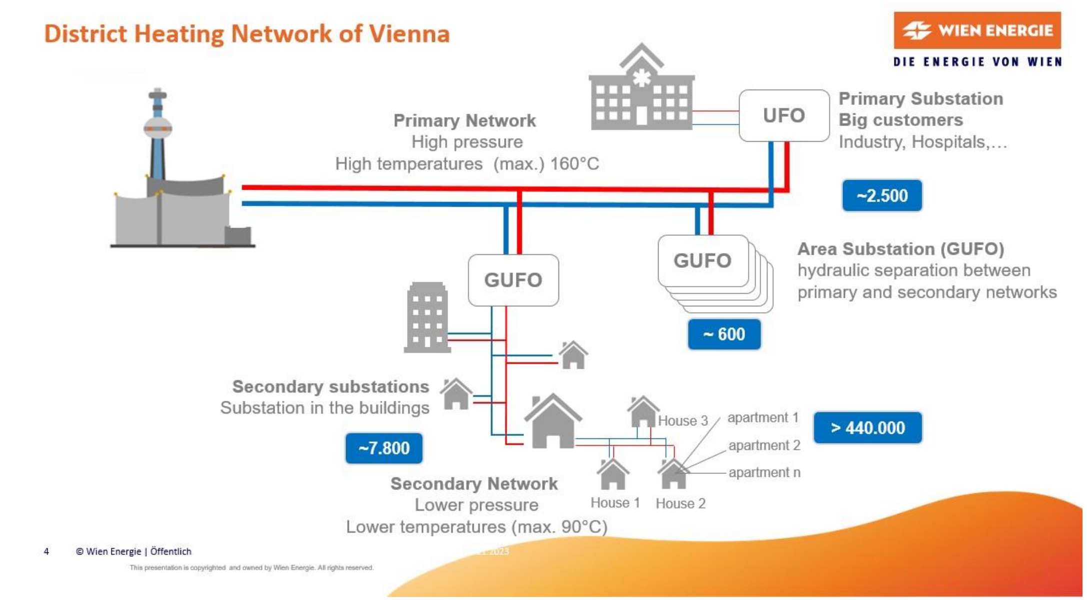
21.11.2023


District Heating
>1.200 km Piping ~ 5.900 GWh/a
> 600 Secondary Networks
> 10.000 Sub-stations
> 440.000 households > 7.800 business costumers
District Cooling
>16 km piping
200 MW
20 Cooling centres
Yearly growing rate 10-15%


District Heating Network of Vienna
WIEN ENERGIE
DIE ENERGIE VON WIEN
Primary Network
High pressure
High temperatures (max.) 160°C
UFO
Primary Substation
Big customers
Industry, Hospitals,…
~2.500
GUFO
GUFO
Area Substation (GUFO)
hydraulic separation between primary and secondary networks
~ 600
Secondary substations
Substation in the buildings
~7.800
House 3
apartment 1
apartment 2
apartment n
> 440.000
House 1
House 2
Secondary Network
Lower pressure
Lower temperatures (max. 90°C)
4
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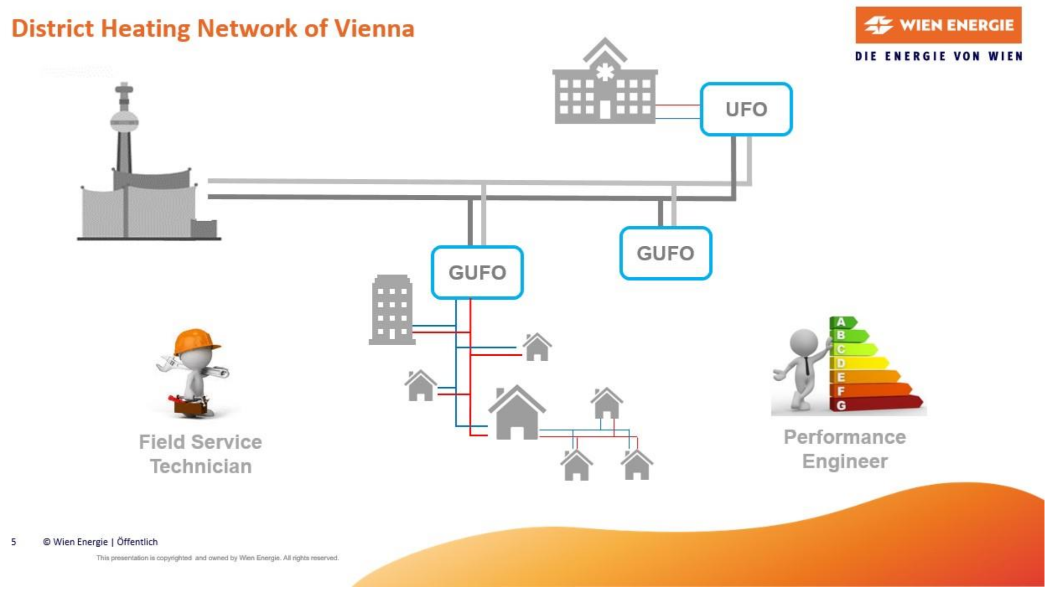
District Heating Network of Vienna
WIEN ENERGIE
DIE ENERGIE VON WIEN
UFO
GUFO
GUFO
Field Service Technician
Performance Engineer
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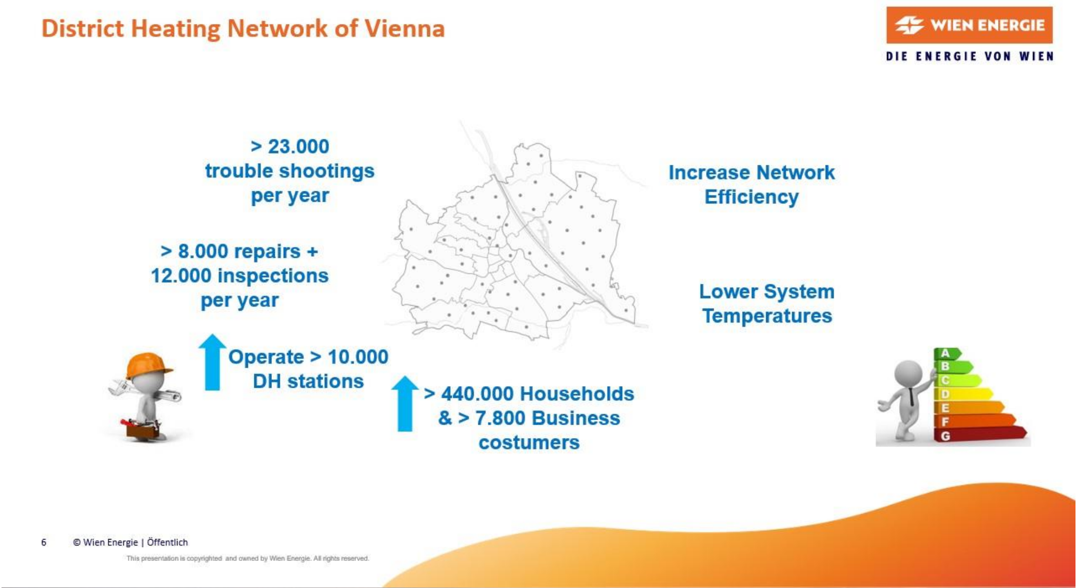
District Heating Network of Vienna
WIEN ENERGIE
DIE ENERGIE VON WIEN
> 23.000 trouble shootings per year
> 8.000 repairs + 12.000 inspections per year
Operate > 10.000 DH stations
> 440.000 Households & > 7.800 Business costumers
Increase Network Efficiency
Lower System Temperatures
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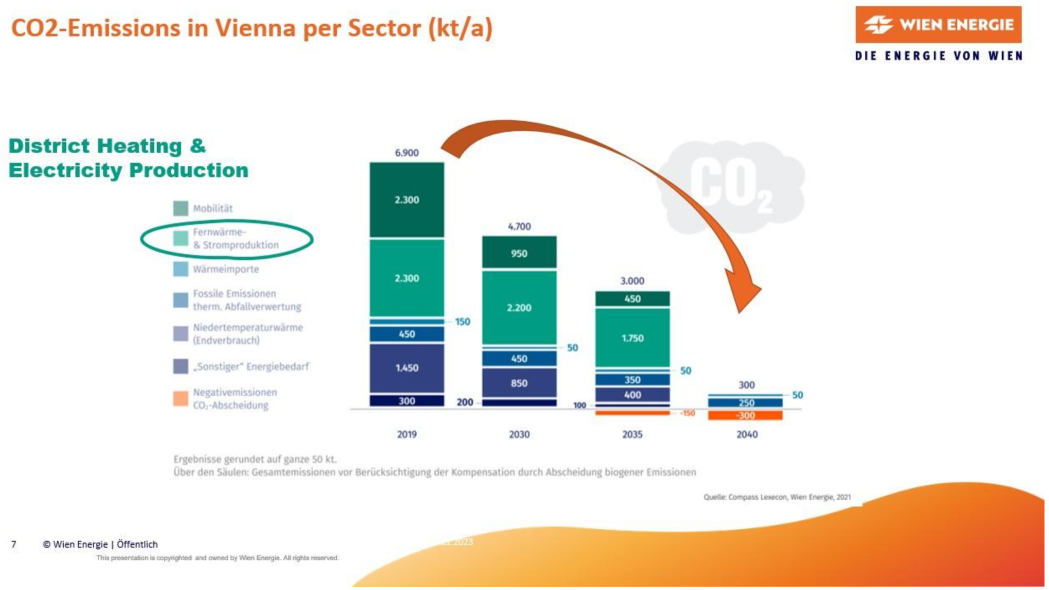
CO2-Emissions in Vienna per Sector (kt/a)
WIEN ENERGIE
DIE ENERGIE VON WIEN
District Heating & Electricity Production
Mobilität
Fernwärme- & Stromproduktion
Wärmeimporte
Fossile Emissionen therm. Abfallverwertung
Niedertemperaturwärme (Endverbrauch)
„Sonstiger" Energiebedarf
Negativemissionen CO₂-Abscheidung
6.900
2.300
2.300
150
450
1.450
300
200
4.700
950
2.200
50
450
850
100
3.000
450
1.750
50
350
400
-150
300
50
250
-300
2019
2030
2035
2040
CO2
Ergebnisse gerundet auf ganze 50 kt.
Über den Säulen: Gesamtemissionen vor Berücksichtigung der Kompensation durch Abscheidung biogener Emissionen
Quelle: Compass Lexecon, Wien Energie, 2021
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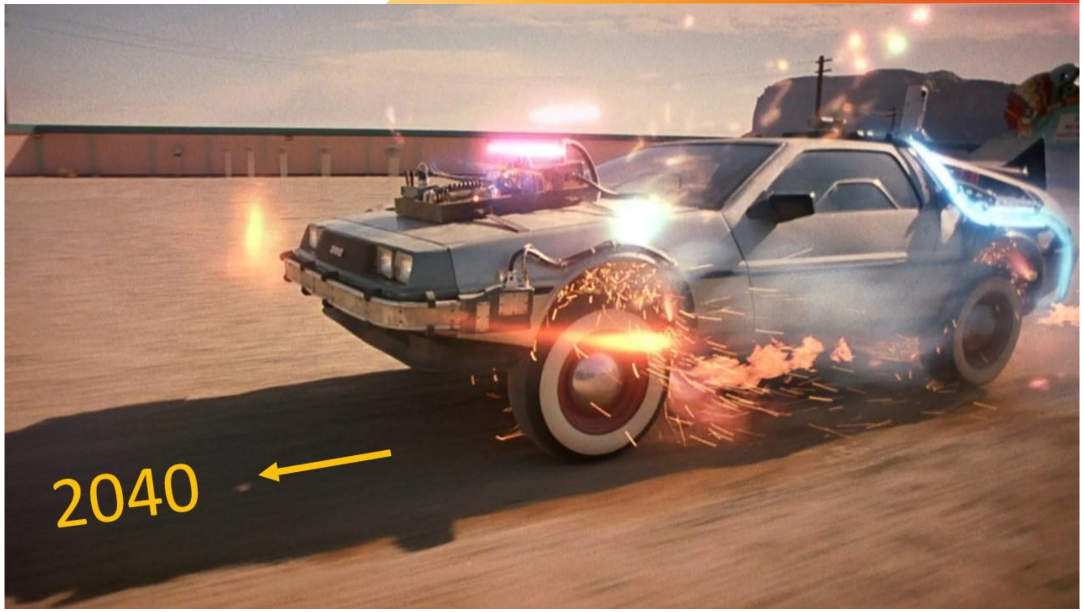
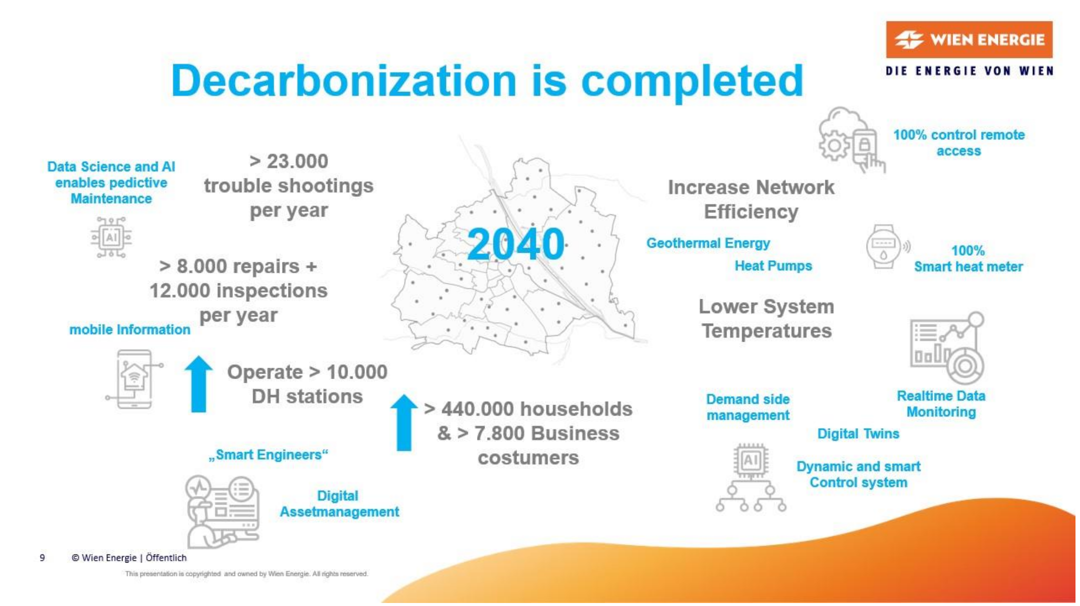

2040


WIEN ENERGIE
DIE ENERGIE VON WIEN
Decarbonization is completed
Data Science and AI enables pedictive Maintenance
> 23.000 trouble shootings per year
> 8.000 repairs + 12.000 inspections per year
mobile Information
Operate > 10.000 DH stations
„Smart Engineers“
Digital Assetmanagement
2040
> 440.000 households & > 7.800 Business costumers
Increase Network Efficiency
Geothermal Energy
Heat Pumps
Lower System Temperatures
Demand side management
Digital Twins
Dynamic and smart Control system
100% control remote access
100% Smart heat meter
Realtime Data Monitoring
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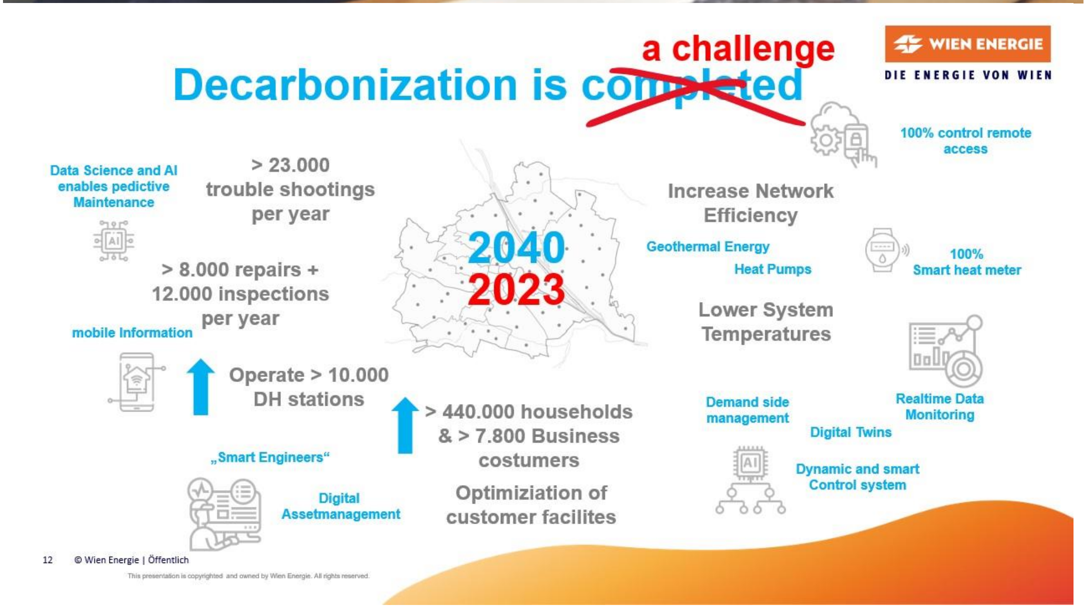
2023


WIEN ENERGIE
DIE ENERGIE VON WIEN
Decarbonization is completed
a challenge
Data Science and AI enables pedictive Maintenance
> 23.000 trouble shootings per year
> 8.000 repairs + 12.000 inspections per year
mobile Information
Operate > 10.000 DH stations
„Smart Engineers“
Digital Assetmanagement
2040
2023
> 440.000 households & > 7.800 Business costumers
Optimiziation of customer facilites
Increase Network Efficiency
Geothermal Energy
Heat Pumps
Lower System Temperatures
Demand side management
Digital Twins
Dynamic and smart Control system
100% control remote access
100% Smart heat meter
Realtime Data Monitoring
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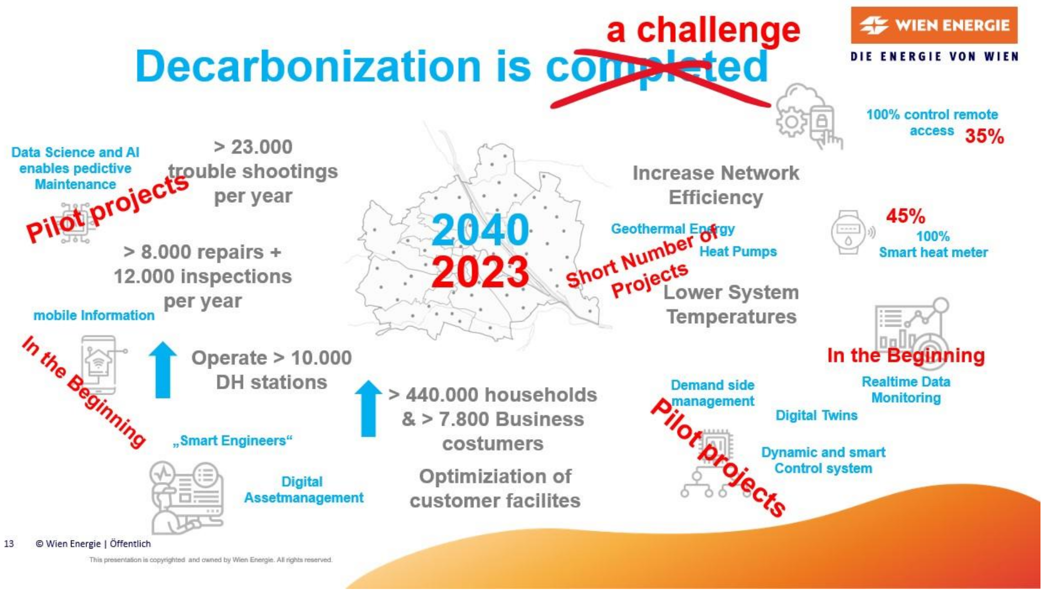
WIEN ENERGIE
DIE ENERGIE VON WIEN
Decarbonization is completed
a challenge
Data Science and AI enables pedictive Maintenance
Pilot projects
> 23.000 trouble shootings per year
> 8.000 repairs + 12.000 inspections per year
mobile Information
In the Beginning
Operate > 10.000 DH stations
„Smart Engineers“
Digital Assetmanagement
2040
2023
> 440.000 households & > 7.800 Business costumers
Optimiziation of customer facilites
Increase Network Efficiency
Geothermal Energy
Heat Pumps
Short Number of Projects
Lower System Temperatures
Demand side management
Pilot projects
Digital Twins
Dynamic and smart Control system
100% control remote access 35%
45%
100% Smart heat meter
In the Beginning
Realtime Data Monitoring
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WIEN ENERGIE
DIE ENERGIE VON WIEN
? ? ? ? ?
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WIEN ENERGIE
DIE ENERGIE VON WIEN
A B C D E F G
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WIEN ENERGIE
DIE ENERGIE VON WIEN
What about a competition of fitting companies?
What about digital twins?
InnoChallenge 2021
Gradyent
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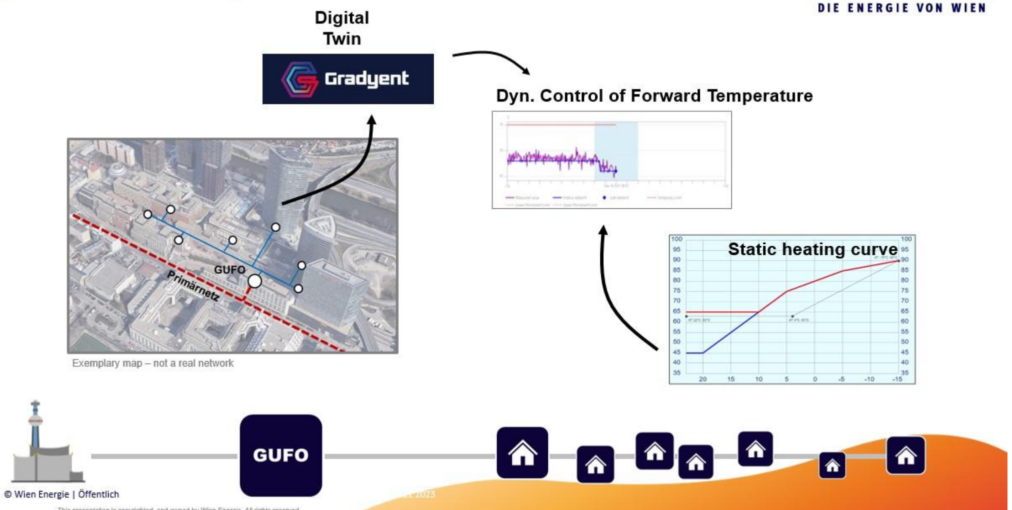
Digital Twin Secondary Network

WIEN ENERGIE
DIE ENERGIE VON WIEN



Digital Twin Secondary Network

WIEN ENERGIE
DIE ENERGIE VON WIEN

	NW 01
Heat consumption p.a.	10 GWh
Efficiency	95%
Smart Heat Meter	100%
Forward Temperature	70°C

Live within 2 months

Validation?

Advantages?

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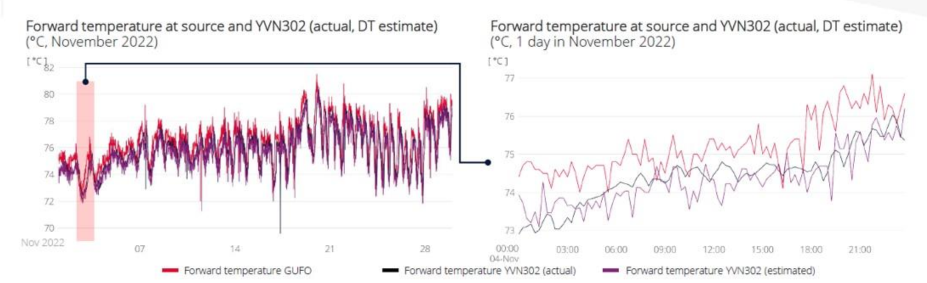
Digital Twin Secondary Network

WIEN ENERGIE
DIE ENERGIE VON WIEN

Validation (Winter)



- The Digital Twin estimates both **heat losses** and **time-of-travel** fairly accurately for the YVN302 near end-of-net sub station as can be seen in the zoom-in of plots on the right
- The time of travel depends on the period selected

Source: 2022 internal Project Report „Smart Thermal Network" Author: Gradyent

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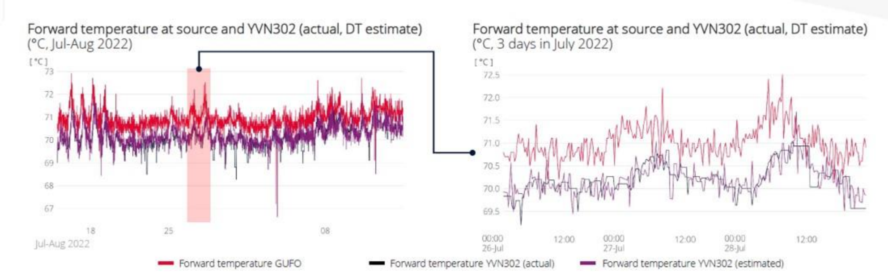
Digital Twin Secondary Network

WIEN ENERGIE
DIE ENERGIE VON WIEN

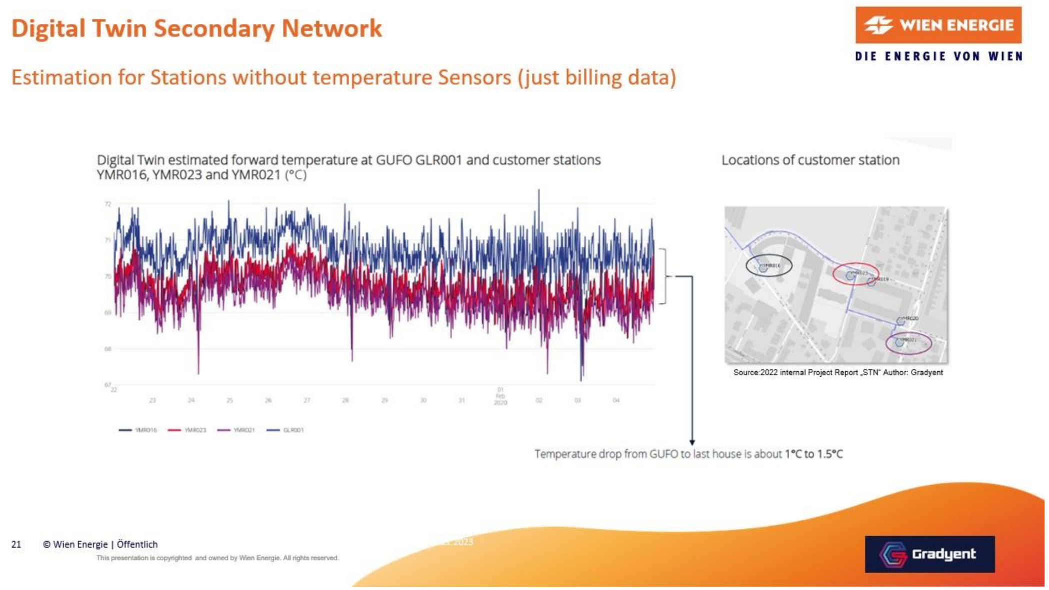
Validation (Sommer)



- The Digital Twin estimates both **heat losses** and **time-of-travel** fairly accurately for the YVN302 near end-of-net sub station as can be seen in the zoom-in of plots on the right

Source: 2022 internal Project Report „Smart Thermal Network" Author: Gradyent

Gradyent


Digital Twin Secondary Network
Estimation for Stations without temperature Sensors (just billing data)
WIEN ENERGIE
DIE ENERGIE VON WIEN
Digital Twin estimated forward temperature at GUFO GLR001 and customer stations YMR016, YMR023 and YMR021 (°C)
Locations of customer station
Source:2022 internal Project Report „STN" Author: Gradyent
Temperature drop from GUFO to last house is about 1°C to 1.5°C
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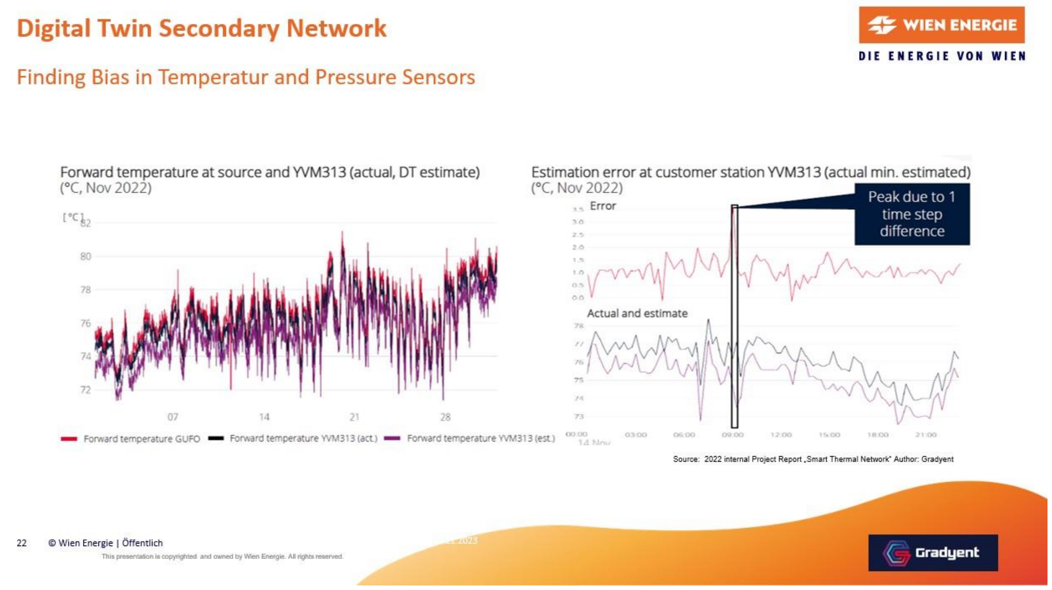
Digital Twin Secondary Network
Finding Bias in Temperatur and Pressure Sensors
WIEN ENERGIE
DIE ENERGIE VON WIEN
Forward temperature at source and YVM313 (actual, DT estimate)
(°C, Nov 2022)
Estimation error at customer station YVM313 (actual min. estimated)
(°C, Nov 2022)
Peak due to 1 time step difference
Error
Actual and estimate
Forward temperature GUFO
Forward temperature YVM313 (act.)
Forward temperature YVM313 (est.)
Source: 2022 internal Project Report „Smart Thermal Network" Author: Gradyent
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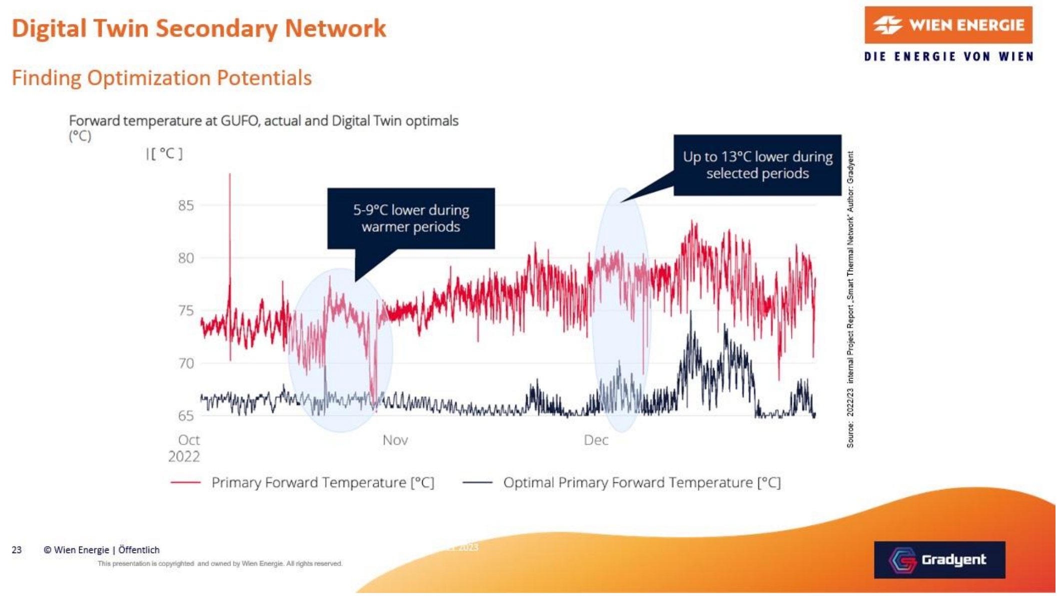
Digital Twin Secondary Network
Finding Optimization Potentials
WIEN ENERGIE
DIE ENERGIE VON WIEN
Forward temperature at GUFO, actual and Digital Twin optimals
(°C)
5-9°C lower during warmer periods
Up to 13°C lower during selected periods
Oct 2022
Nov
Dec
Primary Forward Temperature [°C]
Optimal Primary Forward Temperature [°C]
Source: 2022/23 internal Project Report „Smart Thermal Network" Author: Gradyent
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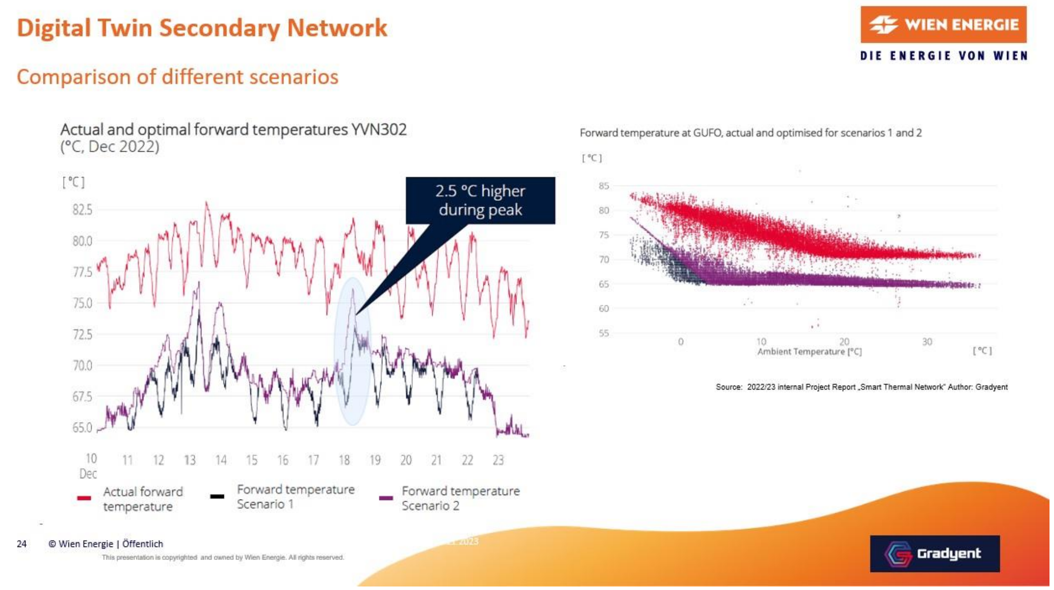
Digital Twin Secondary Network
Comparison of different scenarios
WIEN ENERGIE
DIE ENERGIE VON WIEN
Actual and optimal forward temperatures YVN302
(°C, Dec 2022)
2.5 °C higher during peak
Actual forward temperature
Forward temperature Scenario 1
Forward temperature Scenario 2
Forward temperature at GUFO, actual and optimised for scenarios 1 and 2
Ambient Temperature [°C]
Source: 2022/23 internal Project Report „Smart Thermal Network" Author: Gradyent
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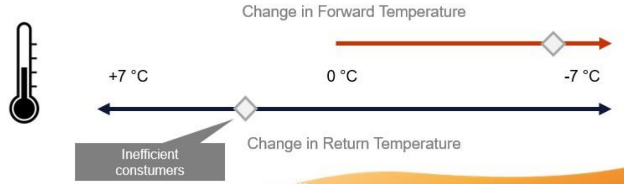
Digital Twin Secondary Network

WIEN ENERGIE
DIE ENERGIE VON WIEN

	NW 01 ◇
Heat consumption p.a.	10 GWh
Efficiency	95%
Smart Heat Meter	100%
Forward Temperature	70°C

Live within 2 months

- Validation?
- Advantages?
- Transferability?



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Digital Twin Secondary Network

WIEN ENERGIE
DIE ENERGIE VON WIEN

Transferability

	NW 01 ◇	NW 02 △	NW 03 □	NW 04 ✚	NW 05 ◎
Heat consumption p.a.	10 GWh	24 GWh	7 GWh	23 GWh	3 GWh
Efficiency	95%	81%	94%	78%	88%
Smart Heat Meter	100%	82%	7%	88%	92%
Forward Temperature	70°C	68°C	70°C	70°C	66°C

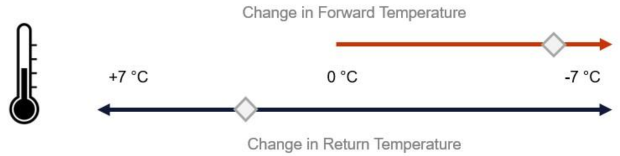
26

Digital Twin Secondary Network

WIEN ENERGIE
DIE ENERGIE VON WIEN

Transferability

	NW 01 ◇	NW 02 △	NW 03 □	NW 04 ✚	NW 05 ◎
Heat consumption p.a.	10 GWh	**24 GWh**	7 GWh	23 GWh	**3 GWh**
Efficiency	**95%**	81%	94%	**78%**	88%
Smart Heat Meter	**100%**	82%	**7%**	88%	92%
Forward Temperature	70°C	68°C	70°C	70°C	**66°C**



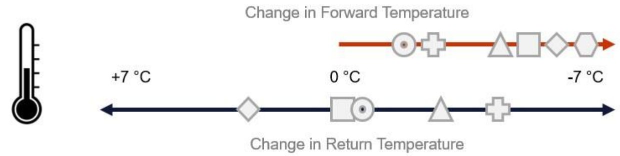
27

Digital Twin Secondary Network

WIEN ENERGIE
DIE ENERGIE VON WIEN

Transferability

	NW 01 ◇	NW 02 △	NW 03 □	NW 04 ✚	NW 05 ◎
Heat consumption p.a.	10 GWh	24 GWh	7 GWh	23 GWh	3 GWh
Efficiency	95%	81%	94%	78%	88%
Smart Heat Meter	100%	82%	7%	88%	92%
Forward Temperature	70°C	68°C	70°C	70°C	66°C



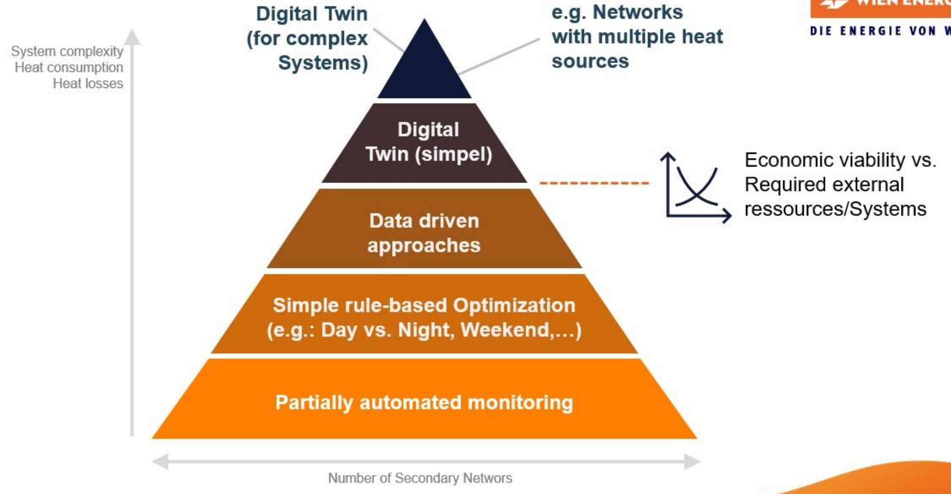
28

Digital Twin Secondary Network

Scaling?

	NW 01 ◇	NW 02 △	NW 03 □	NW 04 ✚	NW 05 ◎
Heat consumption p.a.	10 GWh	24 GWh	7 GWh	23 GWh	3 GWh
Efficiency	95%	81%	94%	78%	88%
Smart Heat Meter	100%	82%	7%	88%	92%
Forward Temperature	70°C	68°C	70°C	70°C	66°C

Value Physical Modell vs. Internal effort

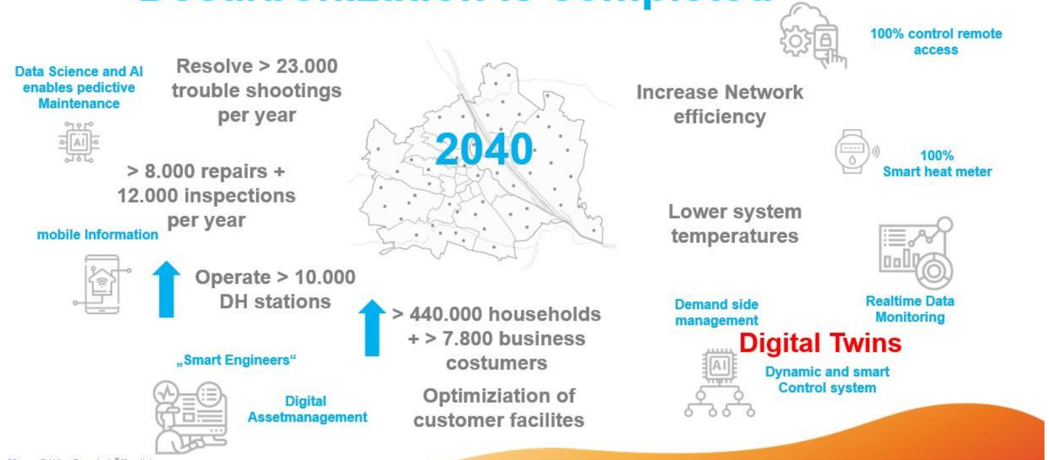


Digital Twin Secondary Network - Pros & Cons

- Fast „go live“
- Fast basic optimization without costumer involvment
- Data Deep Dive and Monitoring
- Simulation & Optimization of complex systems
- Building and calibration with < 100% smart heat meter
- Comparison of different scenarios

- Scaling potential depends on digital readiness of DH-Company
- This kind of digital twin is not economical for all kind of networks
- External partner Who owns the model?
- External partner little internal knowledge creation

Decarbonization is completed

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Smart Management of Integrated Energy Systems Through Model Predictive Control

Prof. Mirko Morini, PhD
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University of Parma, Italy
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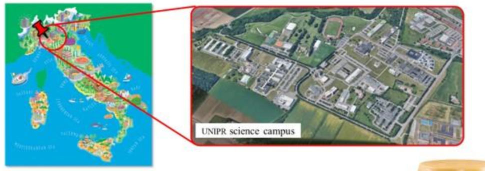
My LinkedIn

21 November, 2023

At the University of Parma, we work on modeling and control of integrated energy systems with a focus on district energy and sustainable fuels

Prof. Dr. Agostino Gambarotta (Director of Center for Energy and Environment)
Prof. Dr. Mirko Morini
Dr. Costanza Saletti
Emanuela Marzi (research fellow)
Andrea Barbaresi (PhD student)
Andrea Vieri (PhD student)



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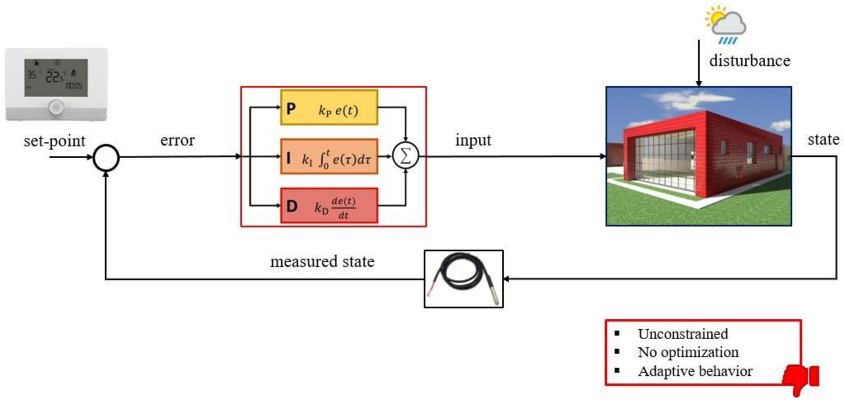
Conventional feedback controllers are widely used, but they do not allow constraint setting, optimization and adaptive behavior



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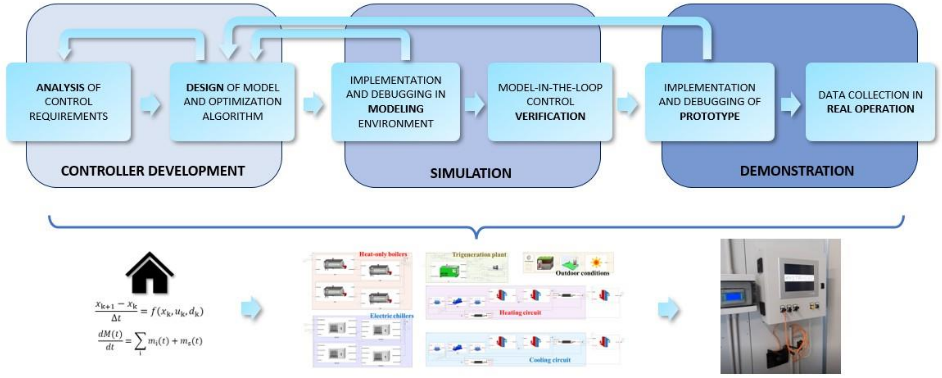
We set-up and apply a complete methodology for developing smart controllers for energy systems from the algorithm to the validation



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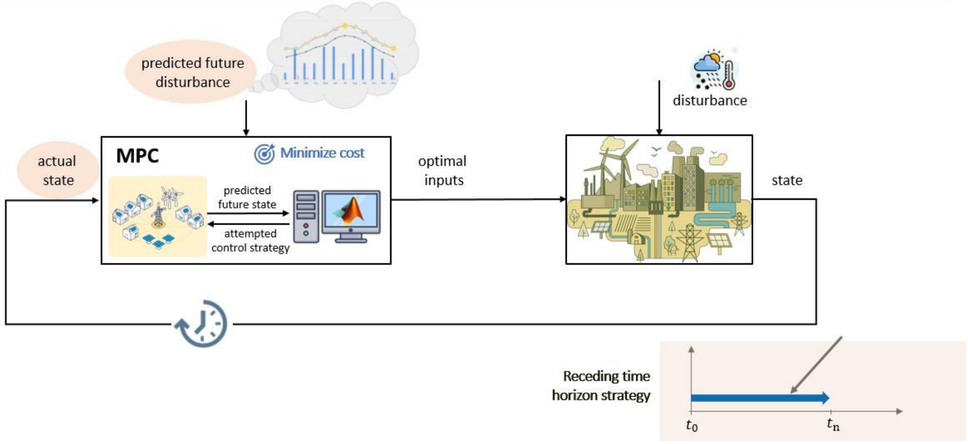
Model Predictive Control (MPC) uses the forecast of future disturbances and an optimization algorithm to calculate the best control action



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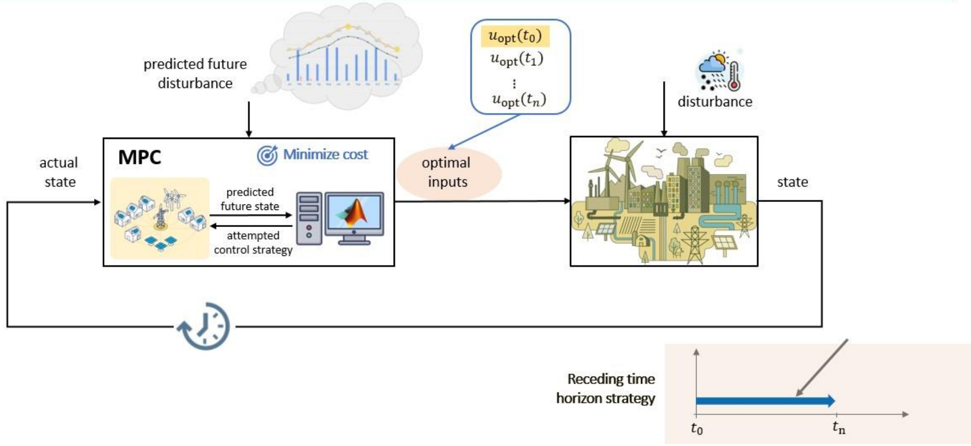
From the optimal trajectory, only the first control signal is applied to the system and the calculation is repeated each time-step



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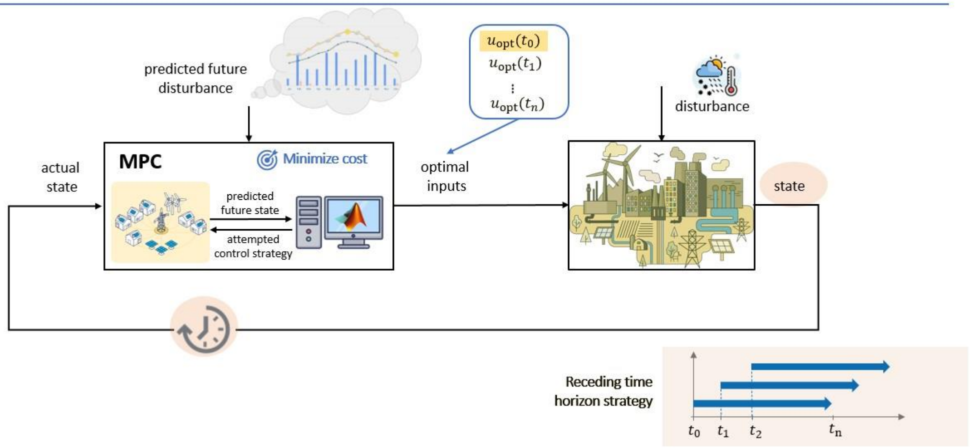
For its prediction, Model Predictive Control requires a model of the system sufficiently fast to be called several times by the optimization algorithm



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The case study is a Hospital in northern Italy, with the aim to minimize the operating cost by acting on energy conversion and distribution systems

www.distrheat.eu

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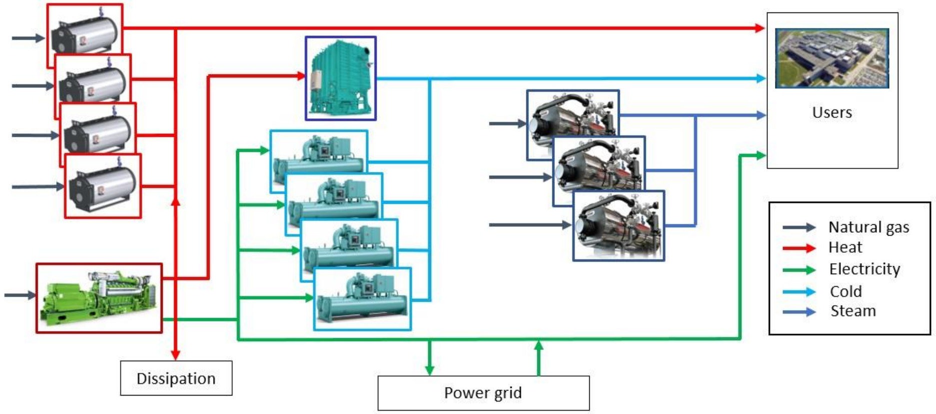
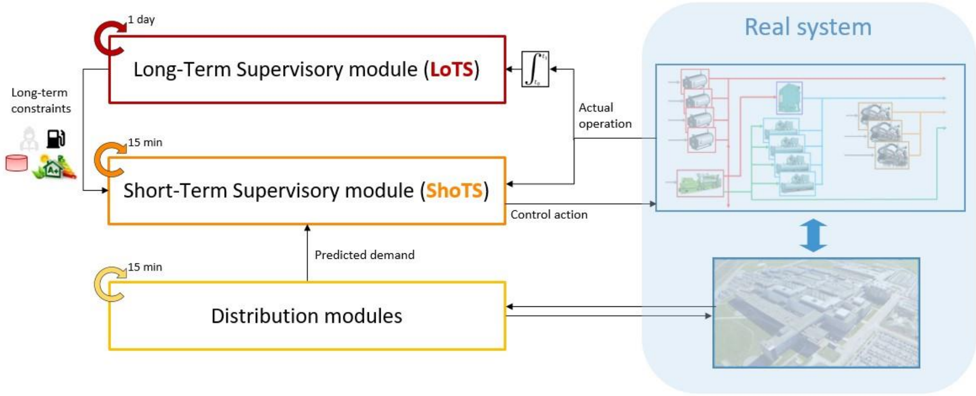
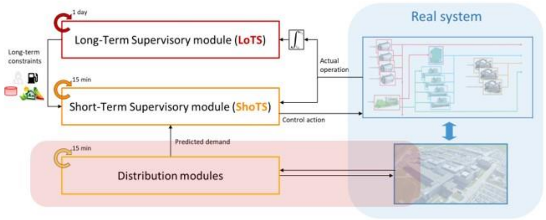
The system includes interacting energy conversion plants, and the vectors are then distributed to the users through dedicated networks



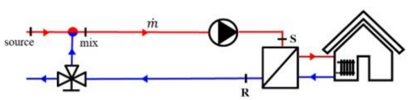
The proposed solution is a multi-level optimal controller with a double time-scale which provides the control action every 15 minutes



The distribution modules minimize the energy delivered to the buildings according to temperature constraints and calculates the demand



- Minimize energy supplied to building
- Keep indoor comfort
- Prediction horizon of 3 days
- Updated every 15 minutes



State, Disturbance

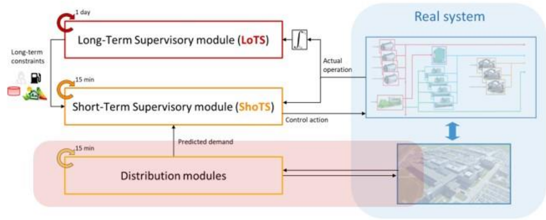
$$\frac{\Delta T}{\Delta t} = -a\,(T - T_{out}) + b\,\dot{Q}$$

$$\dot{Q} = \dot{m}\,c\,(T_S - T_R)$$

$$T_S = T_{mix} - \frac{\dot{Q}_{loss,S}}{\dot{m}\,c}$$

Inputs

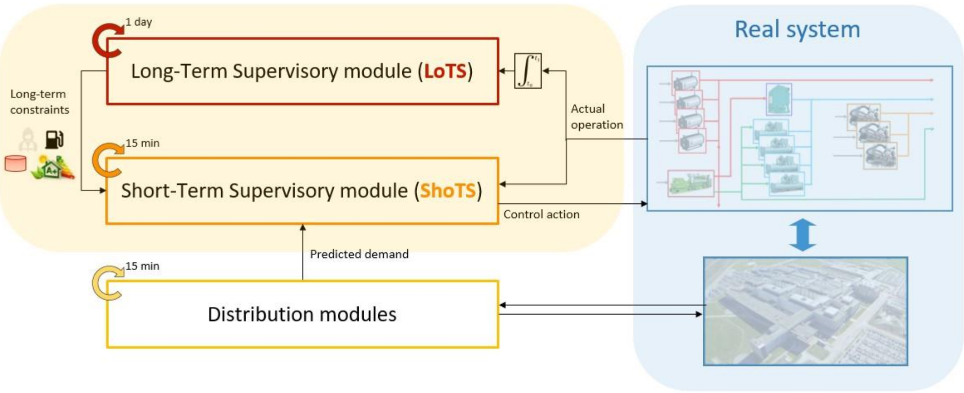
This approach was used in two test cases before and showed good performance: it is now a product of the company that collaborates with us



- Heat distribution network of a school complex
- **-13%** energy consumption

- A section of the Parma University Campus
- **-34%** energy supplied
- Product released by the utility

The forecast of the demand is then used by the double time-scale supervisory module to define the optimal set points of the conversion systems



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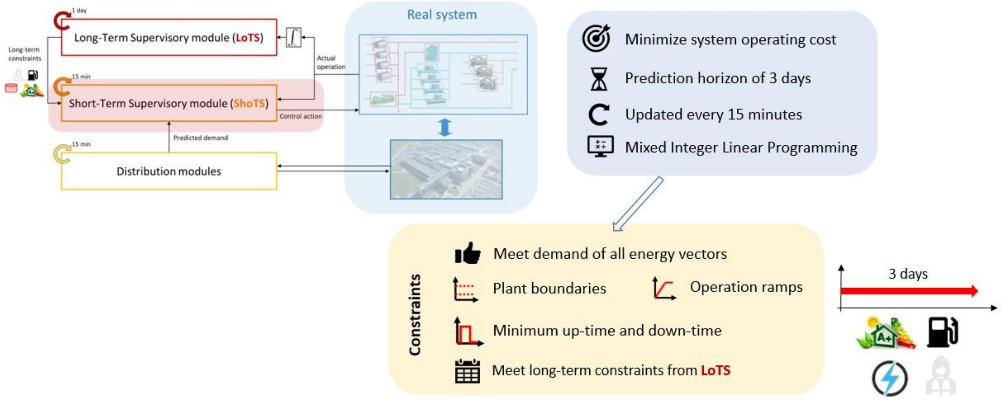
The optimal short-term operation of the plants is defined through a high-detail unit commitment problem and communicated to the management system



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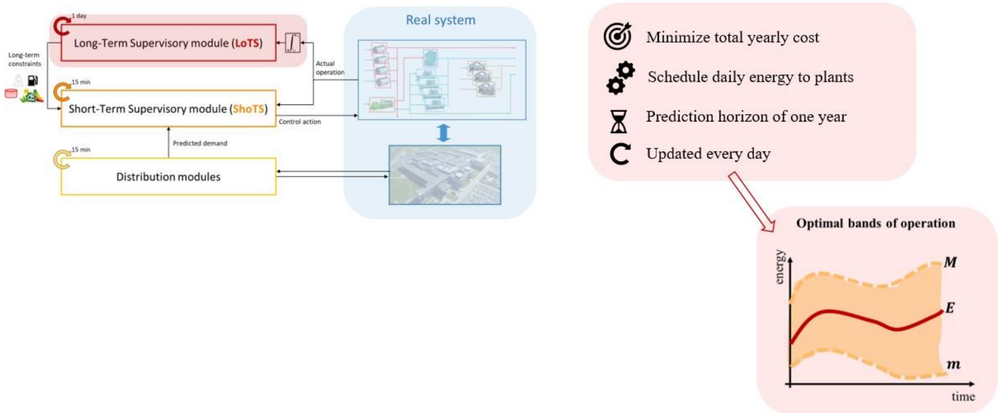
Every day the optimal yearly scheduling provides optimal bands of operation (constraints on the daily cumulative input) for the short-term module



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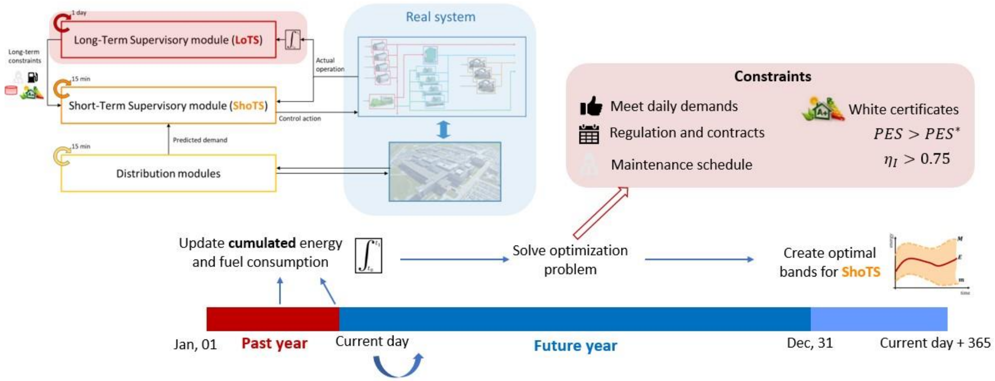
It cumulates the actual operation in the past and, looking to the rest of the year, it finds the best way to fulfill long term contraints



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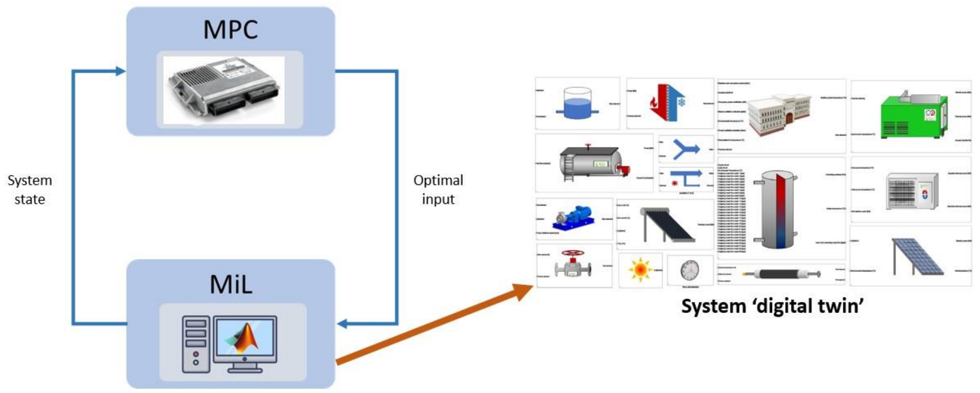
The performance of the MPC was firstly verified in a MiL architecture by using a digital twin of the system developed through a detailed model library



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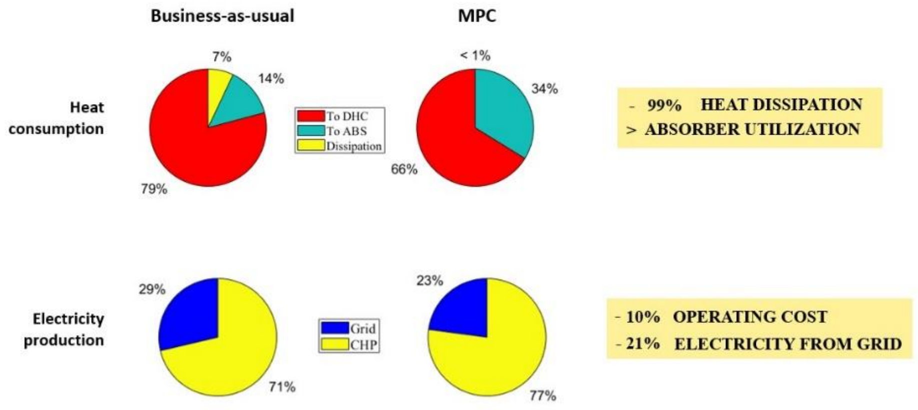
This test was positive, showing a reduction in heat dissipation from the CHP, a higher use of the absorption chiller and a reduction in operating cost



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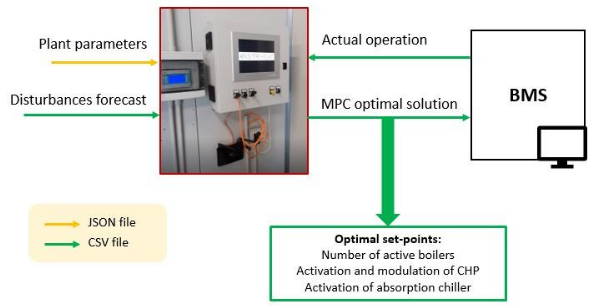
The MPC was implemented in the test site through a local dedicated computer and the communication with the BMS was set,initially operating in background



- Monitoring equipment
- Data collection and processing for business-as-usual operation
- **Implementation and debugging**
- Data collection and processing for new operation
- Results and comparison

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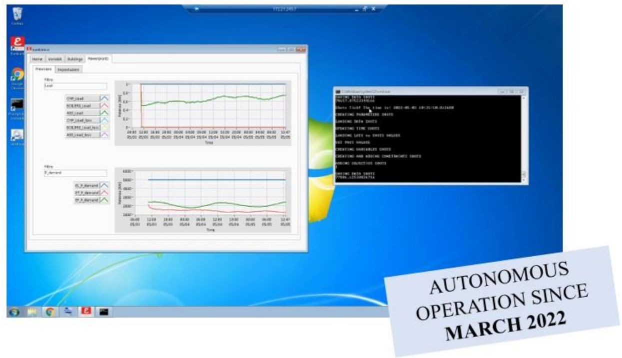
Then it started autonomous operation in March 2022 directly managing the plant, and data were collected for comparison with respect to businnes-as-usual



- Monitoring equipment
- Data collection and processing for business-as-usual operation
- Implementation and debugging
- **Data collection and processing for new operation**
- Results and comparison

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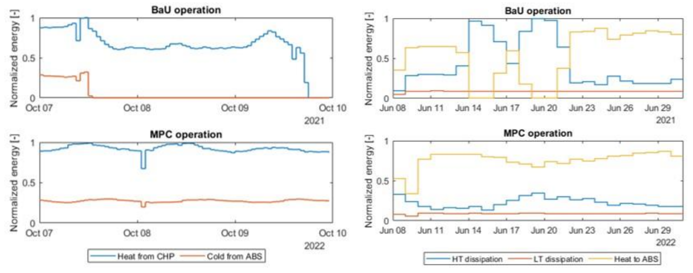
The field tests confirmed what was shown by the simulations, with lower dissipation, higher use of the absorption chiller and lower electricity purchased



- Monitoring equipment
- Data collection and processing for business-as-usual operation
- Implementation and debugging
- Data collection and processing for new operation
- **Results and comparison**

- **- 21 %** electricity purchased
- **+ 1.2 %** incentives
- **- 34 %** heat dissipation

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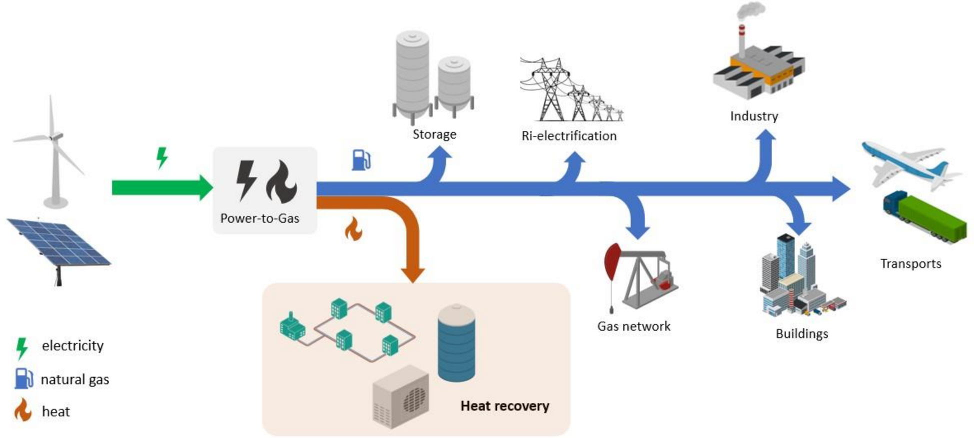
We are now using the same approach on more complex systems that involve Power-to-Gas plants and heat recovery



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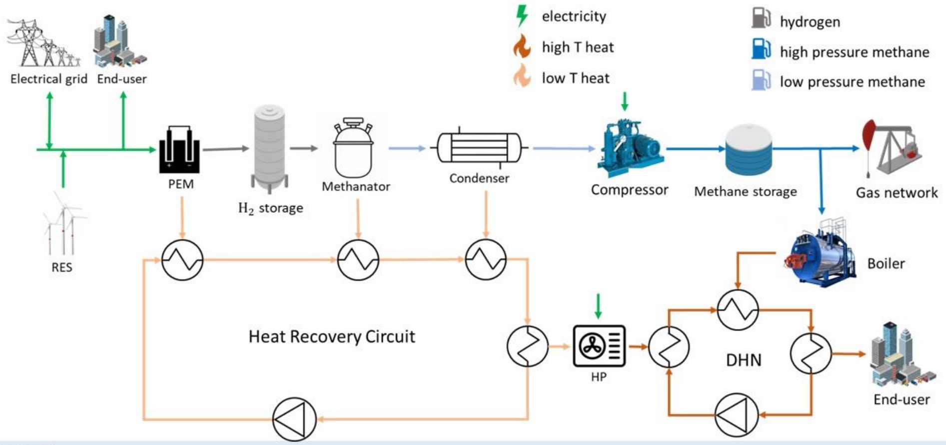
We developed the management system of the integrated energy system also considering the double time-scale for seasonal storages



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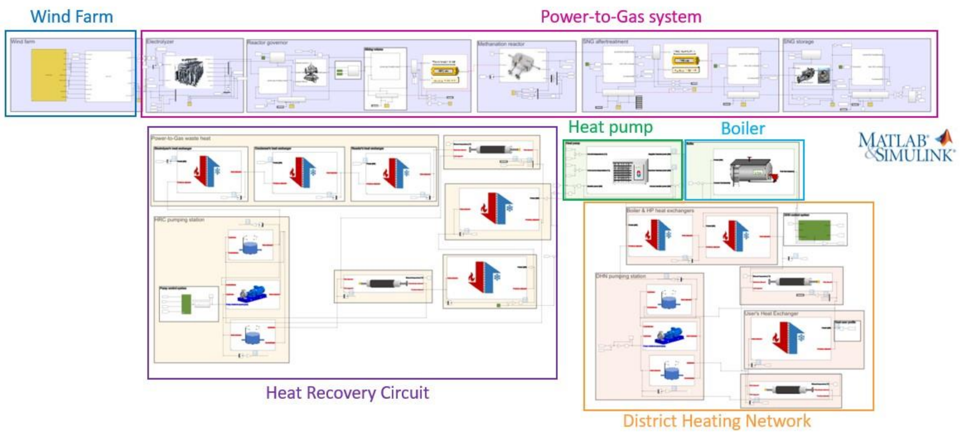
We tested the management system with our simulation platform, which was improved and extended to include Power-to-Gas components



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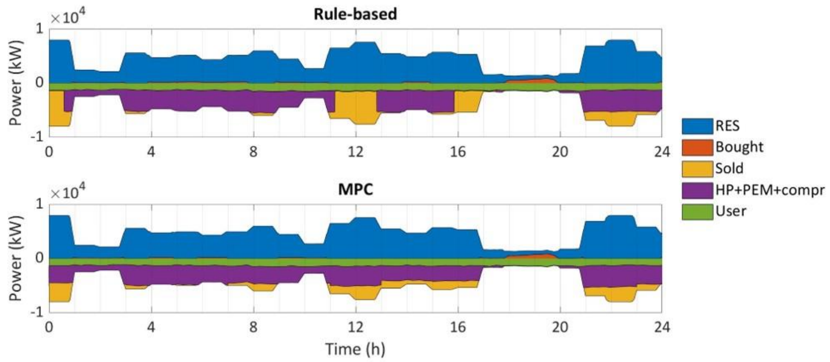
The MPC, which optimizes the system with an holistical perspective, performs better than a conventional rule-based management strategy



+ 54 % operating margin **+ 4.6 %** RES utilization

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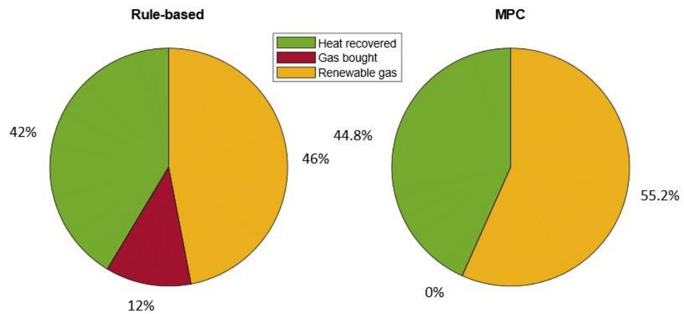
Through system integration, heat recovery and smart management, it is possible to obtain a carbon free fulfilment of the heat demand



+ 2.8 % heat recovered share

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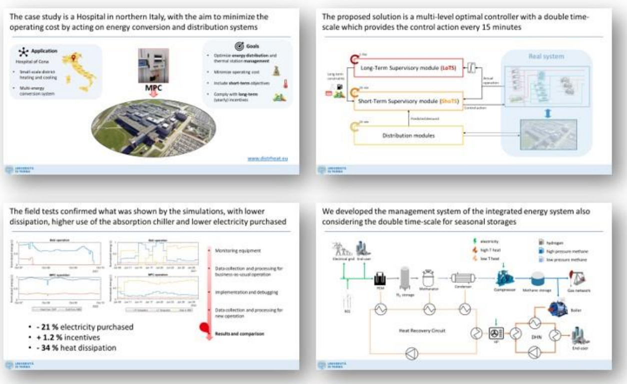
At the University of Parma, we work on modeling and control of integrated energy systems with a focus on district energy and sustainable fuels



Background papers

SCAN ME

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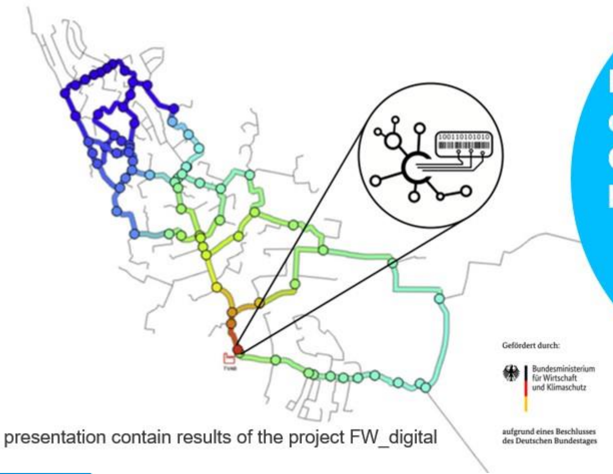
Session VI - Business Models – Unlocking the Value of Digitalization in DHC

Universität Stuttgart
IER Institut für Energiewirtschaft
und Rationelle Energieanwendung



Digitalization of district heating Quaters – a cost benifit analysis

Markus Blesl,
Frank Wendel
Yichen Xu

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

The presentation contain results of the project FW_digital

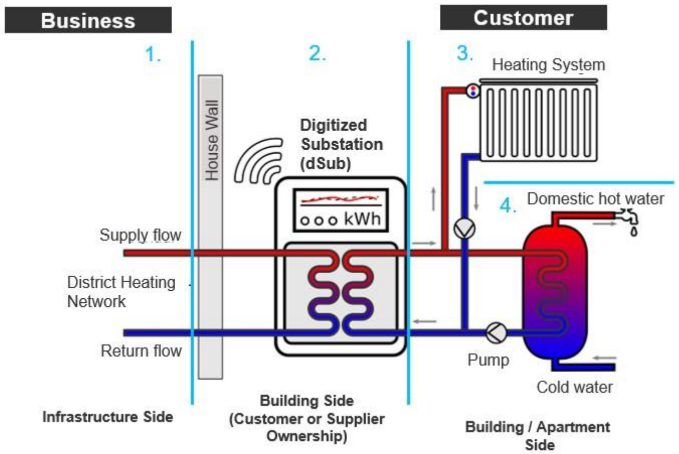
Agenda

- Starting point of the digitalization
- Effects of the digitalization of substations and strategies for quarters
- Cost-Benefit analysis of the digitalization of a quarter
- Conclusion

Starting point of the digitalization

Elements of District Heating

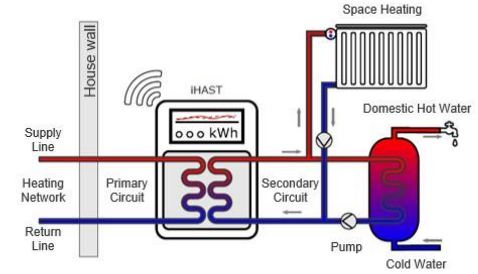
Simplified overview



1. **Stub lines** connecting the district heating network with the house substation (**Sub**)
2. **Substation** (or intelligent and digitized substation (**dSub**)) with heat meter, heat exchanger (for indirect system types), control engineering and, if necessary, communication technology.
3. **Space heating system** with radiators, circulating pumps and thermostatic valves
4. **Domestic hot water storage** with heat exchanger, pump and valves

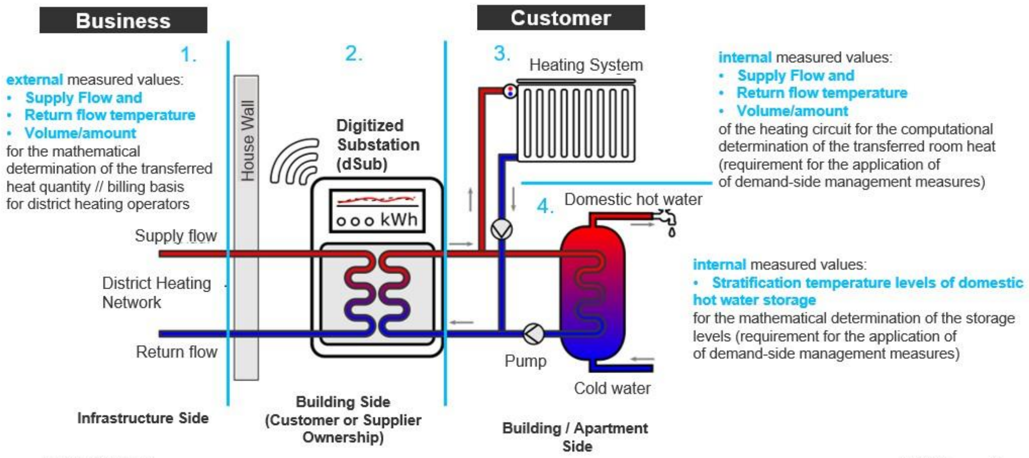
Digitalisation of substations (HAST)

- Six stages of digitalisation of HAST according to Rapp et al. (2020):
- Stage 1: Measured value acquisition primary side (m, p, dT) ≤15 min (enables fault detection)
- Stage 2: + measured value acquisition SH and DHW secondary side
- Stage 3: + operating value detection (more extensive fault detection)
- Stage 4: + active influence on heat consumption on the part of the energy supplier (DSM)
- Stage 5: + Option for decentralised integration of heat
- Stage 6: + active influence on decentralised heat generation on the part of the energy supplier

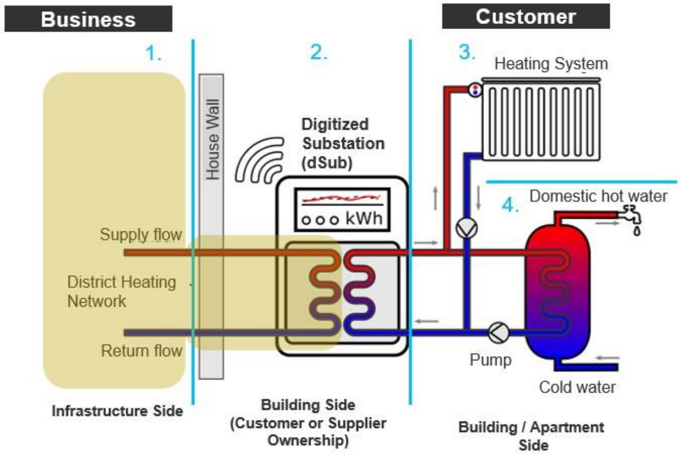


Schematic of an indirect HAST for the provision of space heating and domestic hot water

What data can be used for business modells through digitization?



Business Model for Businesses



Expected effects of digitization for DISTRIBUTION of district heating

- passive: through digitization, lower network-side temperatures can be achieved → lower heat and pressure losses lead to an increase in transport efficiency
- passive: digitization reduces peak loads, thus freeing them up for recompression and network expansion, if necessary → enables cost-efficient expansion of district heating
- active: monitoring of distribution network driven by measurement data enables early identification of dead points and supply bottlenecks → operator gains deep insight into heat network operation and the possibility of efficient operational management + reduction of maintenance and servicing costs

➢ **Optimization of business model through reduction of costs**

Effects of the digitalization of substations and strategies for quarters

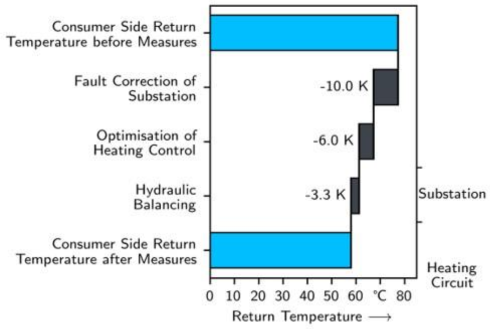
Reduction potentials of consumer side return temperature

In substations and heating circuits

PROBLEMS AND OPTIMISATIONS

- The substations and the heating circuits can have up to three of these reduction potentials
  - Faulty substations (for substations)
  - Unoptimised control (for heating circuits)
  - Hydraulic imbalancing (for heating circuits)
- The corresponding optimisations are
  - Fault correction
  - Control optimisation
  - Hydraulic balancing

ASSUMED IMPACTS



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Digitisation strategies

- Digitalisation strategies are used in an attempt to digitalise:
  - Resource-efficiently (conversion time from HAST to iHAST approx. 3 h)
  - with the levers that can be realised as economically as possible
  - ≫ Prioritisation of the HAST to be preferably digitalised required
- Prioritisation of the HAST to be preferably digitalised according to different criteria:
  - Volume of the domestic hot water storage tanks
  - Total annual heat demand
  - Distance to generation / position in the sub-circuit

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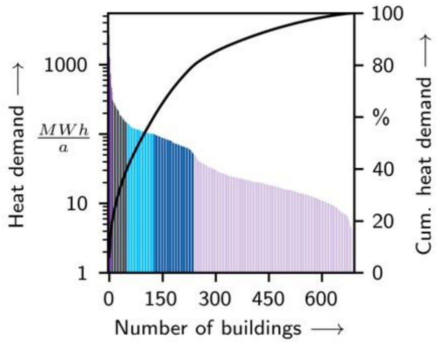
Digitalisation process

Stages and critieria

- **Digitalisation Stages (5 stages as an example)**
  - **Stage 0**: Base stage with no digitalisation.
  - **Stages 1 to 5**: Progressive digitalisation, each stage adding 20% more coverage of the total heat demand.
  - **Final Stage (Stage 5)**: Complete digitalisation of all substations.
- **Digitalisation Criteria**
  - Substations with higher annual heat demand are digitalized earlier.



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Digitalisation measures

- Exchange to smart heat meters (SHM)
- Installation of IT infrastructure
- Applying demand side management (DSM) for space heating (DSM-SH)
- Applying DSM for domestic hot water (DSM-DHW)
- Reduction of consumer side return temperature in substations and heating circuits

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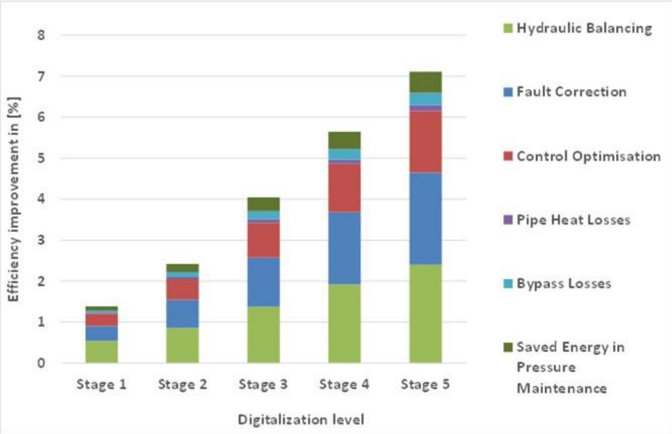
Effects of digitalization

Energy impacts



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Cost-Benefit analysis of the digitalization of a quarter

Techno-economic evaluation

- The costs of digitalisation are compared with any savings that can be achieved
- The evaluation basis is FW 703 for calculating unprofitable costs both in €/a and in €/MWh
- To be considered:
  - Efficiencies on the generator side, fuel requirements and electricity revenues
  - Costs of pressure maintenance on the heating network side, transport-related heat losses, mass flow regulating outflows via bypass valves as well as maintenance and servicing
  - Costs of purchasing and operating digitalised substations (iHASTs) and IT infrastructure
- Derivable conclusions: Identification of economically advantageous
  - Digitalisation stages, and
  - Proportions of HAST to be digitalised

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Cost Components

Associated with the digitalisation process

OPERATING COSTS AND GAINS

- Maintenance and servicing of DHN
- Fuel consumption
- (Revenue from) electricity generation
- Pipe heat losses
- Pressure maintenance costs

COSTS OF DIGITALISATION

- Installation and operating costs
  - Costs of SHM
  - Costs of IT infrastructure
- Costs of optimisations for substations
  - Costs of fault correction
  - Costs of control optimisation
  - Costs of hydraulic balancing

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Scenario "Company"

Network operator pays all costs

OPERATING COSTS AND GAINS

- Maintenance and servicing of DHN
- Fuel consumption
- (Revenue from) electricity generation
- Pipe heat losses
- Pressure maintenance costs

COSTS OF DIGITALISATION

- Installation and operating costs
  - Costs of SHM
  - Costs of IT infrastructure
- Costs of optimisations for substations
  - Costs of fault correction
  - Costs of control optimisation
  - ~~Costs of hydraulic balancing~~

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Scenario "Neutral"

Coustomers pay for additional costs

OPERATING COSTS AND GAINS

- Maintenance and servicing of DHN
- Fuel consumption
- (Revenue from) electricity generation
- Pipe heat losses
- Pressure maintenance costs

COSTS OF DIGITALISATION

- Installation and operating costs
  - Costs of SHM
  - ~~Costs of IT infrastructure~~
- ~~Costs of optimisations for substations~~
  - ~~Costs of fault correction~~
  - ~~Costs of control optimisation~~
  - ~~Costs of hydraulic balancing~~

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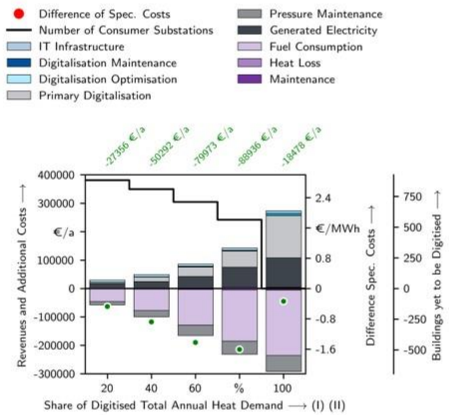
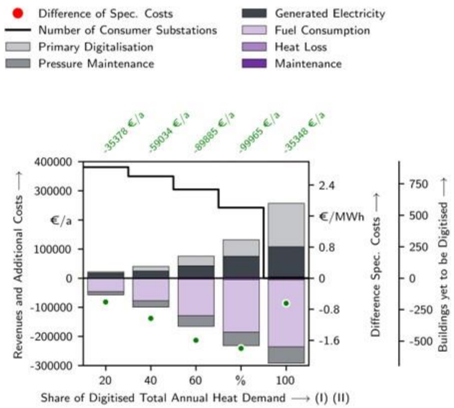
Scenario comparison – implementation of the digitalisation strategy

SCENARIO "COMPANY"



SCENARIO "NEUTRAL"



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Conclusion

Conclusions and outlook

- There is an optimal level of digitalisation depending on the area and the type and age of the substations.
- The digitalisation of the substation can help prepare networks for a transformation.
- Errors are not always a one-time occurrence but can be repeated, which is why permanent controlling makes sense.
- The utilisation of economic options depends heavily on the extent to which sector coupling options are available or will be integrated in the future.
- However, the ownership structure of the substations and the boundaries from the custo
limit the options to some extent.

Gefördert durch:
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aufgrund eines Beschlusses des Deutschen Bundestages

The presentation contain results of the project FW_digital

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Ideas on future business models

November 21, 2023
Kristina Lygnerud

Who is Kristina Lygnerud?

- **Professor** in energy sciences at Lund University since 2022
- **Assistant professor** in energy technology at Halmstad University since 2015
- **Intrapreneur in green DH solutions** at the Swedish Environment Research Institute since 2022
- **Energy department mana**ger at the Swedish Environment Research Institute 2018-2022
- Been **active with district heating research since 2004**. PhD in 2010 with ”Risk management in district heating systems”- NOT AN ENGINEER □
- **Coordinated EU project** on DH (H2020: EU) and **IEA-DHC projects**
- On the **DHC+ board** since 2018 (chair since 2021)

AGENDA

1. What is a business model & the conventional DH model

2. Future business model

1. What is a business model – and the conventional DH model

Business model: What is it?

Much written about them but no universal definition exists…

Not to be confused with:
- strategy (but it reflects strategy)
- products
- industry
- network
- technology
- internal organization
- value chains

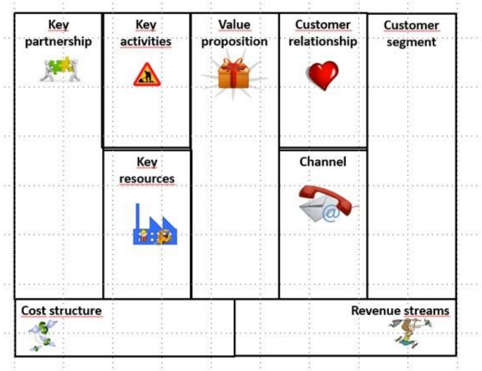
…generic features are:

CUSTOMERS
-value
-relationship
-segment

RESOURCES
-infrastructure
-activities
-partners
-logistics

COST/ INCOME STRUCTURE

Business Model: What is it? (continued)



So..the business model illustrates the components needed for delivering a customer value

Source: Ostewalder & Pigneur (2010)- The business model canvas

The conventional district heating business model

Table 4 The conventional features of Swedish district heating businesses

Key partnerships Fuel providers	**Key resources** Production unit Distribution network	**Customer value** Provider of heat and hot water (utility)	**Customer segment** Business-to-business (largest segment) Private homeowners
	Key activities Production Distribution Maintenance	**Customer channel** Invoicing Campaigns	**Customer relationship** Provider to consumer (push)
Cost structure Large fixed costs		**Income structure** Fixed	

The business logic is to make use of avaliable resources* large scale…the system of production and distribution need to be optimized from a technical point of view to lower the unit cost.

The customer need is standardized

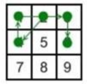
* Conventional ones are: fossil fuels, waste, biofuels, geothermal, industrial waste heat

2. Future business model

BACKGROUND: THE BUSINESS IS SHIFTING

Use the heat sources locally avaliable

Combine the heat sources that exist



Heat supply
- Access varies over time
- Their size is limited
- No centralized, heat production

<u>The fixed asset shift</u>
Production unit is rebuilt/ removed
Equipment for heat recovery (HP?) and network connections
Solar heating panels

<u>The partner and risk shift</u>
New partners in close collaborations- are they prosumers?
Efficient and flexible contracts are key
Who should own and operate assets (risk management)?

Smarta systems
- Supply and demand matching

<u>The operations system shift</u>
Digital structure allowing the customer to make efficient choices and the energy company to recived and send operational signals

The digital work can be outsourced?

THE BUSINESS SHIFTS (CONT)

Supply heat whe it is in demand

Sector coupling

Demand driven heat delivery
-efficient storage solutions

<u>The storage shift</u>
- Small scale storages (where they exist; like buildings)
- Seasonal storage

Storage can be outsourced?

Efficient use of energy
- Identify the most efficient heat supply

<u>The infrastructure shift</u>
- Work beyond the silos of different sectors
- Rules for operation and pricing
- Collaborate over regional boundaries
- New markets bring new competition

PROJECT: DH BUSINESS MODEL 2050

VEOLIA
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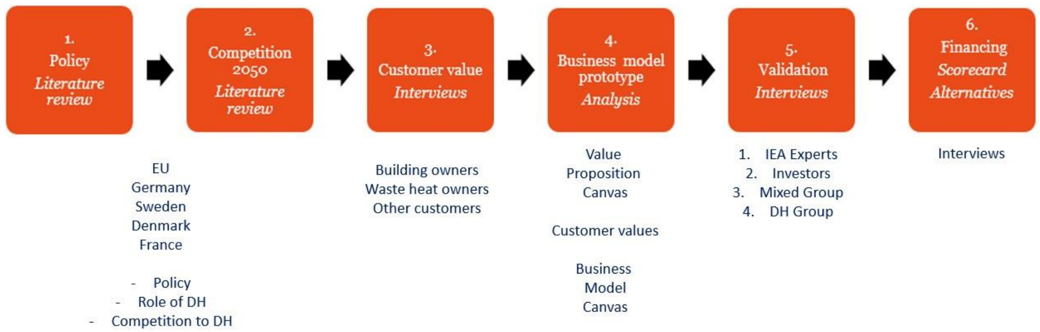
Hochschule für Technik Stuttgart
DBDH
MÉTROPOLE NICE CÔTE D'AZUR
Albertslund Kommune



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Customer value 2050

(i) Provide cost efficient, convenient energy service packages that require a low level of active involvement

"Passive Customer Behavior"

Δ 2022-2050: In 2050, the level of digitalization is high (smart buildings, smart grid, smart consumers)- the offer is carfeeness at competitive price. The green dimension has become standard and is no longer an USP: Majority of customers

(ii) Involve our customers into the process of optimizing the heat system, with maximum transparency on their impact on the system

"Active Customer Behavior"

Δ 2022-2050: In 2050, DH companies develop their offer together with "co-creators": joint investments undertaken, new ideas tested, long-term relationships are built: Minority of customers

Passive customer behavior (2050)

Active customer behavior (2050)

Key partners

Fuel providers

Prosumers Heat providers

Co-creators

Key activities

Operation and maintenance

Identical with the inclusion of the new key resources

Co-creation and relationship building

Key resources

DHN
Production Unit
Operations system
Staff: operations and maintenance

Identical with the addition of heat pumps, electricity generation, storages and digital infrastructure

Staff dedicated to co-creation and relationship building with co-creators

Customer Value

Heat/ cool and hot water

Heat/ cool- possibly hot water

Security of supply, comfort, carefree at reasonable cost

Carefree at reasonable cost

Green energy

Co-creation of value with energy company

Customer Segment

Professional building owners

Professional and private end-users

Identical with the addition of prosumers and active customers from, for example, industry

Customer Relationship

Automized

Identical with the addition of win-win and long-term relationship with prosumers

Personal relationship with co-creators

Customer Channel

Invoice, campaigns, webpage

Digital with an app

Personal meetings

Cost and income structure

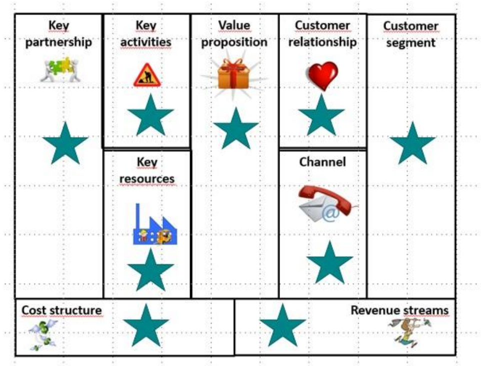
Fixed costs (production unit and network) Remains, with addition of heat pumps, PV, storage and digital Infrastructure: large scale combustion units phased out additiona investment might be needed for co-creation

Staff Remains with addition of staff for prosumer and heat supply arrangements and co-creation

Fuels Remains but are replaced by combustible to a portfolio of diverse sources (size and temperature)

Customer revenue Service package offered, part of it can be linked to a win-win arrangement

Business Model: What is it? (continued)



So..the business model illustrates the components needed for delivering a customer value

Source: Ostewalder & Pigneur (2010)- The business model canvas

Thank you for listening!

Stiftung Umweltenergierecht

Legal Requirements for Data Protection and Cybersecurity in the Digitalization of District Heating and Cooling

IEA DHC Annex TS4
Carsten von Gneisenau
21.11.2023

Future Factory for the law of energy transition

- Non-profit, highly specialized research institute
- Central question: How does the legal framework needs to change in order to meet the aims in energy and climate policy?
- Interdisciplinary research
- Consultation during legislative procedures

Agenda

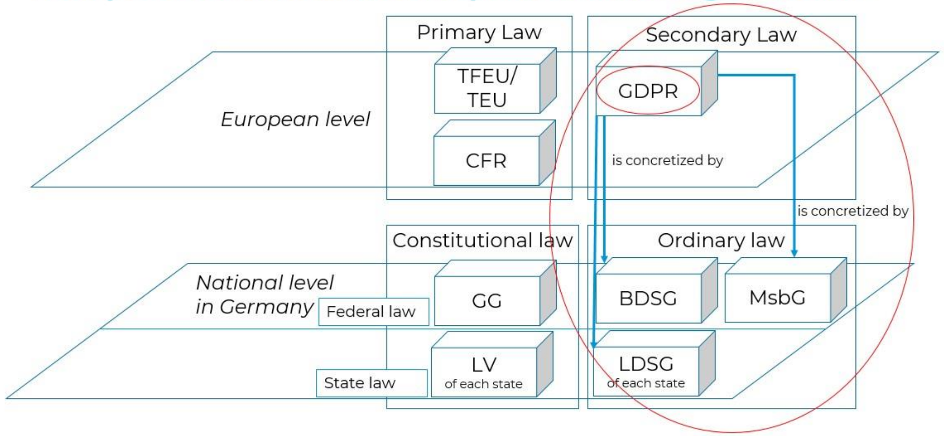
- Data Protection in the field of district heating and cooling
  - Focus on: General Data Protection Regulation (GDPR)
- Cybersecurity in the field of district heating and cooling
  - Focus on: Network and Information Security Directive (NIS II)
- Conclusion

Data Protection

Focus on: General Data Protection Regulation (GDPR)

Presentation 18:
Legal Requirements for Data Protection and Cybersecurity in the Digitalization of District Heating and Cooling

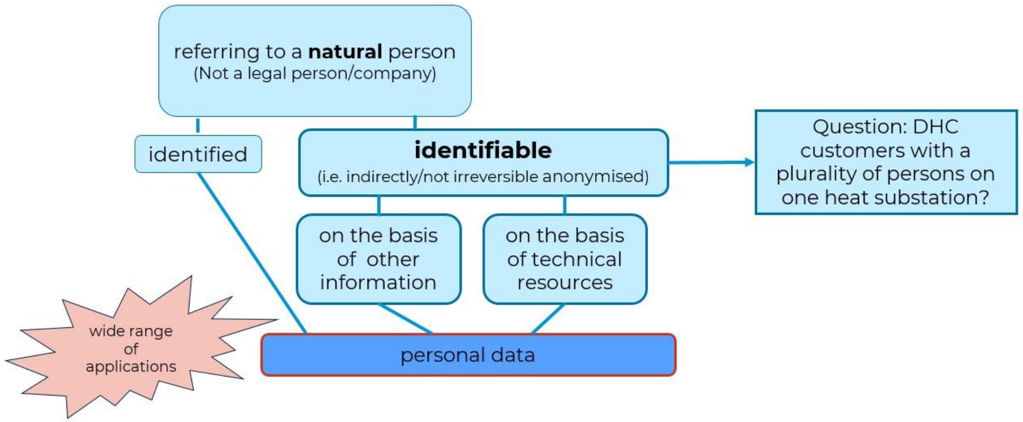
Data protection law in the European multi-level governance



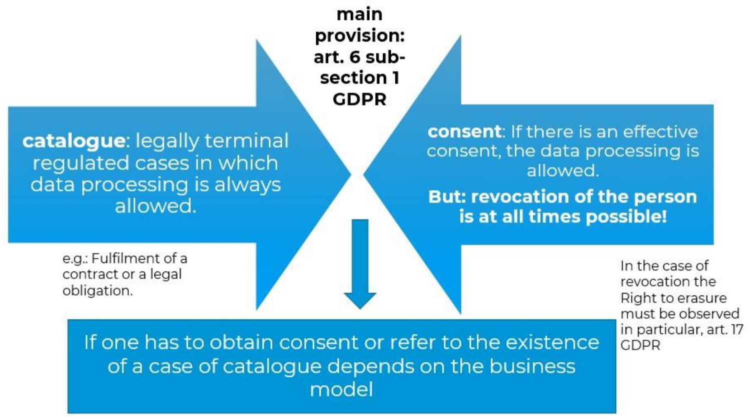
Essential question: Personal data or non-personal data?

Personal data	Other data
Applicability of the GDPR	GDPR not applicable
Data processing is only allowed in cases regulated by law	National law may apply (e.g. § 50 MsbG in the electricity sector)
The obligatory law of the GDPR has to be followed	The obligatory law of the GDPR has not to be followed

When is there a personal reference?



When is it allowed to process personal data?

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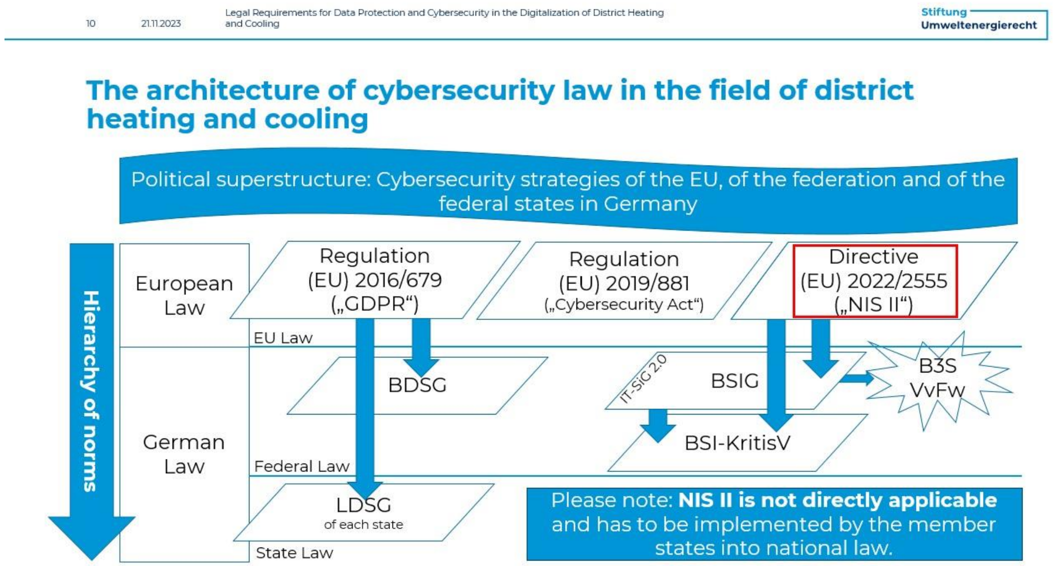
21.11.2023
Legal Requirements for Data Protection and Cybersecurity in the Digitalization of District Heating and Cooling
Stiftung Umweltenergierecht
Cybersecurity
Focus on: Network and Information Security Directive (NIS II)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21.11.2023
Legal Requirements for Data Protection and Cybersecurity in the Digitalization of District Heating and Cooling
Stiftung Umweltenergierecht
The architecture of cybersecurity law in the field of district heating and cooling
Political superstructure: Cybersecurity strategies of the EU, of the federation and of the federal states in Germany
Hierarchy of norms
European Law
Regulation (EU) 2016/679 („GDPR“)
Regulation (EU) 2019/881 („Cybersecurity Act“)
Directive (EU) 2022/2555 („NIS II“)
EU Law
German Law
BDSG
IT-SIG 2.0
BSIG
B3S VvFw
BSI-KritisV
Federal Law
LDSG of each state
State Law
Please note: NIS II is not directly applicable and has to be implemented by the member states into national law.

Scope of the Directive (EU) 2022/2555 („NIS II“) (1)

Scope under Article 2 (1) NIS II

Entities of a specific sector + Entities of a specific size

Sectors are listed in Annex I and II. To this list belongs the **energy sector**, to the energy sector belongs **district heating and cooling** as a subsector and to the dhc subsector belongs the **dhc operator** under Article 2 No. 19 Dir (EU) 2018/2001 („RED II“) as the adressed entity.

„the distribution of thermal energy in the form of steam, hot water or chilled liquids, from central or decentralised sources of production through a network to multiple buildings or sites, for the use of space or process heating or cooling"

Scope of the Directive (EU) 2022/2555 („NIS II“) (2)

Scope under Article 2 (1) NIS II

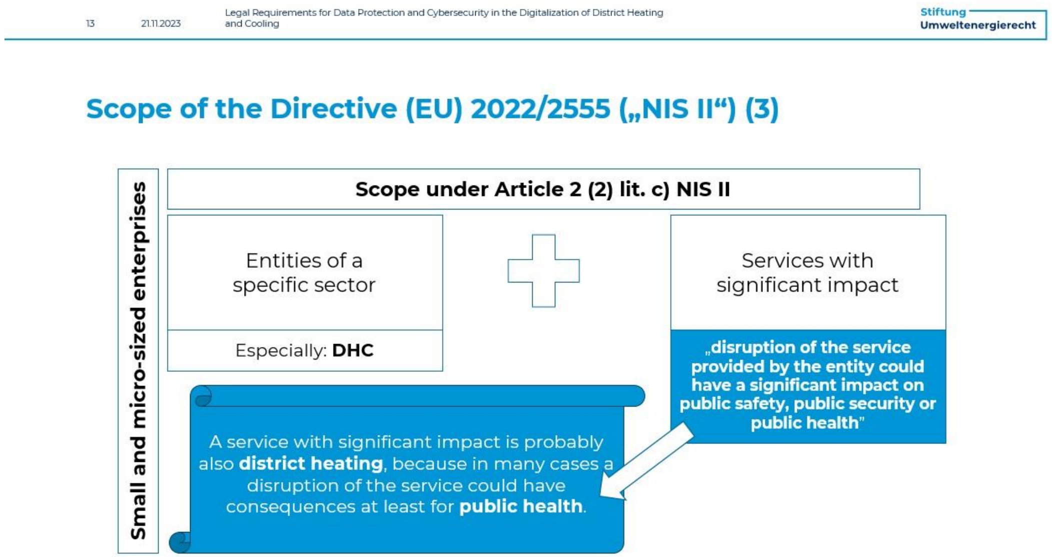
Entities of a specific sector + Entities of a specific size

The entity qualifies as **medium-sized enterprise** or **exceed** the ceilings for medium-sized enterprises.

Medium-sized enterprises

1. **Employees**: min. 50 and less than 250
2. **Annual turnover**: min. 10 Mio. € and max. 50 Mio. €
3. **Annual balance sheet**: min. 10 Mio. € and max. 43 Mio. €

DHC will fall under the scope of Article 2 (1) NIS II in many cases.


13 21.11.2023 Legal Requirements for Data Protection and Cybersecurity in the Digitalization of District Heating and Cooling
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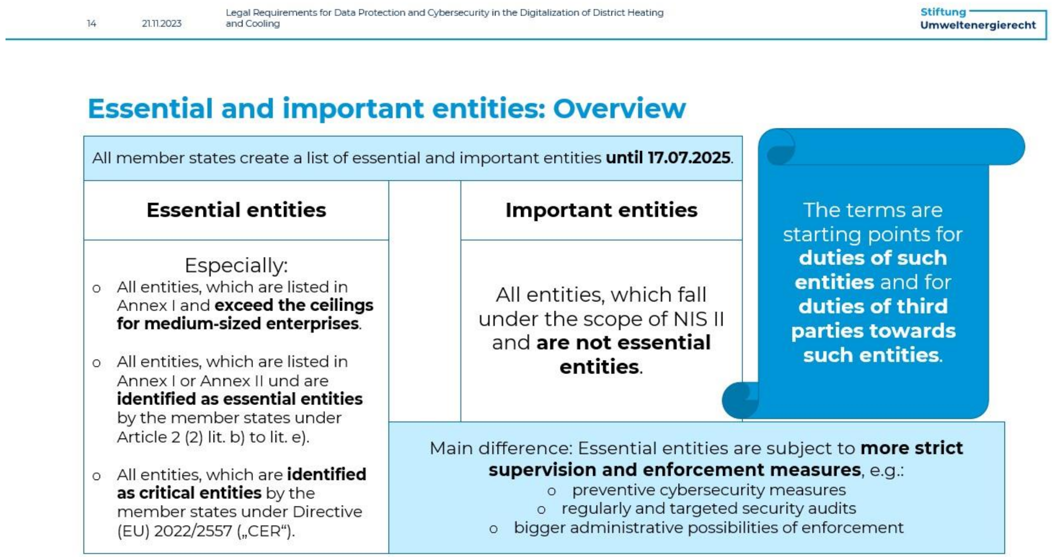
Scope of the Directive (EU) 2022/2555 („NIS II“) (3)
Small and micro-sized enterprises
Scope under Article 2 (2) lit. c) NIS II
Entities of a specific sector
Especially: DHC
Services with significant impact
„disruption of the service provided by the entity could have a significant impact on public safety, public security or public health“
A service with significant impact is probably also district heating, because in many cases a disruption of the service could have consequences at least for public health.


14 21.11.2023 Legal Requirements for Data Protection and Cybersecurity in the Digitalization of District Heating and Cooling
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Essential and important entities: Overview
All member states create a list of essential and important entities until 17.07.2025.
Essential entities
Especially:
All entities, which are listed in Annex I and exceed the ceilings for medium-sized enterprises.
All entities, which are listed in Annex I or Annex II und are identified as essential entities by the member states under Article 2 (2) lit. b) to lit. e).
All entities, which are identified as critical entities by the member states under Directive (EU) 2022/2557 („CER“).
Important entities
All entities, which fall under the scope of NIS II and are not essential entities.
The terms are starting points for duties of such entities and for duties of third parties towards such entities.
Main difference: Essential entities are subject to more strict supervision and enforcement measures, e.g.:
preventive cybersecurity measures
regularly and targeted security audits
bigger administrative possibilities of enforcement

Conclusion

Lessons learned...

- GDPR is applicable for **personal data** only; personal data requires a natural person, who is **identified or identifiable** by the data.
- Operators of DHC are allowed to process personal data, if the requirements of **Article 6 (1) GDPR** are fulfilled; requirements are a **regulated case or consent** by the natural person.
- At least **medium-sized DHC enterprises** will fall under the scope of NIS II; this means enterprises with at least 50 employees, 10 Mio. € annual turnover and 10 € annual balance sheet.
- **Small and micro-sized district heating enterprises** could also fall in many cases under the scope of NIS II, because they might be provide services with a significant impact at least for public health.

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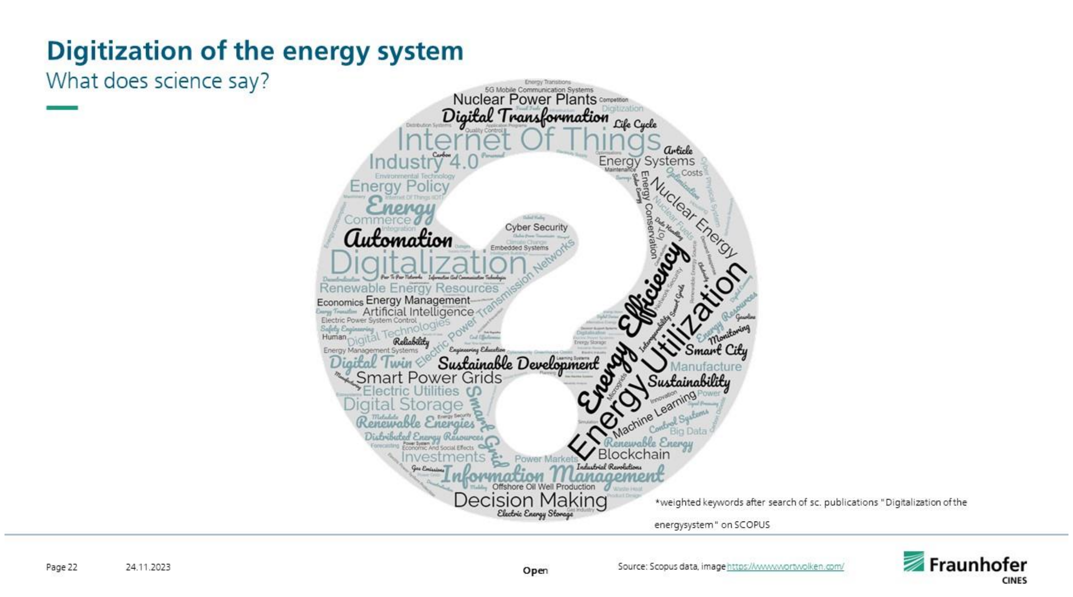
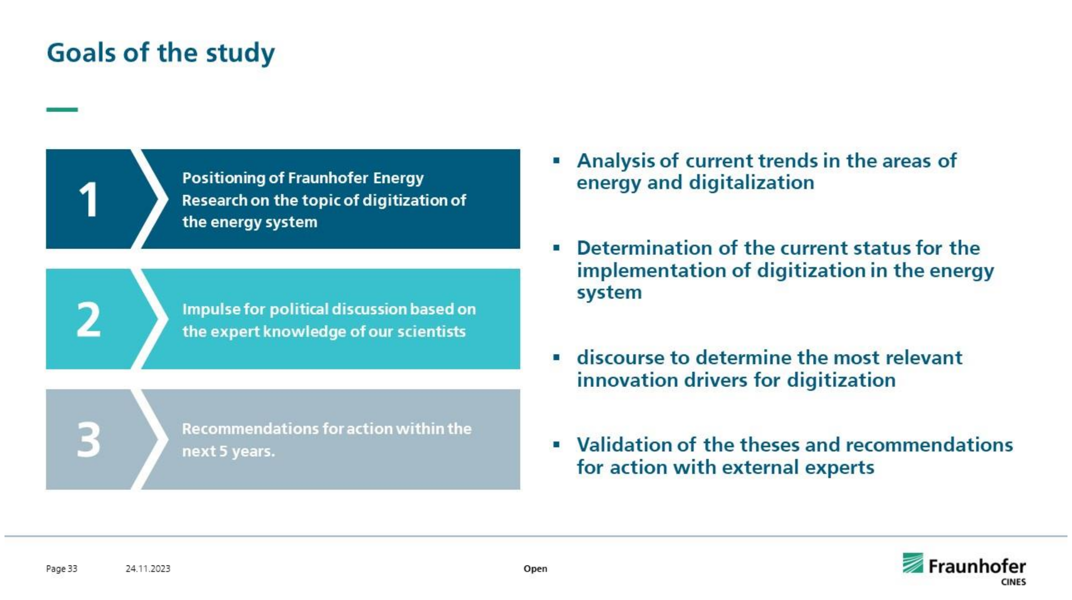
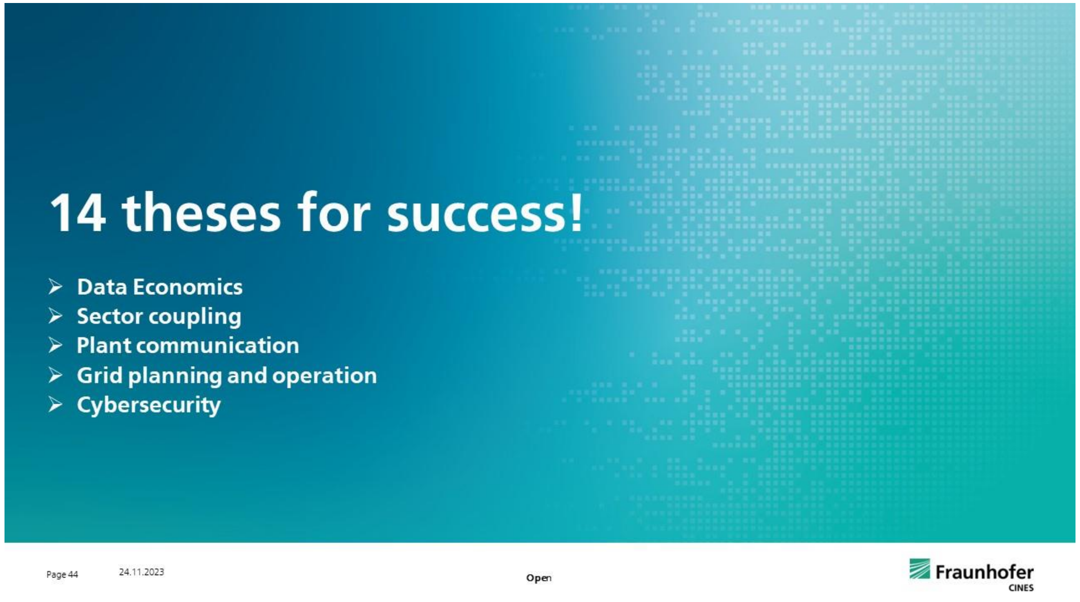
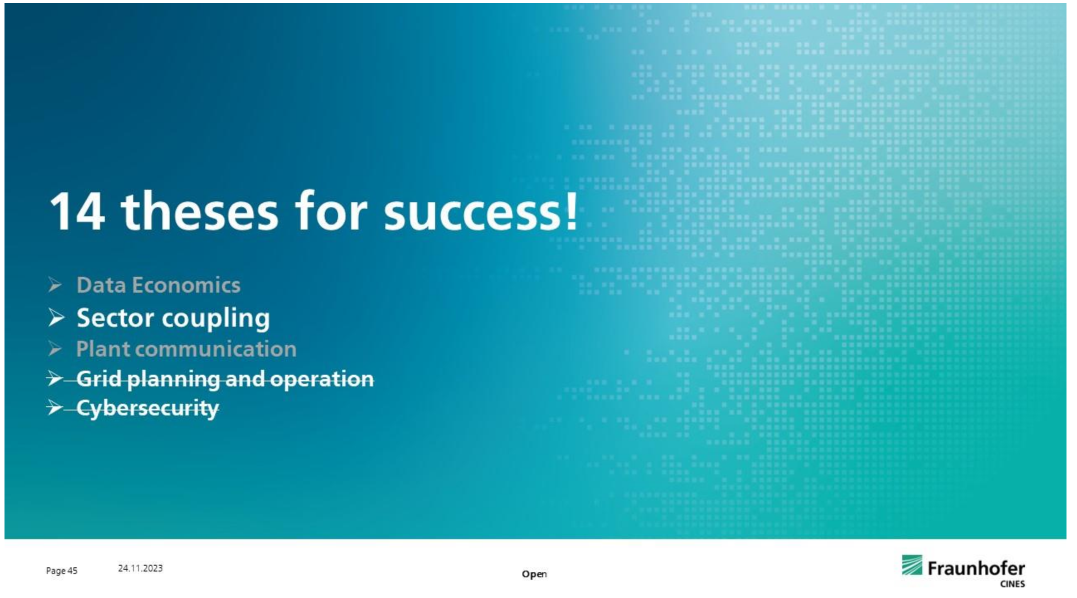






Presentation 19:
Digitalization within the Energy Field: 14 Propositions to Success!


14 theses for success!
Data Economics
Sector coupling
Plant communication
~~Grid planning and operation~~
~~Cybersecurity~~
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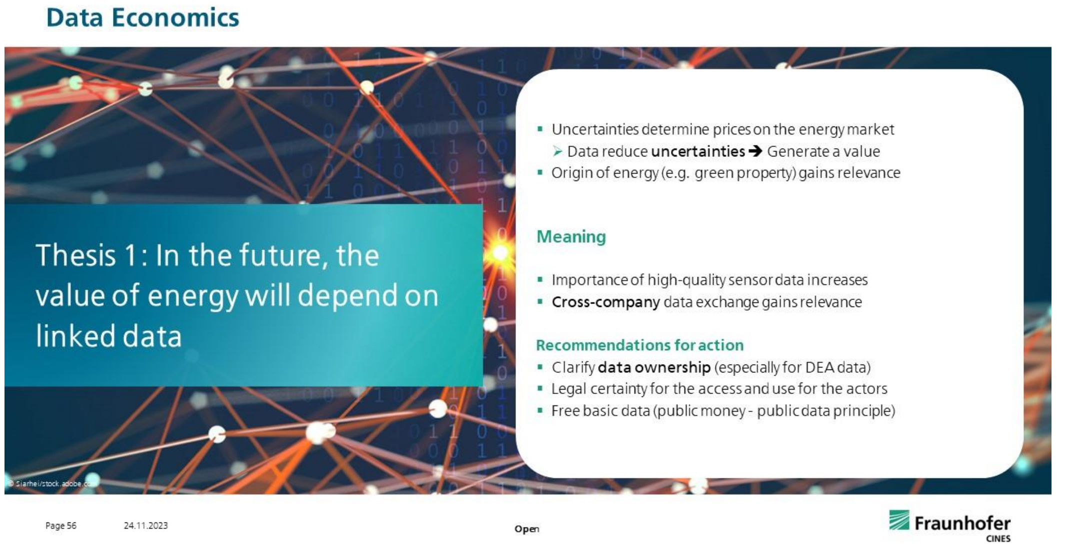
Data Economics
Thesis 1: In the future, the value of energy will depend on linked data
Uncertainties determine prices on the energy market
Data reduce uncertainties → Generate a value
Origin of energy (e.g. green property) gains relevance
Meaning
Importance of high-quality sensor data increases
Cross-company data exchange gains relevance
Recommendations for action
Clarify data ownership (especially for DEA data)
Legal certainty for the access and use for the actors
Free basic data (public money - public data principle)
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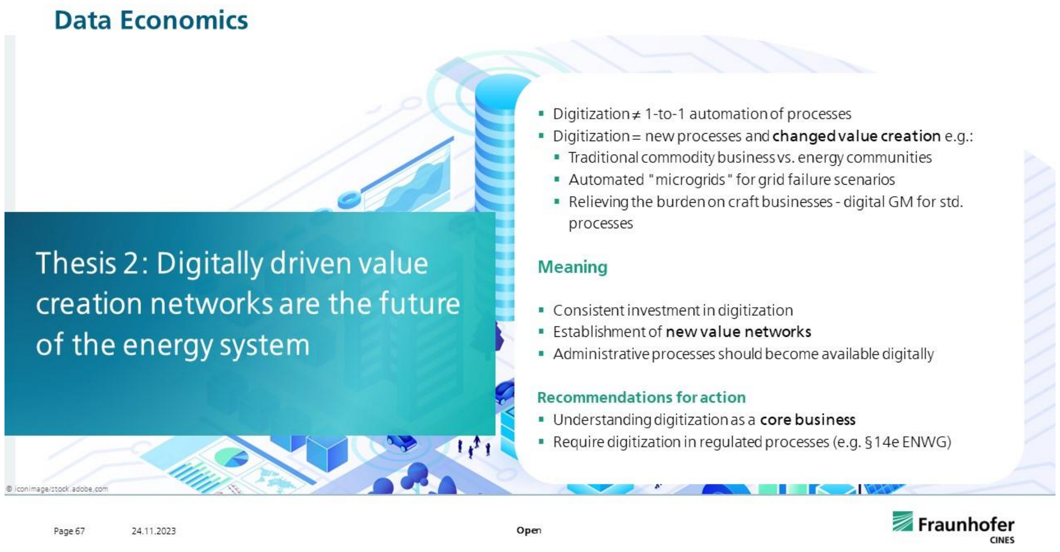
Data Economics
Thesis 2: Digitally driven value creation networks are the future of the energy system
▪ Digitization ≠ 1-to-1 automation of processes
▪ Digitization = new processes and **changed value creation** e.g.:
▪ Traditional commodity business vs. energy communities
▪ Automated "microgrids" for grid failure scenarios
▪ Relieving the burden on craft businesses - digital GM for std. processes
Meaning
▪ Consistent investment in digitization
▪ Establishment of **new value networks**
▪ Administrative processes should become available digitally
Recommendations for action
▪ Understanding digitization as a **core business**
▪ Require digitization in regulated processes (e.g. § 14e ENWG)
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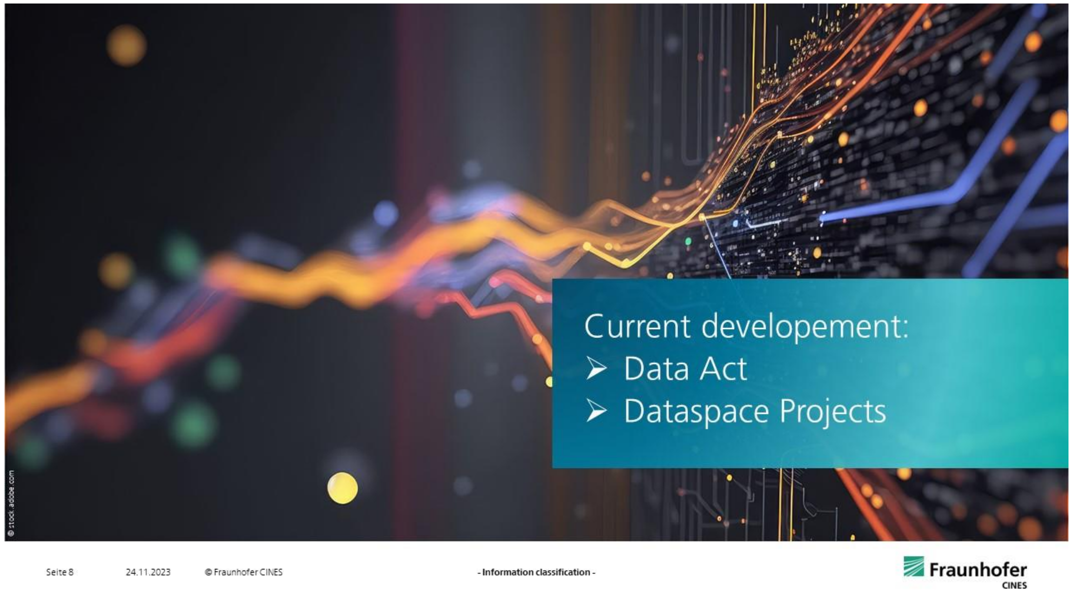
Current developement:
➢ Data Act
➢ Dataspace Projects
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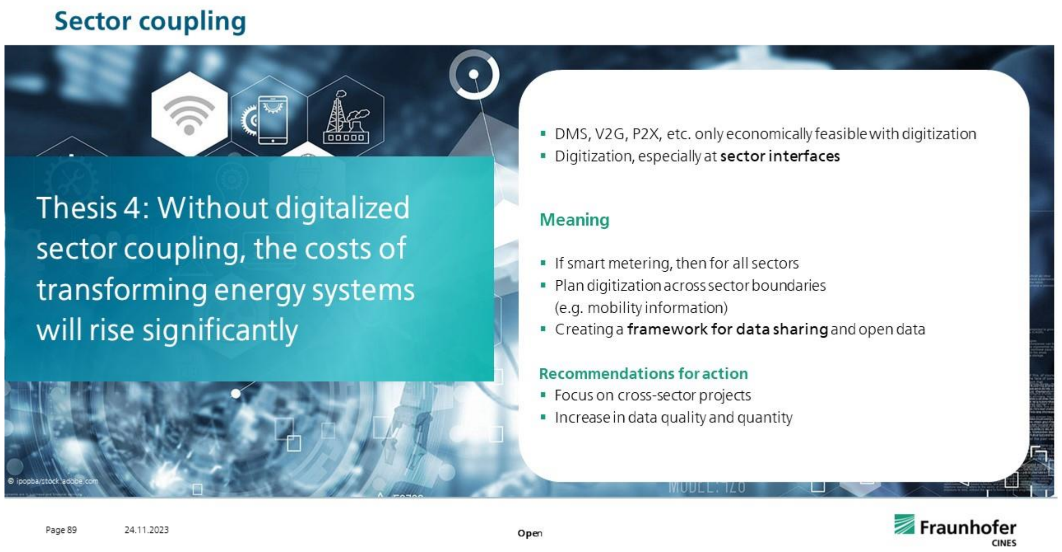
Sector coupling
Thesis 4: Without digitalized sector coupling, the costs of transforming energy systems will rise significantly
▪ DMS, V2G, P2X, etc. only economically feasible with digitization
▪ Digitization, especially at **sector interfaces**
Meaning
▪ If smart metering, then for all sectors
▪ Plan digitization across sector boundaries (e.g. mobility information)
▪ Creating a **framework for data sharing** and open data
Recommendations for action
▪ Focus on cross-sector projects
▪ Increase in data quality and quantity
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Sector coupling
Thesis 5: Viable energy business models for digitalized sector coupling at the district level are currently failing due to regulatory hurdles
▪ Neighborhood level → esp. coupling of the gas, electricity, heat sectors
▪ Regulatory hurdles:
▪ e.g. network charges do not reflect actual usage
Meaning
▪ No law aims to exploit local potentials
▪ No motivation for **grid-compatible sector coupling** at the neighborhood level
Recommendations for action
▪ Restricting **infrastructure** and **grid usage costs to** network levels
▪ Promoting local use of RE electricity
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Sector coupling
Thesis 6: Efficient decarbonization of the heating sector can only be achieved through digital transformation
▪ Heating sector little digitized
▪ Digitization allows:
▪ Short-term efficiency gains in the existing system
▪ Medium-term integration of key technologies such as decentralized feed-in, low-temperature grids, smart heat pumps
Meaning
▪ Flexibilization on the consumption side through digitization
▪ Avoidance of curtailments through intelligent heat concepts
▪ Digitalization supports temperature reduction and integration of renewable heat
Recommendations for action
▪ Strengthening subsidies for intelligent heating concepts
▪ Link efficiency programs (e.g. KfW) with smart solutions
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Current developement:
➤ BEW, GEG
➤ HeizkostenV, FFVAV
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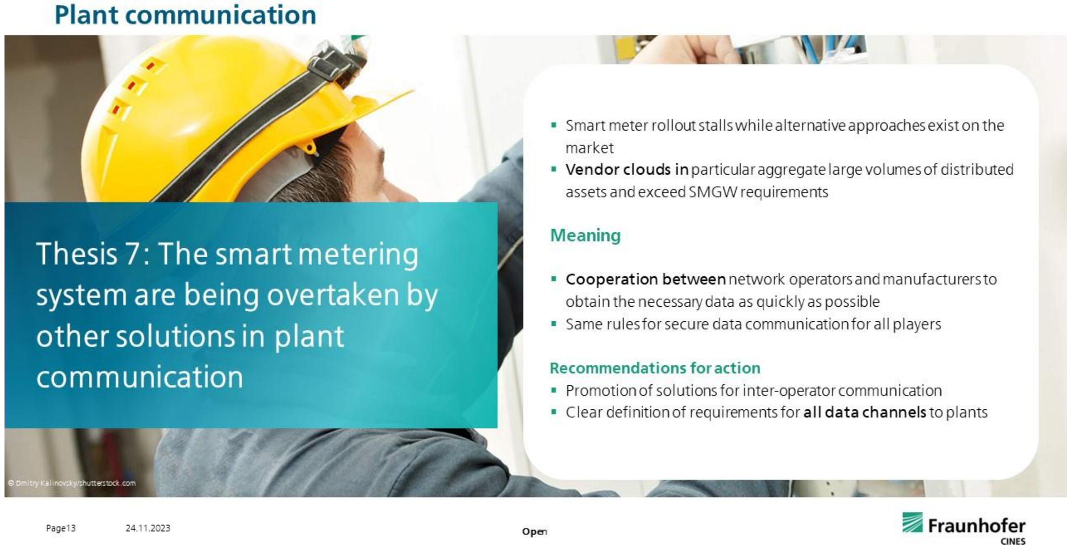
Plant communication
Thesis 7: The smart metering system are being overtaken by other solutions in plant communication
▪ Smart meter rollout stalls while alternative approaches exist on the market
▪ Vendor clouds in particular aggregate large volumes of distributed assets and exceed SMGW requirements
Meaning
▪ Cooperation between network operators and manufacturers to obtain the necessary data as quickly as possible
▪ Same rules for secure data communication for all players
Recommendations for action
▪ Promotion of solutions for inter-operator communication
▪ Clear definition of requirements for all data channels to plants
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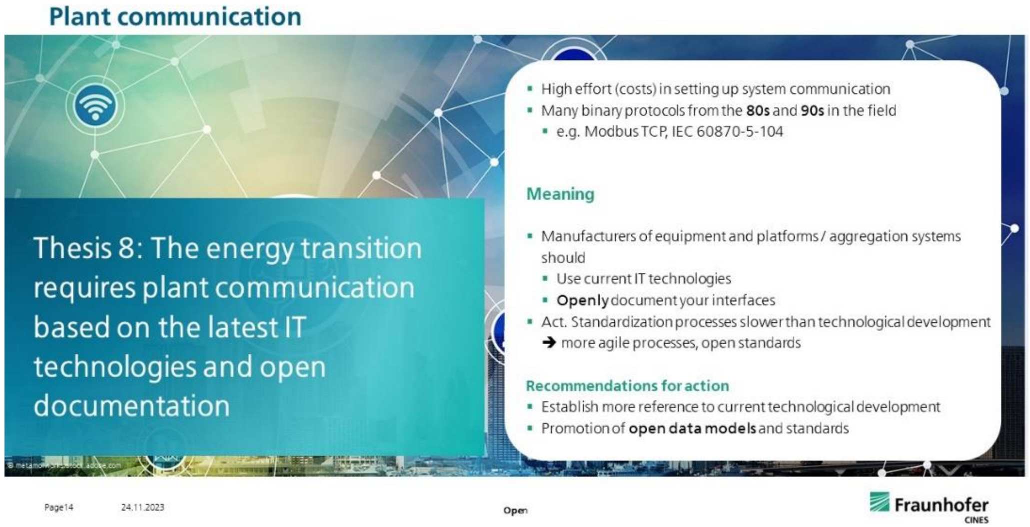
Plant communication
Thesis 8: The energy transition requires plant communication based on the latest IT technologies and open documentation
▪ High effort (costs) in setting up system communication
▪ Many binary protocols from the 80s and 90s in the field
▪ e.g. Modbus TCP, IEC 60870-5-104
Meaning
▪ Manufacturers of equipment and platforms / aggregation systems should
▪ Use current IT technologies
▪ Openly document your interfaces
▪ Act. Standardization processes slower than technological development
➔ more agile processes, open standards
Recommendations for action
▪ Establish more reference to current technological development
▪ Promotion of open data models and standards
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Current developement:
➢ GNDEW+
➢ EEBus
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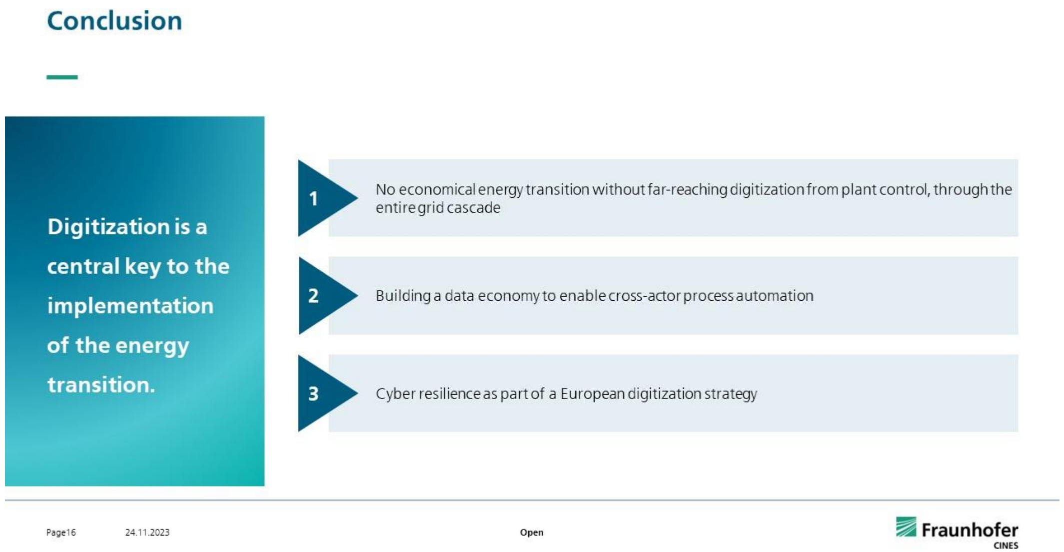
Conclusion
Digitization is a central key to the implementation of the energy transition.
1 No economical energy transition without far-reaching digitization from plant control, through the entire grid cascade
2 Building a data economy to enable cross-actor process automation
3 Cyber resilience as part of a European digitization strategy
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