Proceedings of the IEA DHC Annex TS4 Webinar:

Testbeds for Digitalization Solution in District Heating

27th of April 2022 as a web meeting

Hosted by:
Austrian Institute of Technology AIT

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

Testbeds for Digitalization Solutions in District Heating

Digitalization and sector coupling are key enablers for decarbonizing and integrating district heating systems. As discussed within the international cooperation program "IEA DHC Annex TS4, Digitalisation of District Heating and Cooling", an increasing number of digital solutions for integrated operation are available. However, the development of such solutions is complex and involves considerable time and cost expenditure. Suitable testbeds could enable to overcome these obstacles by providing an environment for the evaluation, (further) development and integration of digitalization solutions for integrated district heating networks.

Aim of the webinar was

- to introduce current developments of digital solutions and testbeds for district heating
- to present the AIT Digital Energy Testbed, an open test environment for digitalization solutions for integrated district heating networks (including a life demonstration)
- to discuss the role of the different testbeds for supporting the digitalization of district heating networks

The webinar was directed towards:

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

This Webinar is held in the framework of the international cooperation program "**IEA DHC Annex TS4, Digitalisation of District Heating and Cooling**". The Austrian participation is financed by the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK).
More information at https://www.iea-dhc.org/the-research/annexes/2018-2024-annex-ts4/ ; and the Austrian project "Digital Energy Testbed", funded by the "Klima- und Energiefonds" and carried out within the framework of the Energy Research Programme 2019 (project #881132)

IEA DHC
Federal Ministry Republic of Austria Climate Action, Environment, Energy, Mobility, Innovation and Technology
IEA Research Cooperation
DIGITAL ENERGY TESTBED
FFG Promoting Innovation.
powered by klima+ energie fonds
AIT AUSTRIAN INSTITUTE OF TECHNOLOGY TOMORROW TODAY
Fraunhofer IEE

Index

The webinar was held in three blocks:

Technology Collaboration Programme
by iea

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

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

Introduction of the Activity

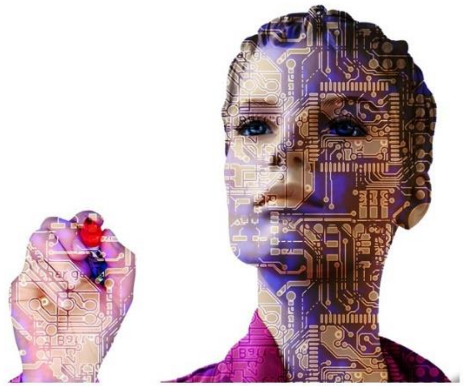
27 April 2022

Dr. Dietrich Schmidt

Fraunhofer IEE

Fraunhofer IEE

Our future Energy system will be digital!



IEA DHC INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

Aims of DHC Annex TS4

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

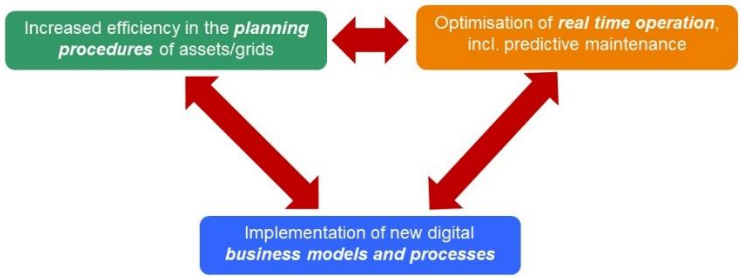
IEA DHC INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

Goals of DHC Annex TS4

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

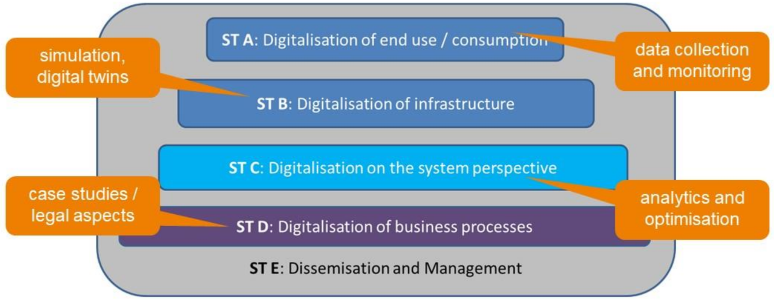
IEA DHC INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

Our focus areas for a digitalization in DHC



INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

DHC Annex TS4 working structure



INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

cooperation with other initiatives

- **German Heat & Power Association (AGFW)**
- **DHC+**
- **Danish Board of District Heating (dbdh)**
- **IEA EBC Annexes on:**
  "Demand Response of Buildings in DHC networks / Annex 84" **&**
  "Data-Driven Smart Buildings / Annex 81"
- And others…
  as **IEA HPT Annex 57** „Flexibility by implementation of heat pump in multi-vector energy systems and thermal networks"
  & Annex 56 „Internet of things for Heat Pumps"

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

Technology Collaboration Programme
by iea

Or meet us in Denmark!
special session on
IEA Annex TS4

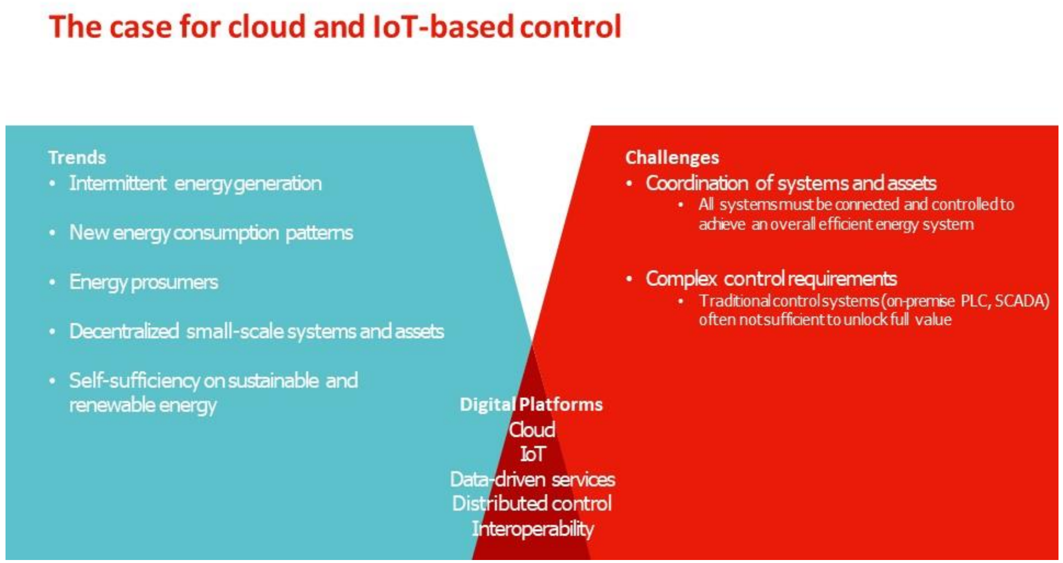
Contact:

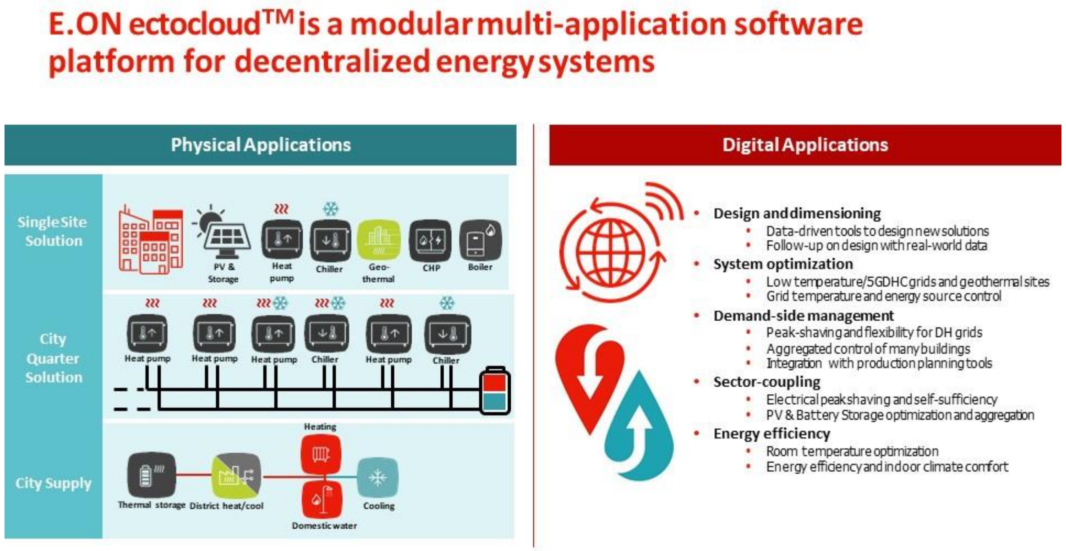
Dr. Dietrich SCHMIDT
Fraunhofer Institute for Energy Economics and Energy Technology / Germany
+49 561 7294 1517
dietrich.schmidt@iee.fraunhofer.de

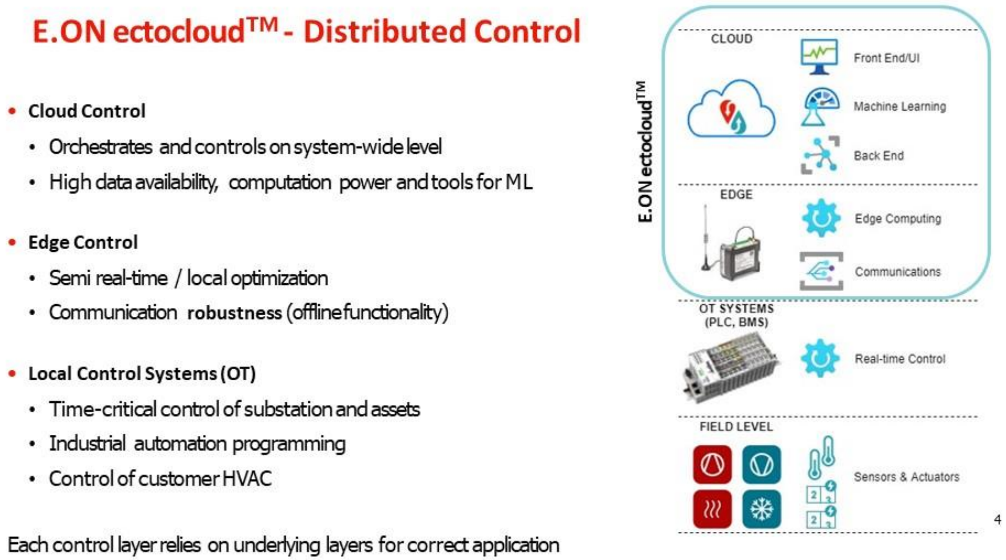
www.iea-dhc.org/the-research/annexes/2018-2024-annex-ts4/

INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME ON
DISTRICT HEATING AND COOLING

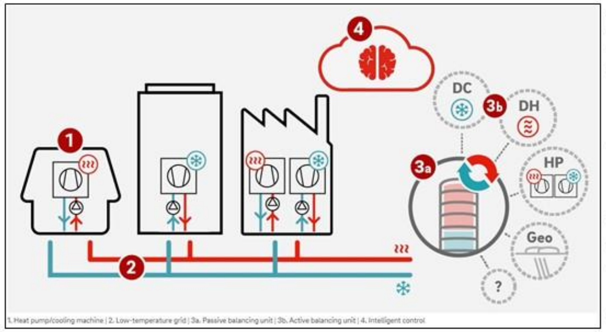

Daniel Stenberg
Daniel.Stenberg@eon.se
E.ON Energy Infrastructure Solutions Sweden
2022-04-27
ectocloud™ for ectogrid™
and the role of cloud and IoT-based control for highly decentralized energy systems
e.on


The case for cloud and IoT-based control
Trends
• Intermittent energy generation
• New energy consumption patterns
• Energy prosumers
• Decentralized small-scale systems and assets
• Self-sufficiency on sustainable and renewable energy
Challenges
• Coordination of systems and assets
• All systems must be connected and controlled to achieve an overall efficient energy system
• Complex control requirements
• Traditional control systems (on-premise PLC, SCADA) often not sufficient to unlock full value
Digital Platforms
Cloud
IoT
Data-driven services
Distributed control
Interoperability


E.ON ectocloud™ is a modular multi-application software platform for decentralized energy systems
Physical Applications
Single Site Solution
PV & Storage
Heat pump
Chiller
Geo-thermal
CHP
Boiler
City Quarter Solution
Heat pump
Heat pump
Heat pump
Chiller
Heat pump
Chiller
City Supply
Thermal storage
District heat/cool
Heating
Cooling
Domestic water
Digital Applications
• Design and dimensioning
• Data-driven tools to design new solutions
• Follow-up on design with real-world data
• System optimization
• Low temperature/5GDHC grids and geothermal sites
• Grid temperature and energy source control
• Demand-side management
• Peak-shaving and flexibility for DH grids
• Aggregated control of many buildings
• Integration with production planning tools
• Sector-coupling
• Electrical peak shaving and self-sufficiency
• PV & Battery Storage optimization and aggregation
• Energy efficiency
• Room temperature optimization
• Energy efficiency and indoor climate comfort


E.ON ectocloud™ - Distributed Control
• Cloud Control
• Orchestrates and controls on system-wide level
• High data availability, computation power and tools for ML
• Edge Control
• Semi real-time / local optimization
• Communication robustness (offline functionality)
• Local Control Systems (OT)
• Time-critical control of substation and assets
• Industrial automation programming
• Control of customer HVAC
Each control layer relies on underlying layers for correct application
E.ON ectocloud™
CLOUD
Front End/UI
Machine Learning
Back End
EDGE
Edge Computing
Communications
OT SYSTEMS (PLC, BMS)
Real-time Control
FIELD LEVEL
Sensors & Actuators
4

E.ON ectogrid™ - E.ONs flagship solution for 5GDHC

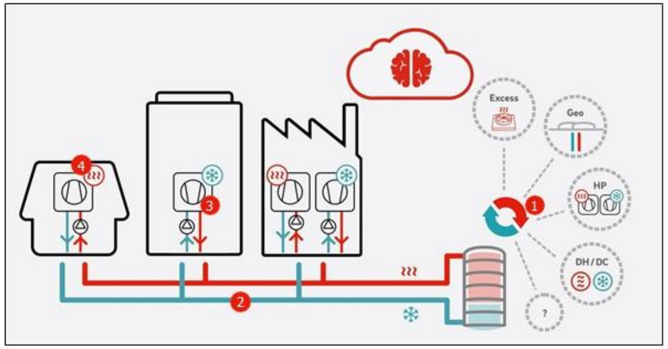


Key features

- Heating and cooling in the same system
- Low temperature grid
  - Temperatures varied based on circumstances
- Highly decentralized
  - Generation
  - Pumping/distribution
- Bidirectional
- Electrified generation using heat pumps
- Recycles excess energy between prosumers
- Efficient integration of low temp waste heat
- Modular and flexible
- Built with standard components
- Managed by digital system ectocloud™
  - Deep integration with all substations and assets

5

E.ON ectocloud™ Control and Optimization



Control:

1. Merit order prioritization and control of active balancing units
2. Control of the grid temperatures
3. Control and prioritization of heat pumps and chillers
4. Control of building's heating and cooling loads

Value:

- Grid capacity (Quality of Service)
- Functional solution operating within technical envelope (Quality of Service)
- Energy performance (COP)
- Financial performance (€)
- Reduced emissions (CO_2e)

6

E.ON ectocloud™ is a software ecosystem built for collaboration

- Technology reused for multiple E.ON initiatives in the energy sector
- New digital services provided continously to connected E.ON energy systems and customers
- A flexible platform applying open standards, data models and APIs allows E.ON to integrate and collaborate with
  - Customers
  - Selected partners
  - Research groups and institutes
- In relation to E.ON ectogrid™ we could benefit from physical and digital test beds to more quickly evaluate ideas and enhance our products
- We are creating a digital ecosystem for operating energy system, enabling a more sustainable business **together** with customers and partners

Daniel Stenberg
Daniel.Stenberg@eon.se

E.ON Energy Infrastructure Solutions Sweden
2022-04-27

Thank you!

e.on

The laboratory for Combined Smart Energy Systems (CoSES)

Daniel Zinsmeister, Technical University of Munich

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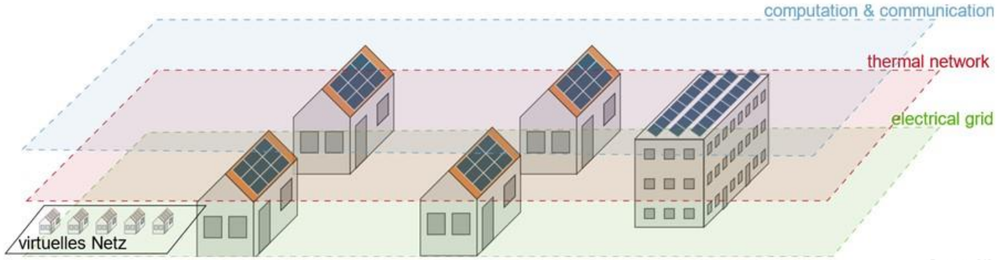
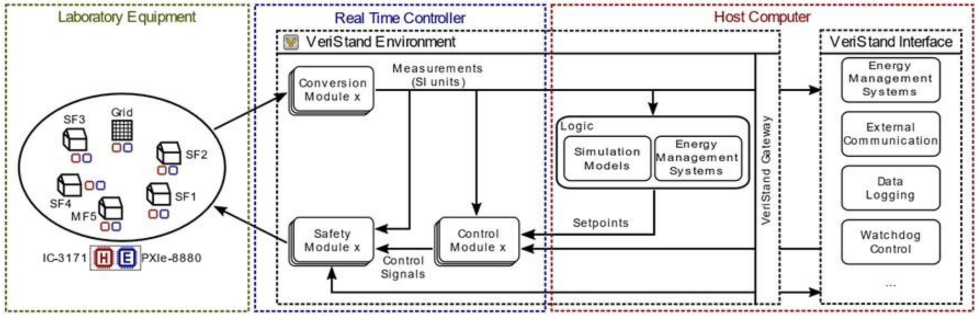
Smart Energy System with 5 Buildings



Source: [1]

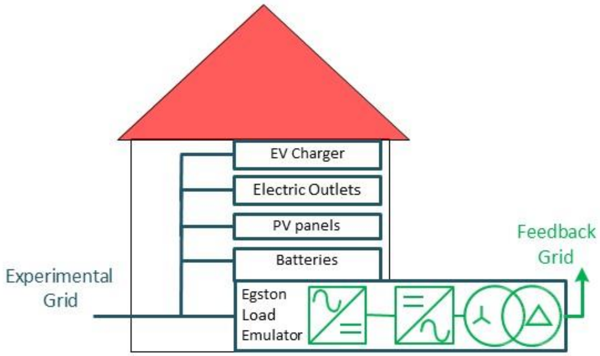
Center for Combined Smart Energy Systems (CoSES) @ TUM MEP 2

Control Structure



Center for Combined Smart Energy Systems (CoSES) @ TUM MEP 3

Electrical House Emulator



Source: [1]

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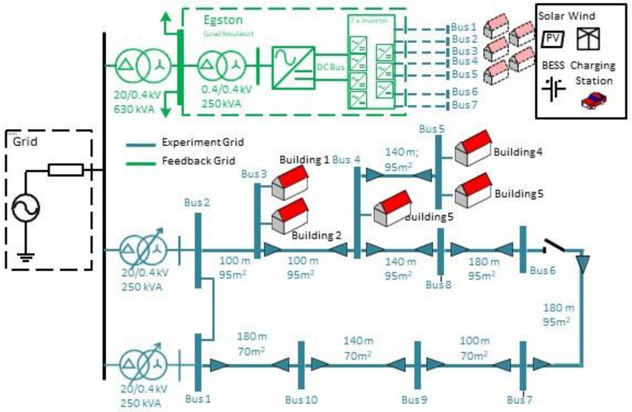
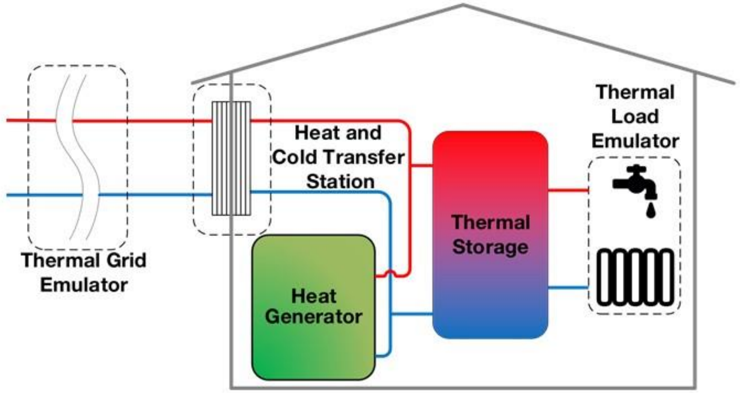
Center for Combined Smart Energy Systems (CoSES) @ TUM MEP 4

Electrical Grid

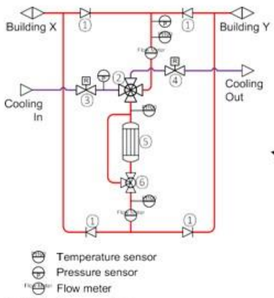


Source: [1]

Thermal House Emulator

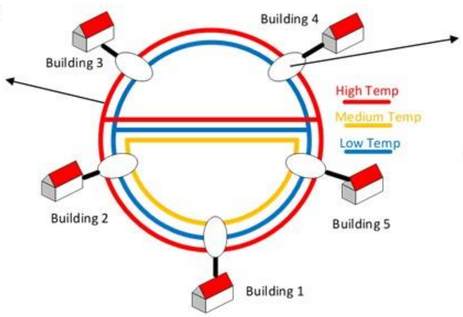


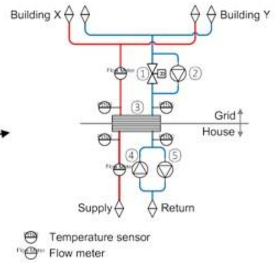
Thermal Grid



Grid / pipe emulator

Bidirectional thermal network with prosumers [1]





Bidirectional heat & cold transfer station

Presentation 3:
Daniel Zinsmeister: The CoSES Lab: A Laboratory Environment for Combined Smart Energy Systems

MEP

CoSES-Team

Vedran Perić, Head of Research Group
Anurag Mohapatra, PhD Candidate
Verena Kleinschmidt, PhD Candidate
Prashant Pant, PhD Candidate
Tomas Licklederer, PhD Candidate
Ruihao Song, PhD Candidate
Peiyao Guo, PhD Candidate
Kun Fu, PhD Candidate

Daniel Zinsmeister, PhD Candidate (TUM EWK)
Stefan Adldinger, PhD Candidate (Stadtwerke Neuburg)

?

Open Position:

Research Associate Position (m/f/d) in the field of Bidirectional District Heating and Cooling Networks

Center for Combined Smart Energy Systems (CoSES) @ TUM MEP 9

MEP

Key message:

- CoSES laboratory for smart energy system analysis
- Detailed emulation of the houses and the thermal and electric grid

Daniel Zinsmeister
+49 89 289 28299
d.zinsmeister@tum.de

Technical University of Munich
TUM School of Engineering and Design
Chair of Energy Economy and Application Technology

[1] Peric et al. (2020).
CoSES Laboratory for Combined Energy Systems At TU Munich.
2020 IEEE Power & Energy Society General Meeting (PESGM), November, 1–5.

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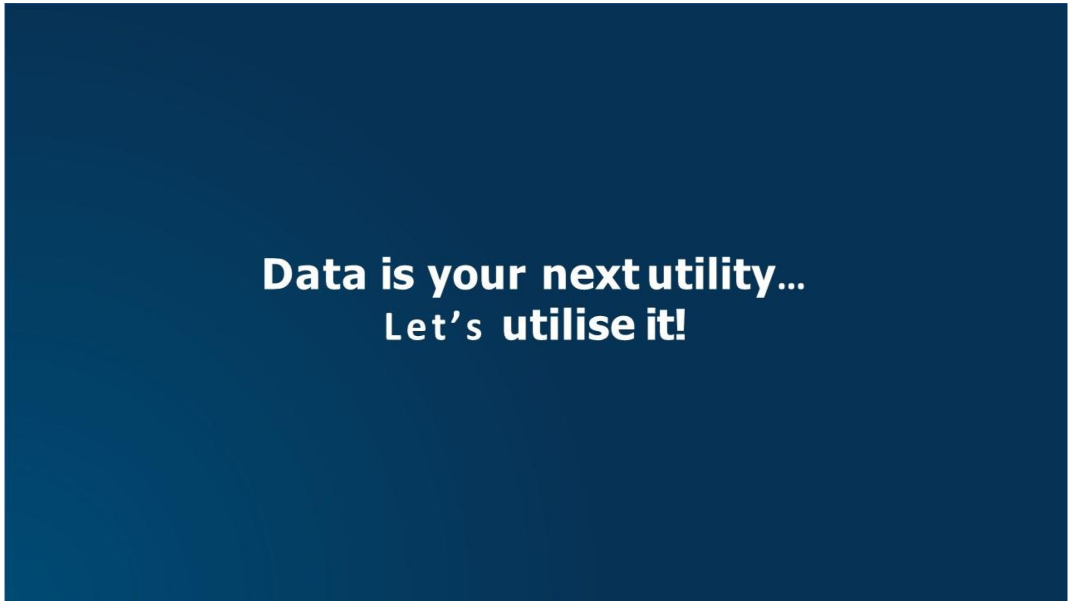
MEP

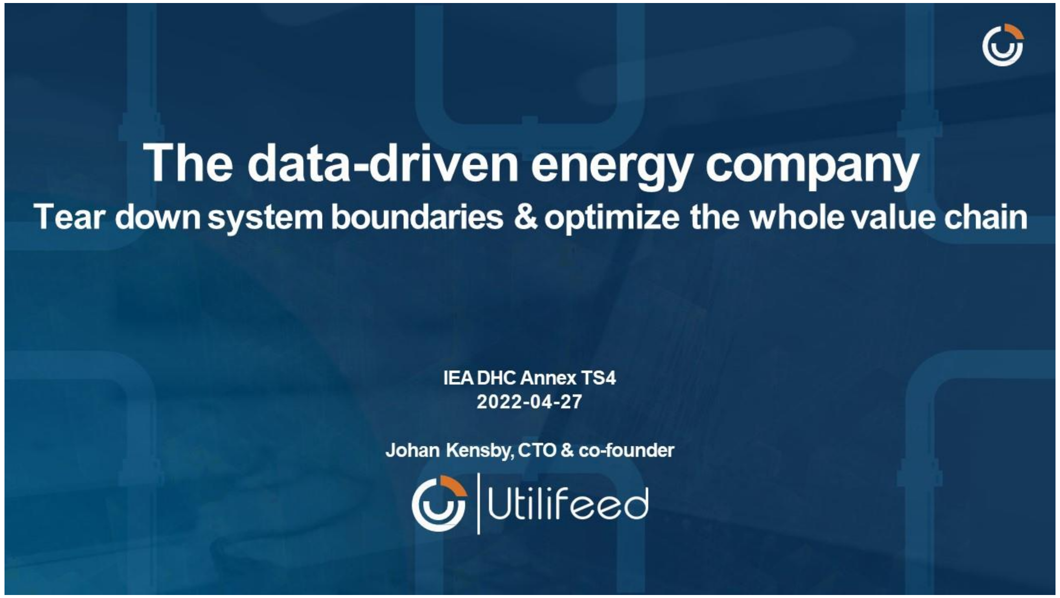
Thermal Devices

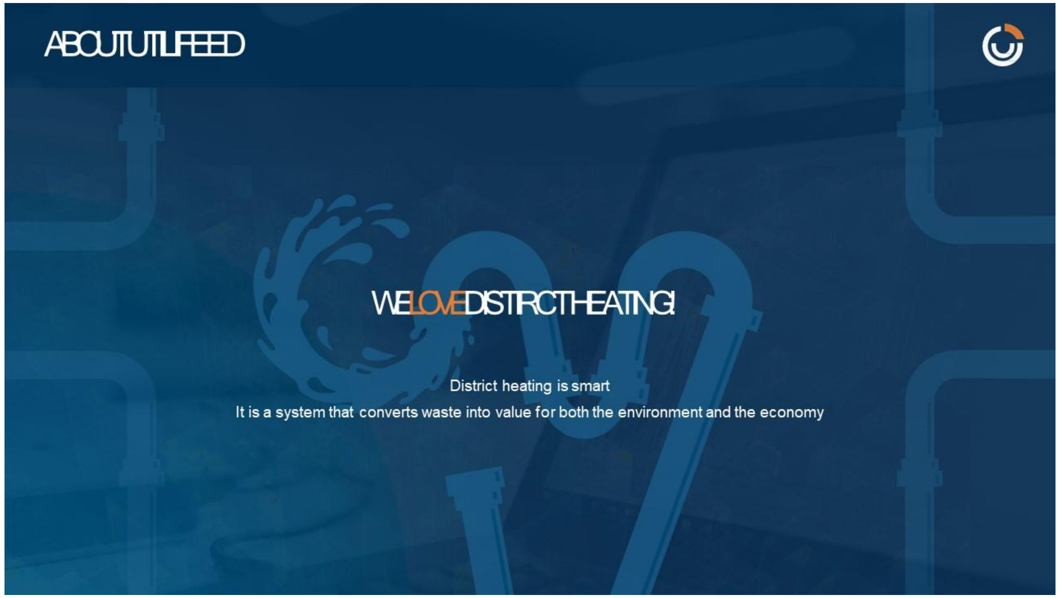
	House 1	House 2	House 3	House 4	House 5
Heat Generator	CHP (2 kW_{el}, 5,2 kW_{th}) Condensing Boiler (20 kW_{th}) Solar Thermal (9 kW_{th})	Condensing Boiler (20 kW_{th}) Air source heat pump (19 kW_{heat}, 9 kW_{cold}) Solar Thermal (9 kW_{th})	Ground source heat pump (19 kW_{heat}) Solar Thermal (9 kW_{th})	Stirling Engine (1 kW_{el}, 6 kW_{th}) Integrated auxiliary boiler (20 kW_{th})	CHP (5 kW_{el}, 11,9 kW_{th}) CHP (18 kW_{el}, 34 kW_{th}) Condensing Boiler (50 kW_{th})
Thermal Storage	800 l	785 l	1000 l	1000 l	2000 l
Domestic Hot Water	Fresh water storage (500 l)	Fresh water station	Fresh water station	Internal heat exchanger	Fresh water station
Transfer Station	Bidirectional Transfer Station (30 kW_{th}) Booster heat pump (19 kW_{heat}, 14 kW_{cold})	Bidirectional Transfer Station (30 kW_{th})	Bidirectional Transfer Station (30 kW_{th})	Bidirectional Transfer Station (30 kW_{th})	Bidirectional Transfer Station (60 kW_{th})
Thermal Load Emulator	30 kW_{heat}, 9 kW_{cold}	30 kW_{heat}, 9 kW_{cold}	30 kW_{heat}, 9 kW_{cold}	30 kW_{heat}	60 kW_{heat}

Source: [1]

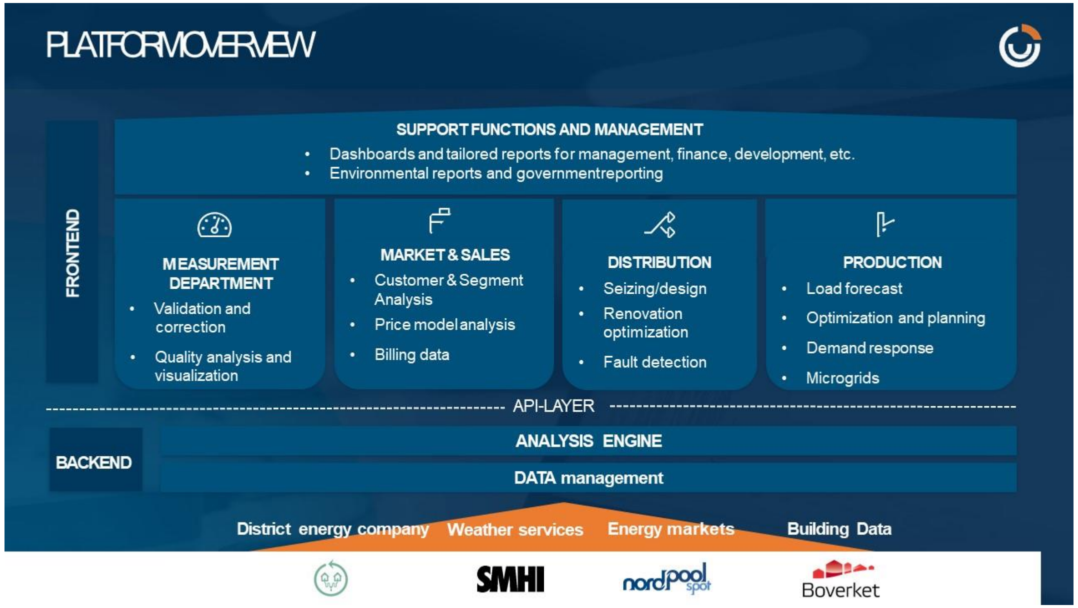
Center for Combined Smart Energy Systems (CoSES) @ TUM MEP 11

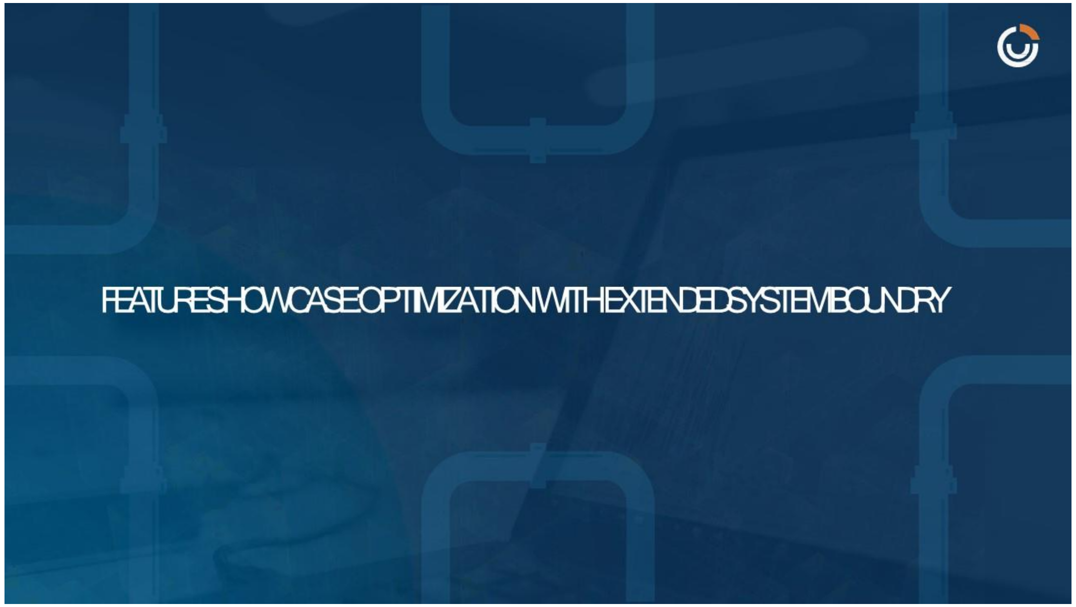






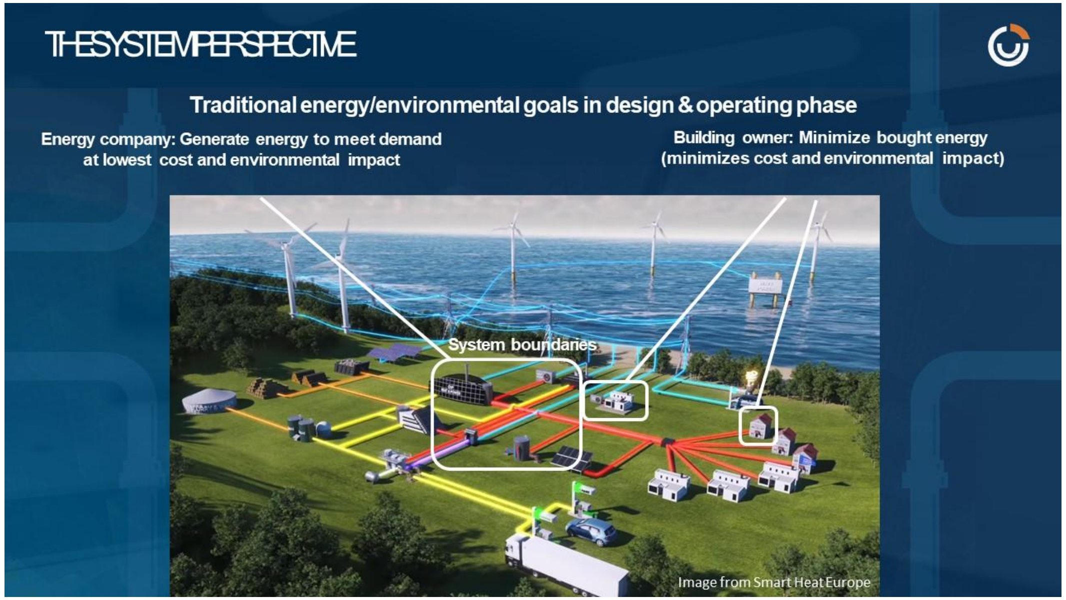
Presentation 4:
Johan Kensby: The data-driven energy company - Tear down system boundaries & optimize the whole value chain

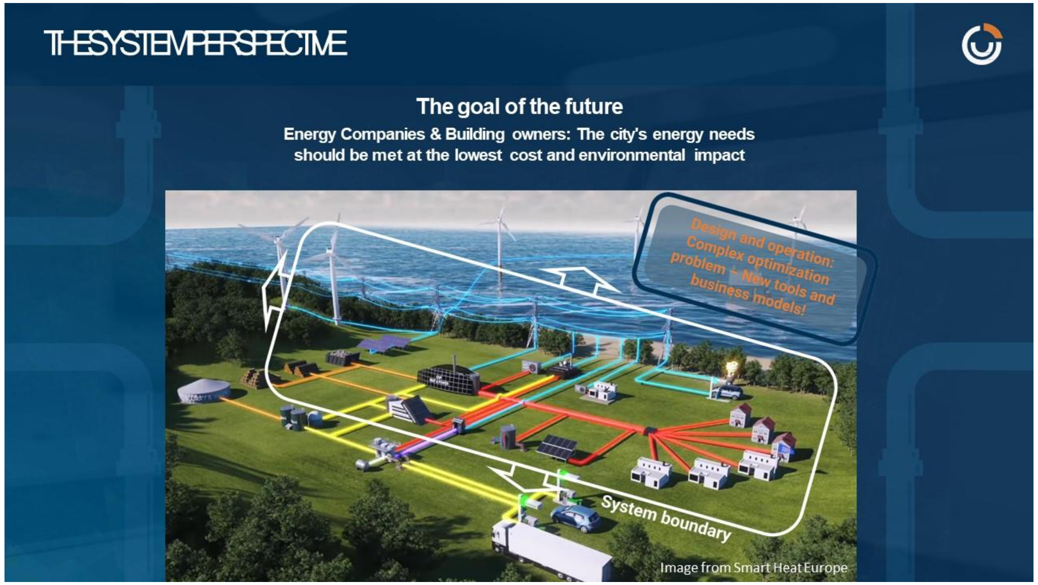


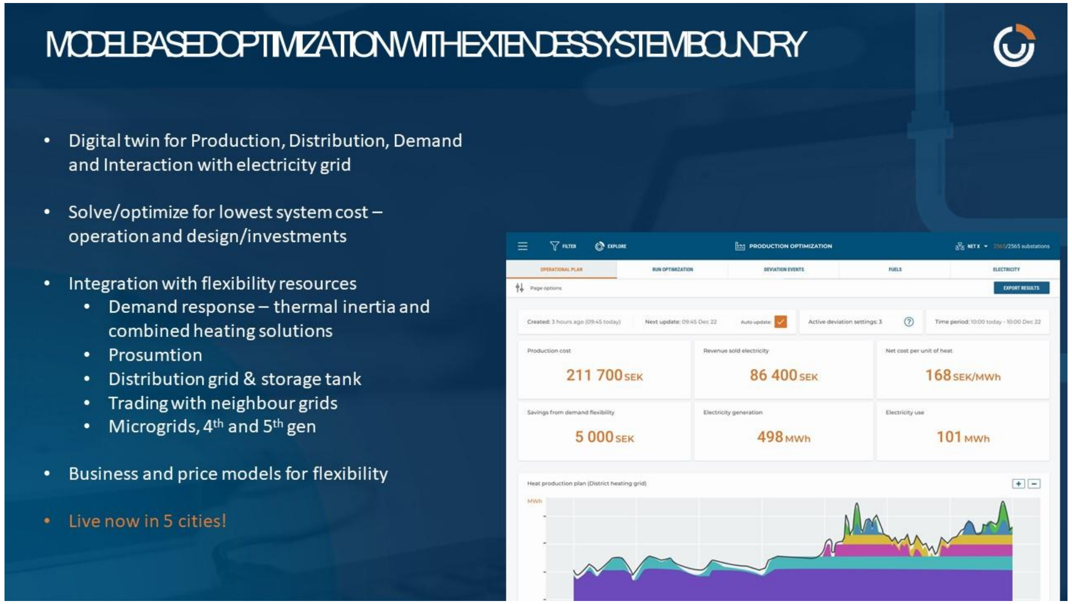


Presentation 4:
Johan Kensby: The data-driven energy company - Tear down system boundaries & optimize the whole value chain


THE SYSTEM PERSPECTIVE
Traditional energy/environmental goals
in design & operating phase
Energy company: Generate energy to meet demand at lowest cost and environmental impact
Demand profile
Building owner: Minimize bought energy (minimizes cost and environmental impact)
1 kWh ≠ 1 kWh

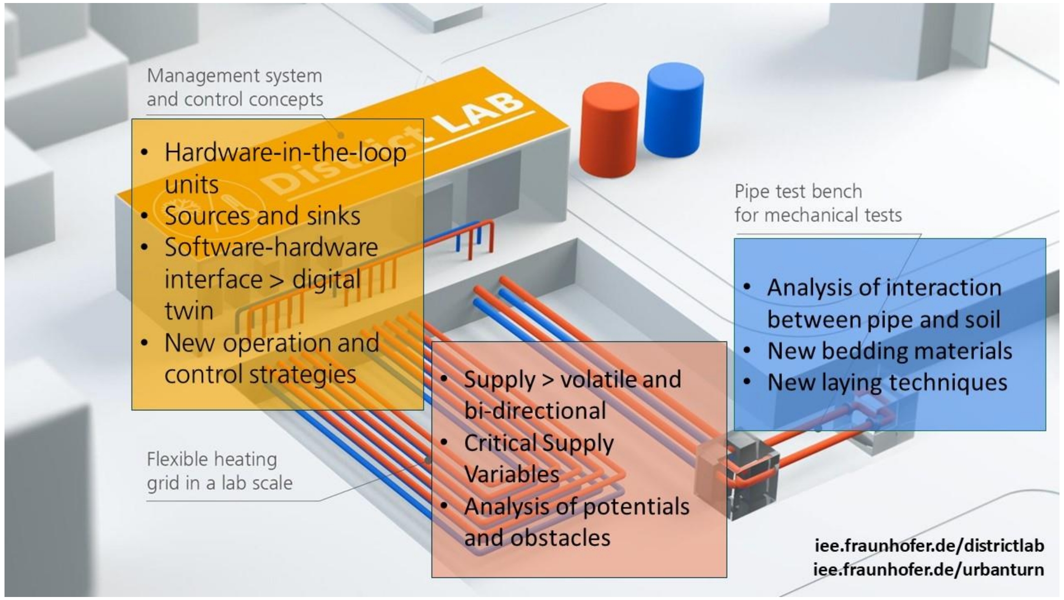

THE SYSTEM PERSPECTIVE
Traditional energy/environmental goals in design & operating phase
Energy company: Generate energy to meet demand at lowest cost and environmental impact
Building owner: Minimize bought energy (minimizes cost and environmental impact)
System boundaries
Image from Smart Heat Europe

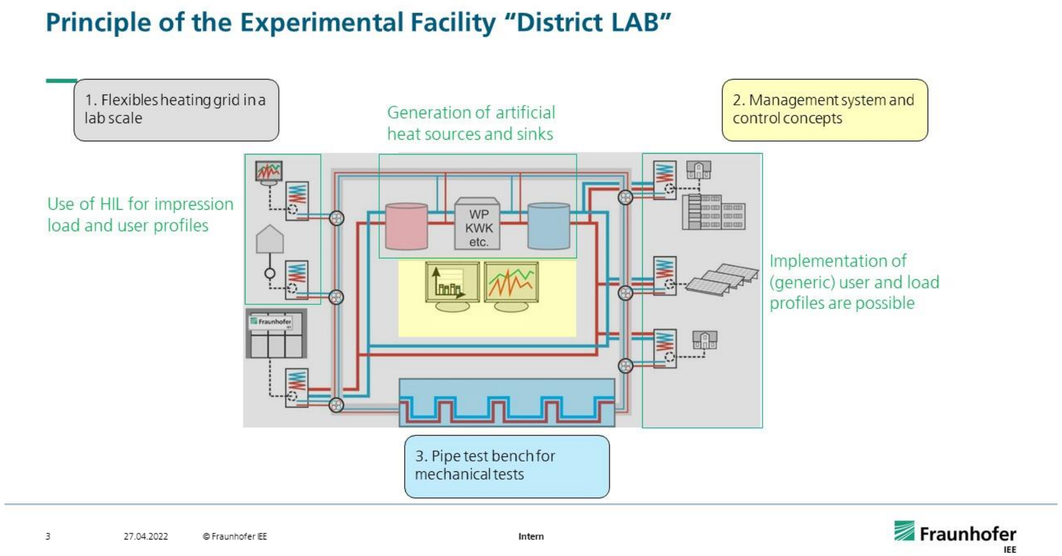

THE SYSTEM PERSPECTIVE
The goal of the future
Energy Companies & Building owners: The city's energy needs should be met at the lowest cost and environmental impact
Design and operation: Complex optimization problem -> New tools and business models!
System boundary
Image from Smart Heat Europe


MODEL BASED OPTIMIZATION WITH EXTENDED SYSTEM BOUNDRY
• Digital twin for Production, Distribution, Demand and Interaction with electricity grid
• Solve/optimize for lowest system cost – operation and design/investments
• Integration with flexibility resources
• Demand response – thermal inertia and combined heating solutions
• Prosumtion
• Distribution grid & storage tank
• Trading with neighbour grids
• Microgrids, 4th and 5th gen
• Business and price models for flexibility
• Live now in 5 cities!
PRODUCTION OPTIMIZATION
211 700 SEK
86 400 SEK
168 SEK/MWh
5 000 SEK
498 MWh
101 MWh


THANKS
Utilifeed
Johan Kensby
CTO & co-founder
+46 70 653 1373
johan@utilifeed.com


Fraunhofer
IEE
IEA DHC Annex TS4 Webinar „Testbeds for Digitalization Solutions in District Heating ", 27. April 2022, virtuell
DistrictLAB test center for innovative heating network solutions
Dr. Anna Marie Kallert and Dennis Lottis (Fraunhofer IEE)
Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag
AGFW
BRUGG Pipes
Danfoss
GEF Ingenieur AG
hcu HafenCity Universität Hamburg


Management system and control concepts
Hardware-in-the-loop units
Sources and sinks
Software-hardware interface > digital twin
New operation and control strategies
Pipe test bench for mechanical tests
Analysis of interaction between pipe and soil
New bedding materials
New laying techniques
Flexible heating grid in a lab scale
Supply > volatile and bi-directional
Critical Supply Variables
Analysis of potentials and obstacles
iee.fraunhofer.de/districtlab
iee.fraunhofer.de/urbanturn


Principle of the Experimental Facility "District LAB"
1. Flexibles heating grid in a lab scale
Generation of artificial heat sources and sinks
2. Management system and control concepts
Use of HIL for impression load and user profiles
WP KWK etc.
Implementation of (generic) user and load profiles are possible
3. Pipe test bench for mechanical tests
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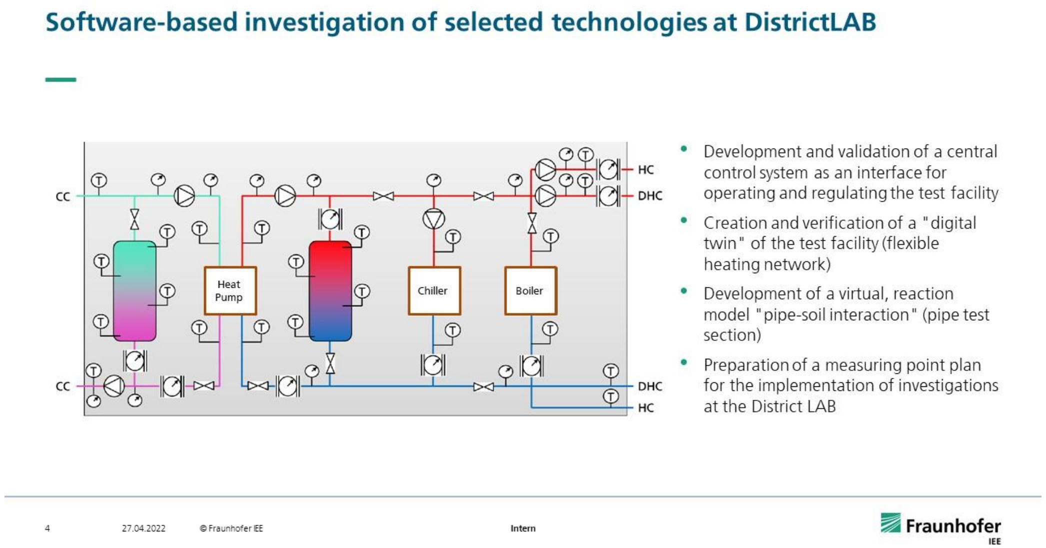
Software-based investigation of selected technologies at DistrictLAB
CC
HC
DHC
Heat Pump
Chiller
Boiler
Development and validation of a central control system as an interface for operating and regulating the test facility
Creation and verification of a "digital twin" of the test facility (flexible heating network)
Development of a virtual, reaction model "pipe-soil interaction" (pipe test section)
Preparation of a measuring point plan for the implementation of investigations at the District LAB
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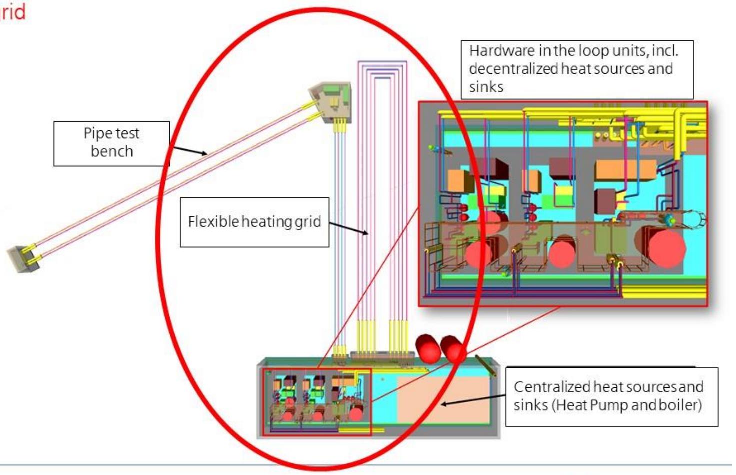
Experimental investigations at the DistrictLAB test facility

Investigation flexible heating grid

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



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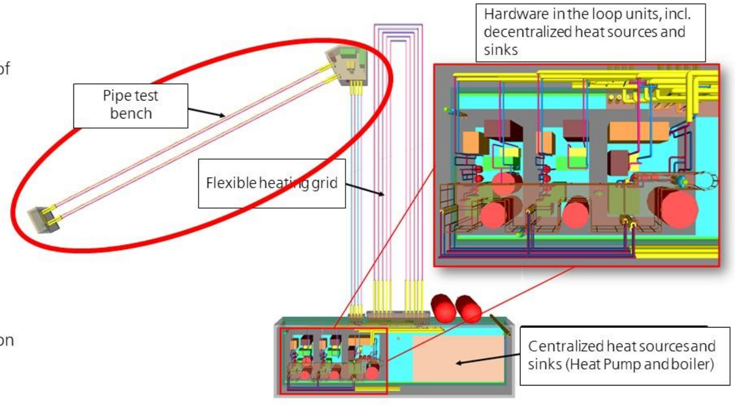
Experimental investigations at the DistrictLAB test facility

Investigation pipe test bench

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



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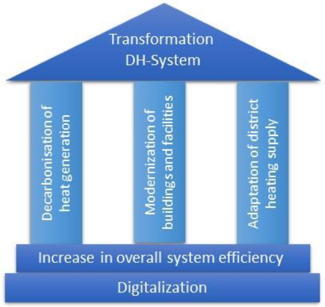
Joint Project: EnEff:Wärme: UrbanTurn:

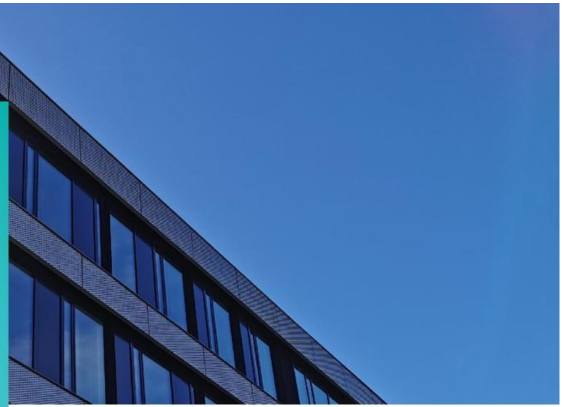
Transformation of the urban district heating supply

Transformation, decarbonization and digitization of district heating, taking into account volatile pressures and temperatures when feeding in renewable energies and waste heat sources

- Development and validation of measures for the transformation of existing district heating systems
- Development of novel procedures for operation management and control in the context of the digitalisation of heating networks through experimental investigations
- Development of new design criteria for system components taking into account a characteristic overall system behavior
- Development of proposals for the amendment of the technical regulations
- Preparation of a catalogue of measures for network operators for the transfer of the investigated technologies into existing heating networks



7 27.04.2022 AGFW BRUGG Pipes Danfoss GEF Ingenieur AG hcu HafenCity Universität Hamburg Fraunhofer IEE



Contact

Dr.-Ing. Anna Marie Kallert
Head of Department Thermal Energy System Technology
Phone: +49 160 238 51 34
anna.kallert@iee.fraunhofer.de

Dipl.- Ing. Dennis Lottis
Department Thermal Energy System Technology
Phone: +49 561 7294-1547
dennis.lottis@iee.fraunhofer.de

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

Project partners
AGFW Danfoss GEF Ingenieur AG hcu HafenCity Universität Hamburg BRUGG Pipes

Presentation 5:
Anna Maria Kallert: DistrictLAB test center for innovative heating network solutions

DIGITAL ENERGY TESTBED

AUSTRIAN INSTITUTE OF TECHNOLOGY TOMORROW TODAY

The AIT Digital Energy Testbed – INTRODUCTION

IEA DHC Annex TS4 Webinar on Testbeds for Digitalization Solutions in District Heating, 27.04.2022 (online)

Edmund Widl, Ralf-Roman Schmidt, Andreas Sporr, Aurelien Bres, Catalin Gavriluta, Jawad Kazmi, Thomas Natiesta, Martin Mairhofer, Nicolas Marx

BACKGROUND, MOTIVATION

- **Digitalization and sector coupling are key enablers for decarbonizing and integrating district heating systems**
  - overcoming the complexity of a fully integrated energy system.
  - an increasing number digital solutions for integrated operation are available
- However, the **development, adaptation and integration of such digital solutions is complex** and involves considerable time and cost expenditure;
- furthermore, the **transferability and comparability of results can be limited**

BACKGROUND – REAL TESTBEDS

- **Existing real testbeds** for special purpose applications at AIT
  - Testbed for district heating substations
  - Testbed for heat pumps
- **Smart grid** laboratory at AIT
  - Configurable low-voltage networks
  - E-mobility, batteries, PV systems
- …

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BACKGROUND – VIRTUAL TESTBEDS

- Dynamic **District Heating** network simulations in Modelica (Dymola)
  - Thermal transients and hydraulic behaviour
  - Detailed models of supply units, substations, pipes, etc.
- **Building** system simulations
  - TRNSYS
  - EnergyPlus
  - Modelica (Dymola)
- …

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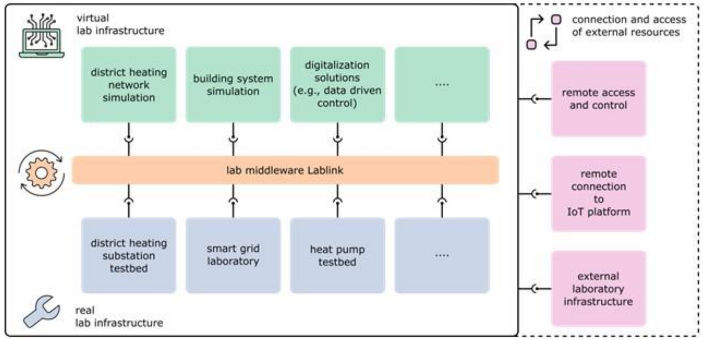
THE AIT DIGITAL ENERGY TESTBED

An open test environment for the evaluation, (further) development and integration of digitalization solutions for integrated district heating networks



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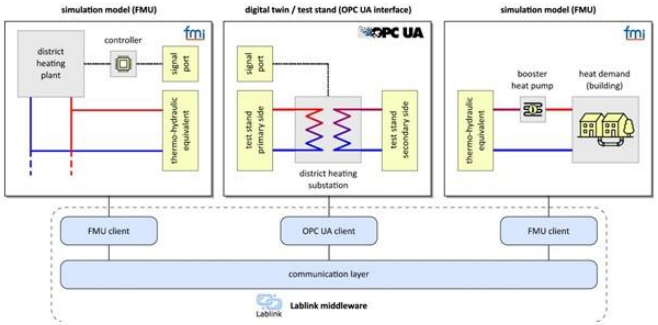
CURRENT IMPLEMENTATION

- As a **proof-of-concept**, a testbed prototype has been implemented around an existing DH substation test stand
- **assess individual DH substations** and the overall system in response to remote control signals sent by the network operator.



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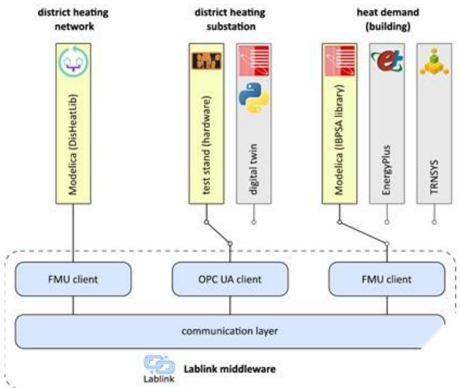
CURRENT IMPLEMENTATION

The DigitalEnergyTestbed is based on Lablink an open-source middleware for lab experiments,

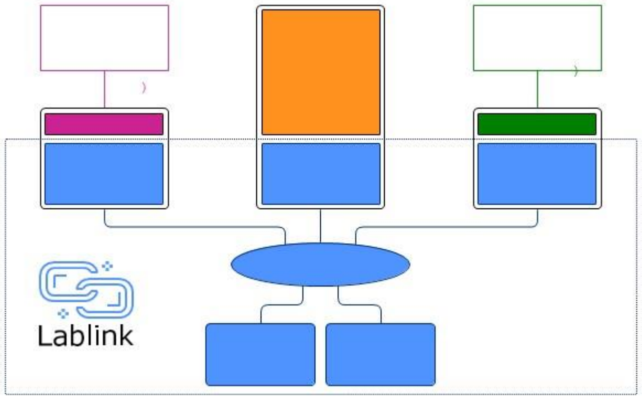
- **communicating with test stands** via the OPC Unified Architecture.
- **interfacing simulation tools** via the Functional Mockup Interface (FMI) / Functional Mock-up Unit (FMU).

synchronization of the operation of the test stand with simulators for thermal systems (Dymola, TRNSYS, EnergyPlus …)



13/05/2022 Stahleder, D., Reihs, D., & Lehfuss, F. (2018). Lablink–a novel co-simulation tool for the evaluation of large scale ev penetration focusing on local energy communities 8

LABLINK CLIENTS



DIGITAL ENERGY TESTBED

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The AIT Digital Energy Testbed – THE LABLINK MIDDLEWARE

IEA DHC Annex TS4 Webinar on Testbeds for Digitalization Solutions in District Heating, 27.04.2022 (online)

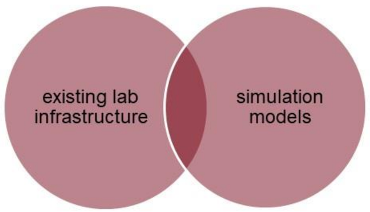
Edmund Widl, Ralf-Roman Schmidt, Andreas Sporr, Aurelien Bres, Catalin Gavriluta, Jawad Kazmi, Thomas Natiesta, Martin Mairhofer, Nicolas Marx

Testbeds for integrated energy systems

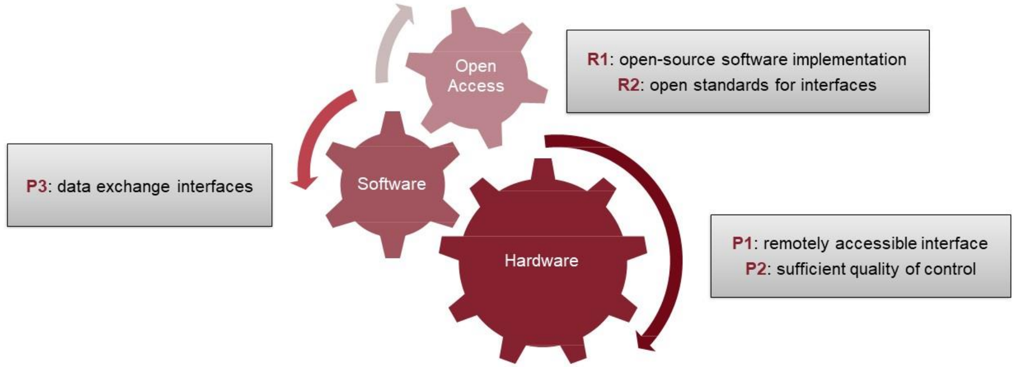
- So far, only few automation solutions for integrated energy systems exist
  - usually complex, specifically configured for (demo) projects, developed for specific requirements
- Hardware-in-the-loop (HIL) test environments are required for further development
  - critical components / subsystems realized as hardware
  - rest of the system emulated using real-time simulation
- Traditional HIL approaches are relatively expensive ➋ rely on proprietary hardware and software
  - new developments try to establish **cost-effective alternatives**
  - new trends: **open standards**, **open-source software** & **simulation coupling**

Concept for open HIL testbeds

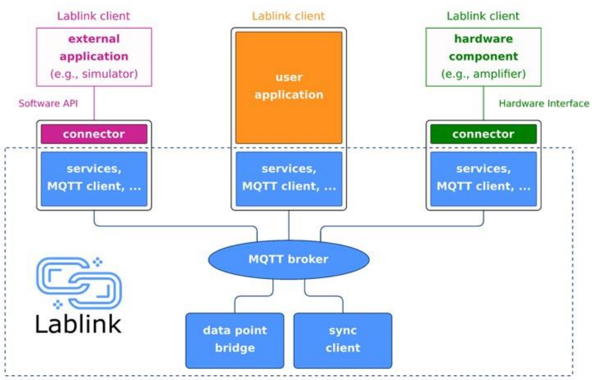
- Propose a concept for open HIL testbeds for thermal CPES
  - focus on smart applications for DH networks
- Aim: combine **existing lab infrastructure** and available **simulation models**
- Goal: create **affordable HIL testbeds** for **integrated energy systems**



Prerequisites and requirements for open testbeds



Lablink – a laboratory middleware



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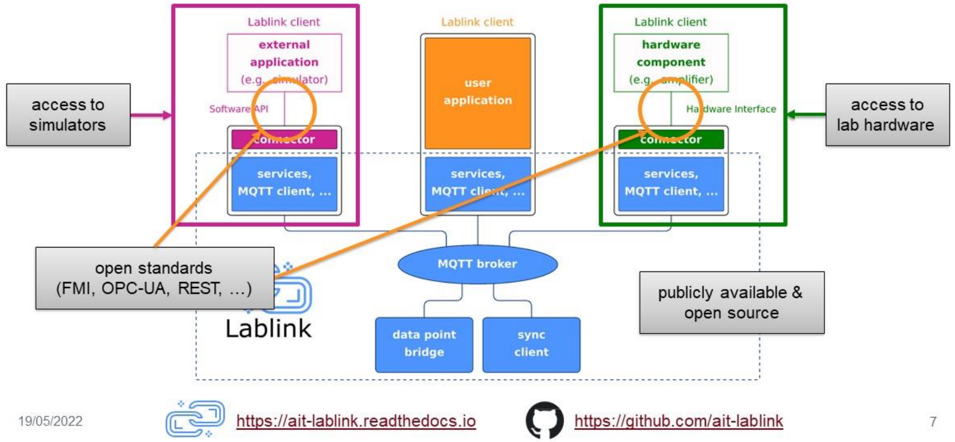
Lablink – a laboratory middleware



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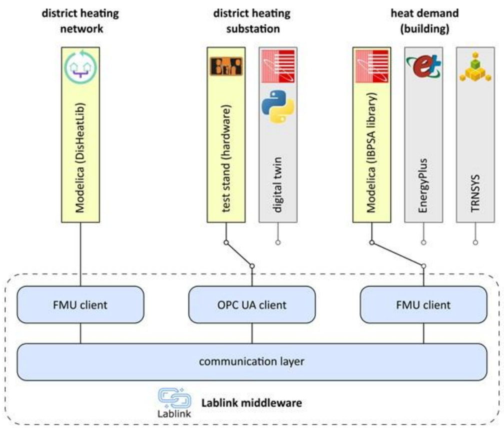
Testbed prototype for smart applications in DH



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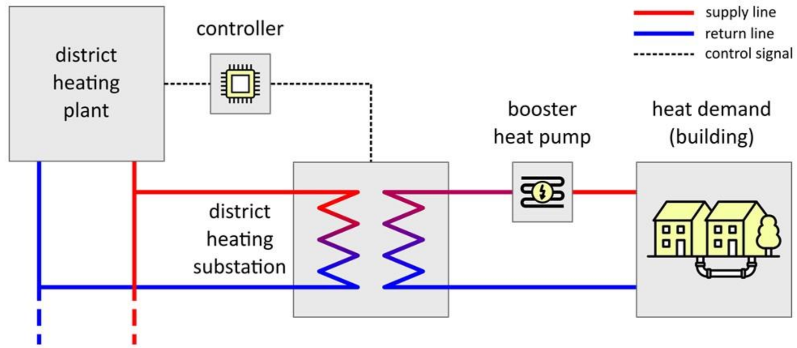
Example application



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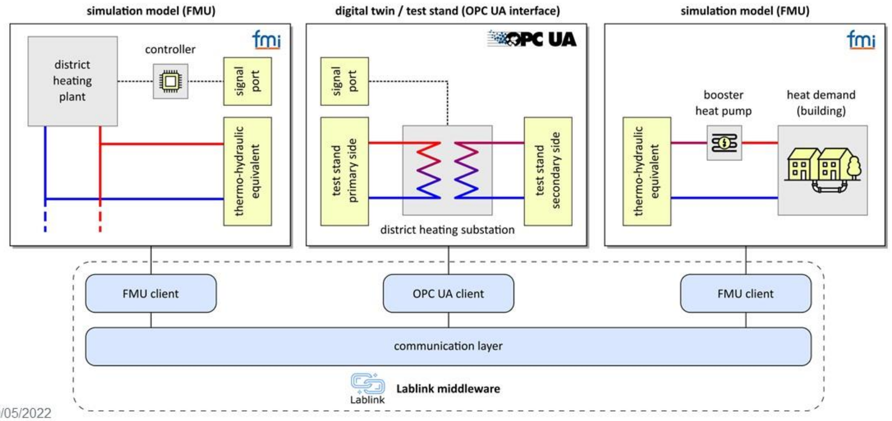
Example testbed implementation



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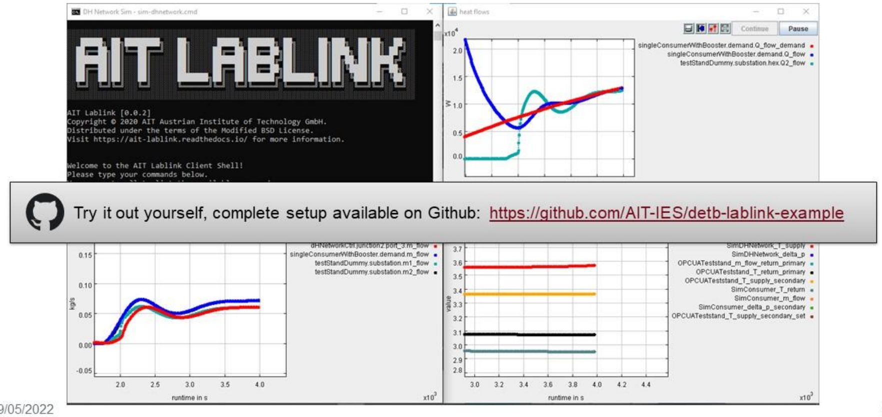
Example study with virtual twin



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Conclusion & outlook

- Aim: combine existing lab infrastructure and simulation models
- Goal: create affordable testbeds for thermal integrated energy systems
- Key enabling technology: Lablink
  - open-source middleware for lab experiments
  - relies on open standards for interfacing automation systems (OPC UA) and simulation tools (FMI)

Lablink

https://ait-lablink.readthedocs.io https://github.com/ait-lablink

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DIGITAL ENERGY TESTBED

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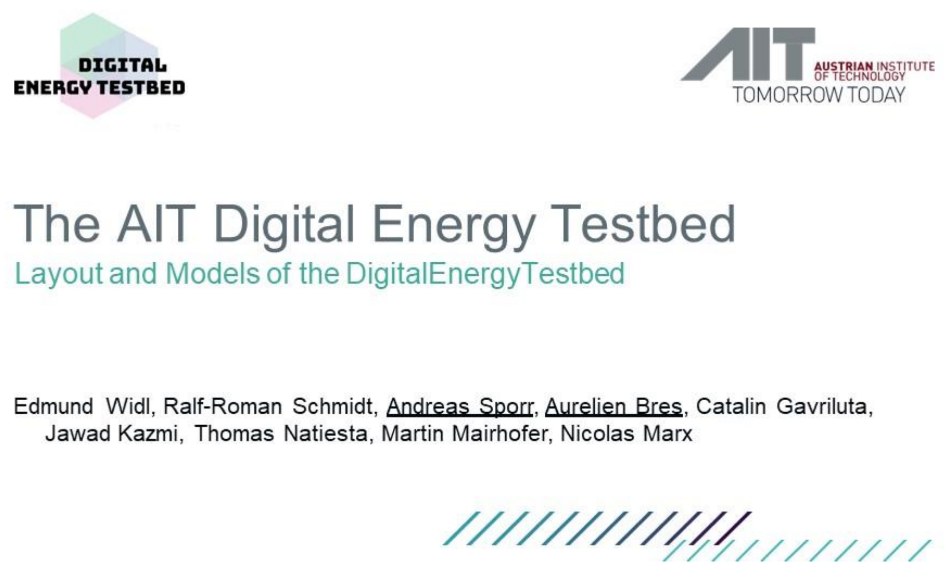
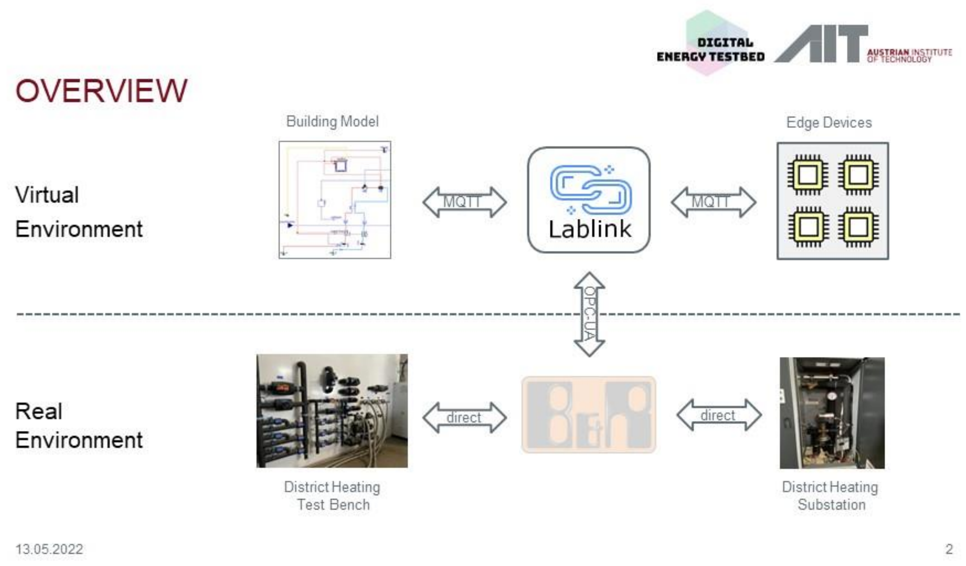
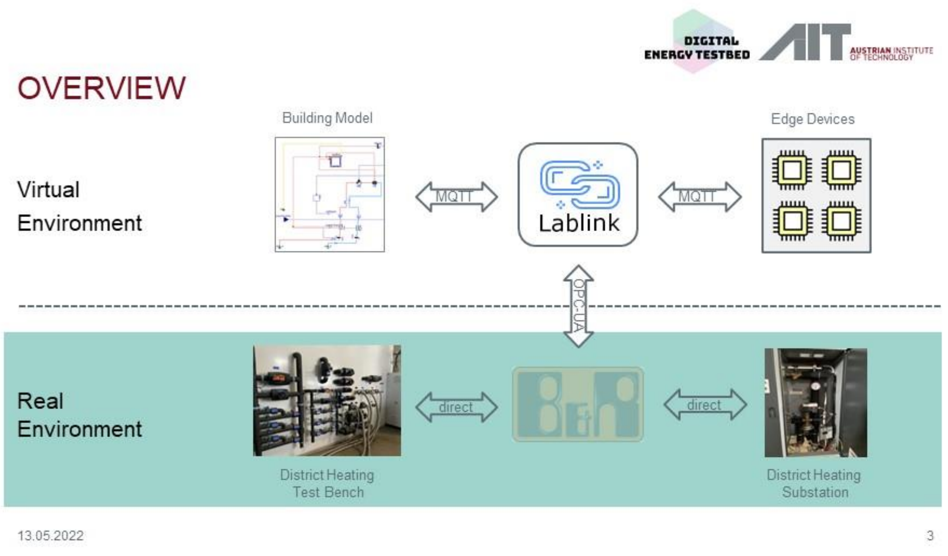
Thanks for your attention!

Dr. Edmund Widl

AIT Austrian Institute of Technology GmbH
Giefinggasse 2 | 1210 Vienna | Austria
T +43 50550-6034 | M +43 664 8251489
edmund.widl@ait.ac.at | www.ait.ac.at/profile/detail/Widl_Edmund


DIGITAL ENERGY TESTBED
AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY
The AIT Digital Energy Testbed
Layout and Models of the DigitalEnergyTestbed
Edmund Widl, Ralf-Roman Schmidt, Andreas Sporr, Aurelien Bres, Catalin Gavriluta, Jawad Kazmi, Thomas Natiesta, Martin Mairhofer, Nicolas Marx


DIGITAL ENERGY TESTBED
AUSTRIAN INSTITUTE OF TECHNOLOGY
OVERVIEW
Building Model
Edge Devices
Virtual Environment
MQTT
Lablink
MQTT
OPC-UA
Real Environment
direct
direct
District Heating Test Bench
District Heating Substation
13.05.2022
2


DIGITAL ENERGY TESTBED
AUSTRIAN INSTITUTE OF TECHNOLOGY
OVERVIEW
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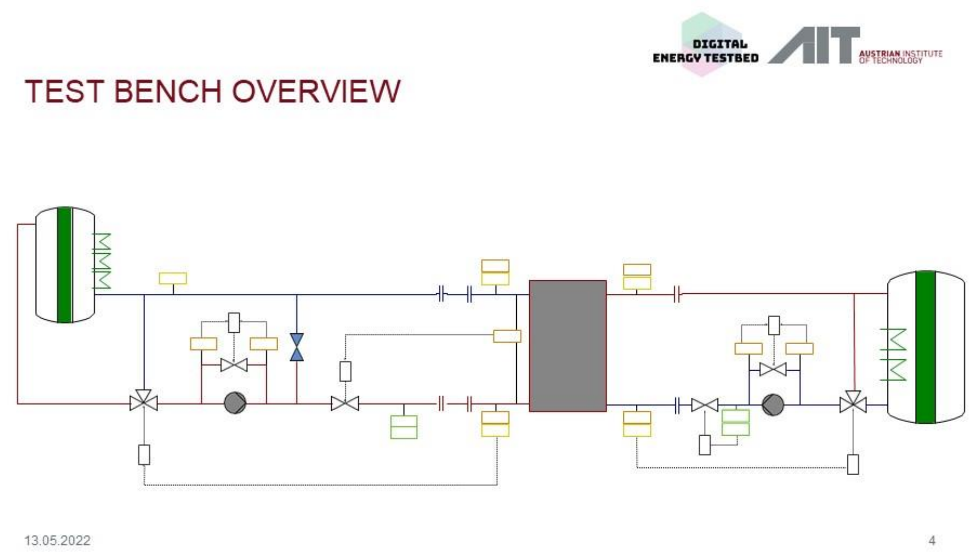
13.05.2022
3


DIGITAL ENERGY TESTBED
AUSTRIAN INSTITUTE OF TECHNOLOGY
TEST BENCH OVERVIEW
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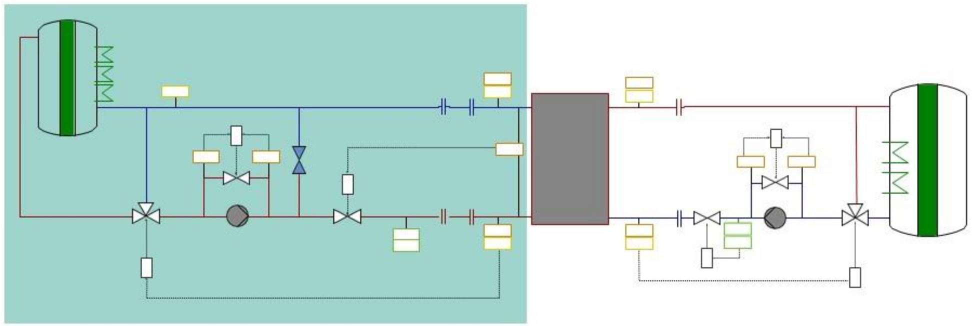
DIGITAL ENERGY TESTBED AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

PRIMARY SIDE (DISTRICT HEATING)



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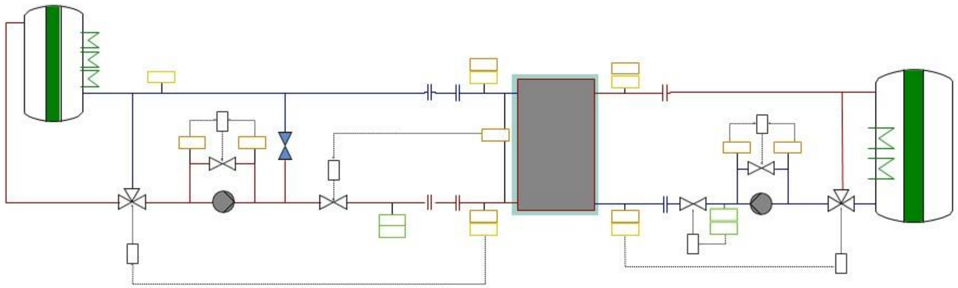
DISTRICT HEATING SUBSTATION



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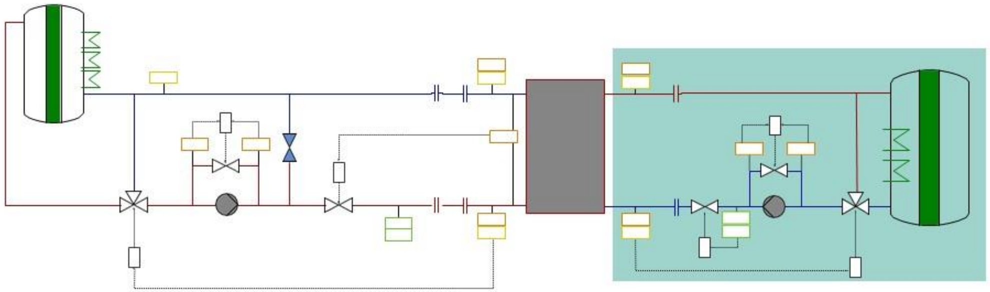
SECONDARY SIDE (BUILDING HEAT SUPPLY)



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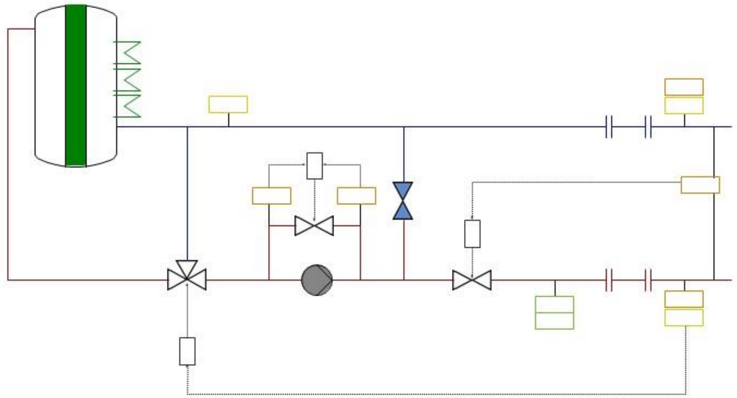
PRIMARY SIDE (DISTRICT HEATING)



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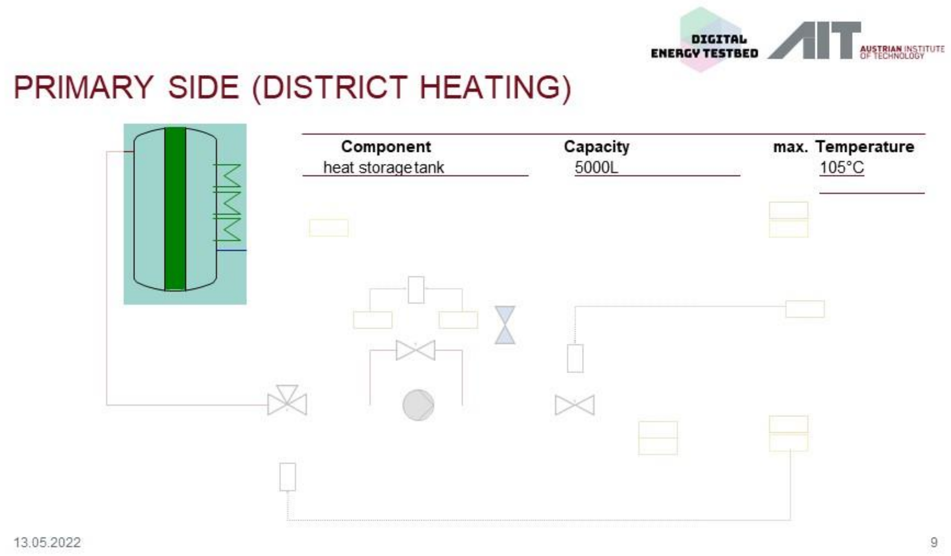
DIGITAL ENERGY TESTBED
AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
PRIMARY SIDE (DISTRICT HEATING)
Component | Capacity | max. Temperature
heat storage tank | 5000L | 105°C
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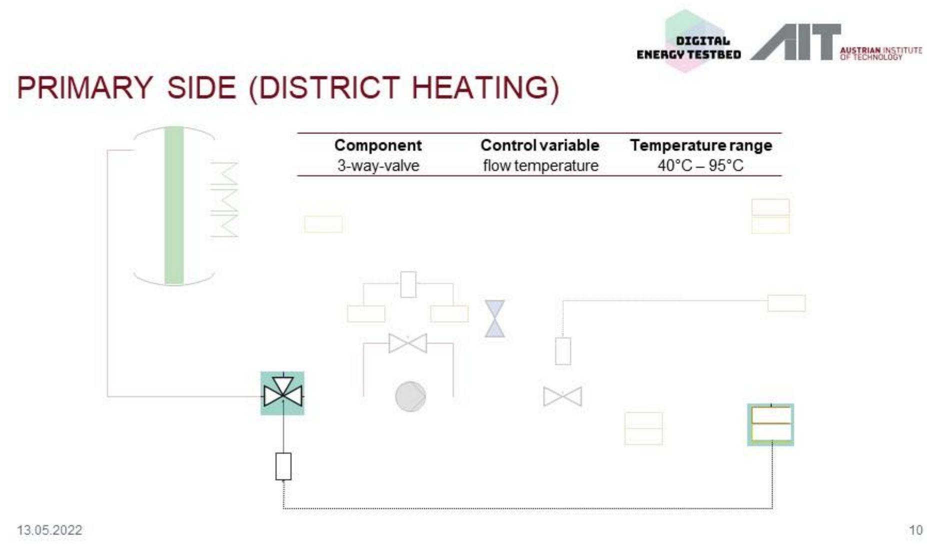
DIGITAL ENERGY TESTBED
AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
PRIMARY SIDE (DISTRICT HEATING)
Component | Control variable | Temperature range
3-way-valve | flow temperature | 40°C – 95°C
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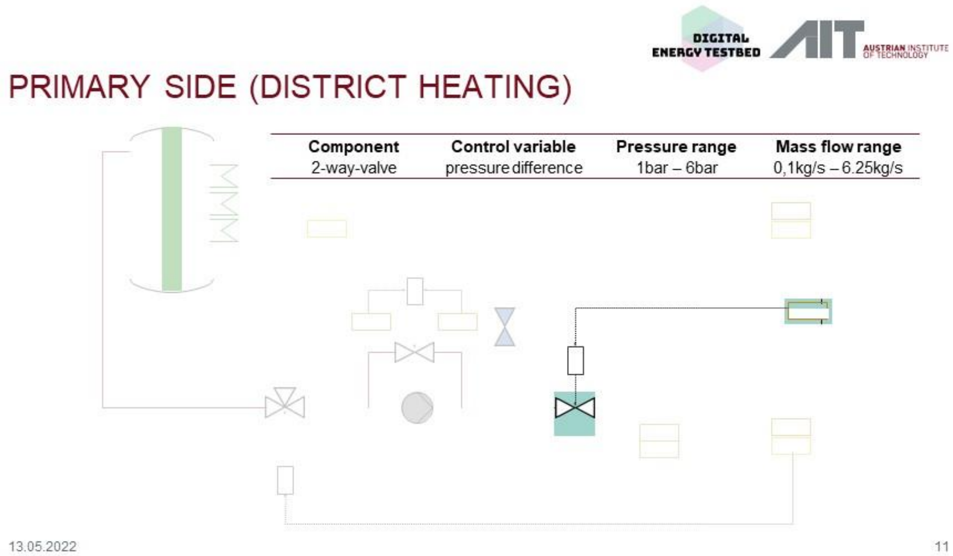
10


DIGITAL ENERGY TESTBED
AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
PRIMARY SIDE (DISTRICT HEATING)
Component | Control variable | Pressure range | Mass flow range
2-way-valve | pressure difference | 1bar – 6bar | 0,1kg/s – 6.25kg/s
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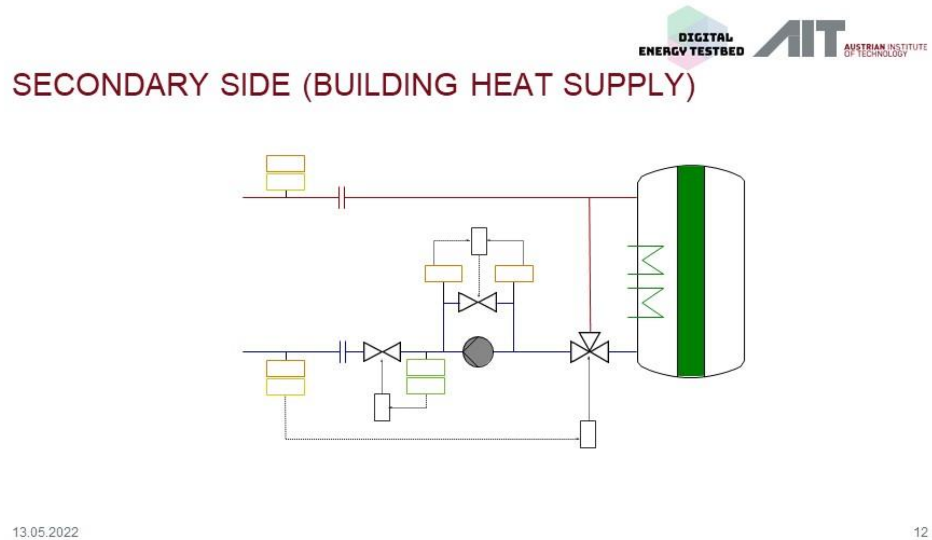
DIGITAL ENERGY TESTBED
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SECONDARY SIDE (BUILDING HEAT SUPPLY)
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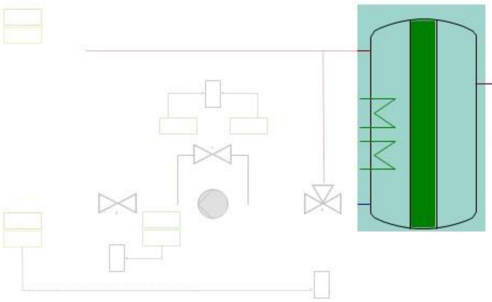
SECONDARY SIDE (BUILDING HEAT SUPPLY)



Component	cold storage tank
Capacity	5000L
min. Temperature	10°C

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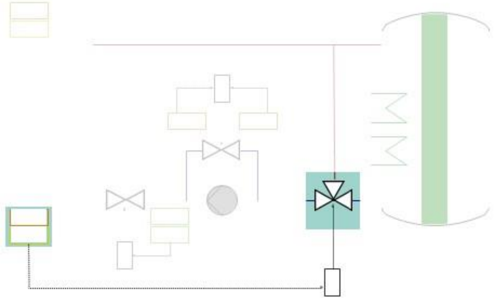
SECONDARY SIDE (BUILDING HEAT SUPPLY)



Component	3-way-valve
Control variable	return temperature
Temperature range	15°C – 60°C

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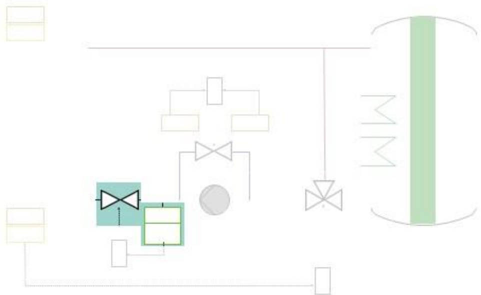
SECONDARY SIDE (BUILDING HEAT SUPPLY)



Component	2-way-valve
Control variable	mass flow
Mass flow range (tested)	0,1kg/s – 0,5kg/s
Mass flow range	0,1kg/s – 6,25kg/s

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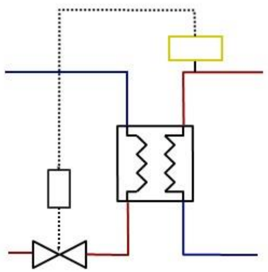
DISTRICT HEATING SUBSTATION



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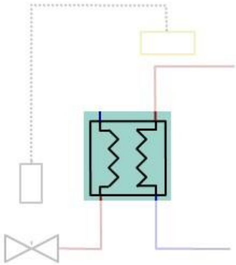
DISTRICT HEATING SUBSTATION



Component	heat exchanger
Thermal power	42kW
Temperature (in/out) primary	90°C / 60°C
Temperature (in/out) secondary	55°C / 75°C
mass flow (prim/sec)	1,23m³/h / 1,84m³/h

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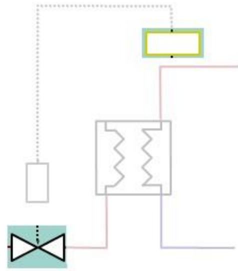
DISTRICT HEATING SUBSTATION



Component	2-way-valve
Control variable	flow temperature
Temperature range	35°C – 80°C

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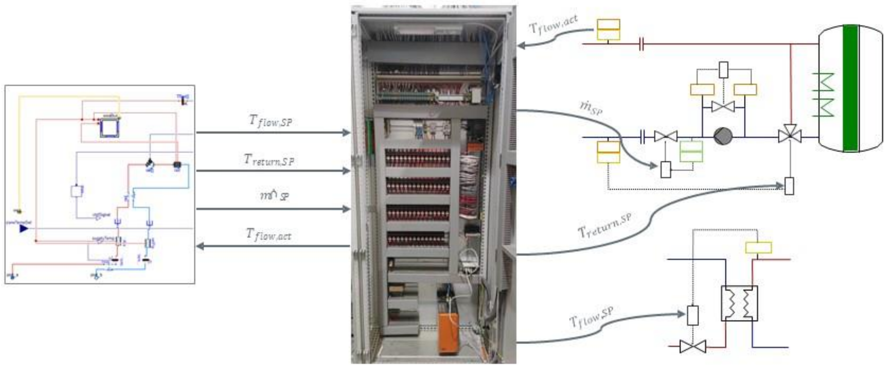
SUMMARY



Virtual Environment Real Environment

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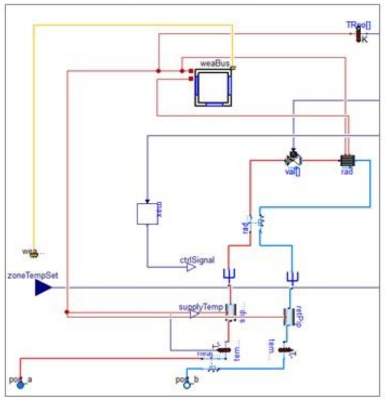
BUILDING MODEL



- Modelled building
  - 860 m² gross floor area
  - 30 kW nominal power
  - Radiator heating
- Interfaces
  - Inputs: secondary supply temperature
  - Outputs: secondary return temperature, secondary mass flow
- Model
  - *Modelica* language
  - *Dymola* modeling environment
  - Based on *Modelica Buildings Library*
  - Model exported as *Functional Mock-up Unit (FMU)*

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BUILDING MODEL CHARACTERISTICS

- System boundaries (secondary side of substation)
  energy conversion | **heat distribution** | **heat delivery** | **building envelope**
- HVAC system modeling approach:
  idealized | system-based | **component-based** | **equation-based**
- Physical quantities: **powers** | **mass flows** | **temperatures** | **pressures**
- Connection logic: causal | **acausal**
- Modeling approach: black-box models | **white-box models**
- Dynamics: static | **dynamic**

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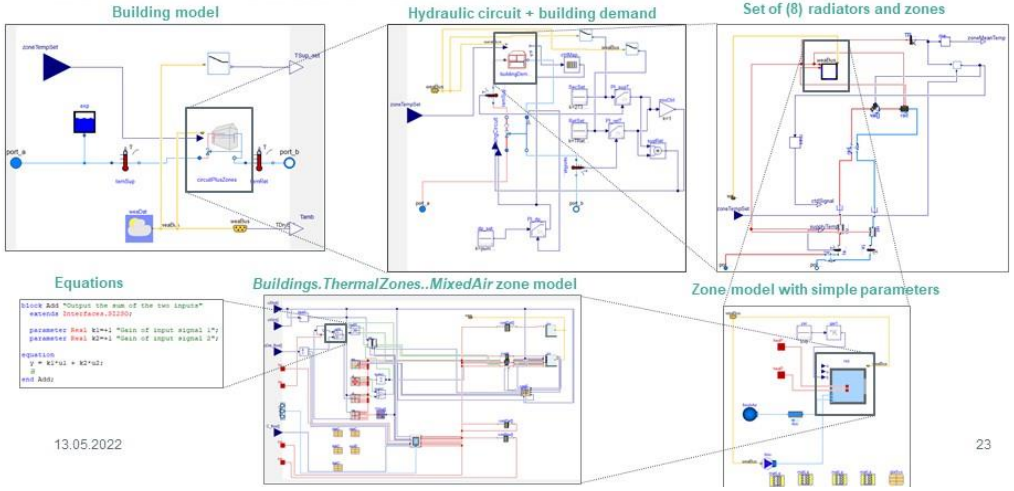
BUILDING MODEL OVERVIEW



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THANKS FOR YOUR ATTENTION!

Dr. Aurelien Bres
Dr. Andreas Sporr
AIT Austrian Institute of Technology GmbH
Giefinggasse 2 | 1210 Vienna | Austria
M +43(0) 664 88 39 00 13
Aurelien.Bres@ait.ac.at
M +43(0) 664 88 25 61 46
Andreas.Sporr@ait.ac.at

DIGITAL ENERGY TESTBED

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the AIT Digital Energy Testbed - CONCLUSIONS & OUTLOOK

IEA DHC Annex TS4 Webinar on Testbeds for Digitalization Solutions in District Heating, 27.04.2022 (online)

Edmund Widl, Ralf-Roman Schmidt; Andreas Sporr, Aurelien Bres, Catalin Gavriluta, Jawad Kazmi, Thomas Natiesta, Martin Mairhofer, Nicolas Marx

CONCLUSIONS

- As a proof-of-concept, a **testbed prototype of the Digital Energy Testbed** has been implemented around an existing DH substation test stand
- There is still some **optimization potential** on the substation test stand (i.e. responsiveness, dynamic operation), however, **static testing is possible already**
- The **software functionalities** are well developed, especially the connection and communication via LabLink have been successful tested – **key enabling technology**

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OUTLOOK

- The Digital Energy Testbed is available for **static testing procedures**
- Optimization of the hardware for **dynamic operation**
- implementation of **other AIT testbeds** (smart grids, heat pumps …)
- **Extension** of the Digital Energy Testbed to partners outside AIT
- Possible application of the Digital Energy Testbed in **research projects**

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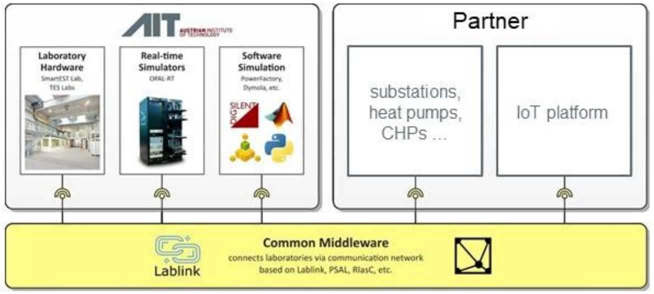
FUTURE APPLICATIONS

- Lablink's flexibility and extensibility **offers a large range of possibilities** to devise testbed setups
- including the **integration of various digitization solutions** and test stands



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DIGITAL ENERGY TESTBED

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POSSIBLE USE CASES

- Supporting the design and operation of **innovative systems combining different (hardware) components**
  - such as substations, heat pumps, batteries, electric boilers, thermal storages, and fluctuating renewables (e.g., wind or PV via direct power lines).
- Supporting the development and validation of **system-level software such as IoT platforms and their applications**. This includes
  - the development and validation of digital twins (based on analytical and/or data-driven models) for predictive simulation and controls in integrated energy systems.

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THANKS FOR YOUR ATTENTION!

Dr.-Ing. Ralf-Roman Schmidt

AIT Austrian Institute of Technology GmbH
Giefinggasse 2 | 1210 Vienna | Austria
T +43(0) 50550-6695 | M +43(0) 664 235 19 01 | F +43(0) 50550-6679
Ralf-Roman.Schmidt@ait.ac.at | http://www.ait.ac.at

DIGITAL ENERGY TESTBED

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY TOMORROW TODAY

Testbeds for Digitalization Solutions in District Heating

IEA DHC Annex TS4 Webinar - **summary**

Wednesday, 27th April 2022, 13:30 to 17:30 (CET)

Edmund Widl, Ralf-Roman Schmidt; Andreas Sporr, Aurelien Bres, Catalin Gavriluta, Jawad Kazmi, Thomas Natiesta, Martin Mairhofer, Nicolas Marx

This Webinar is held in the framework of the international cooperation program "IEA DHC Annex TS4, Digitalisation of District Heating and Cooling", the Austrian participation is financed by the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK), more information at https://www.iea-dhc.org/the-research/annexes/2018-2024-annex-ts4/; and the Austrian project "Digital Energy Testbed", funded by the "Klima- und Energiefonds" and carried out within the framework of the Energy Research Programme 2019 (project #881132)

DIGITAL ENERGY TESTBED AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

AGENDA

BLOCK I	CURRENT DEVELOPMENTS OF TESTBEDS AND DIGITALIZATION SOLUTIONS IN DISTRICT HEATING	13:30 – 14:45
BLOCK II	AIT DIGITAL ENERGY TESTBED	15:00 – 16:20
BLOCK III	WORKSHOP AND KNOWLEDGE EXCHANGE	16:40 – 17:30

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DIGITAL ENERGY TESTBED AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

AGENDA IN DETAIL

Block I – Current Developments of Testbeds and Digitalization Solutions in District Heating *(MS Teams)*

13:25	*Testing of technical connections*
13:30	**Introduction to the Webinar** *(Ralf-Roman Schmidt, AIT)*
	Introduction to the IEA DHC Annex TS4 *(Dietrich Schmidt, Fraunhofer-Institut für Energiewirtschaft und Energiesystemtechnik IEE)*
	Ectocloud for ectogrid: The role of cloud and IoT-based control for highly decentralized energy systems *(Daniel Stenberg, EON)*
	The CoSES Lab: A Laboratory Environment for Combined Smart Energy Systems *(Daniel Zinsmeister, TU München)*
	The data-driven energy company - Tear down system boundaries & optimize the whole value chain *(Johan Kensby, utilifeed)*
	DistrictLAB test center for innovative heating network solutions *(Anna Maria Kallert, Fraunhofer-Institut für Energiewirtschaft und Energiesystemtechnik IEE)*
14:30	*End of Block I and Coffee Break*

Block II – AIT DigitalEnergyTestbed *(MS Teams)*

14:40	*Testing of technical connections*
14:45	**Introduction to Block II** *(Ralf-Roman Schmidt, AIT)*
	Introduction to the DigitalEnergyTestbed Hardware *(Thomas Natiesta, AIT)*
	The LabLink Middleware *(Edmund Widl, AIT)*
	Layout of the DigitalEnergyTestbed *(Andreas Sporr, AIT)*
	Models of the DigitalEnergyTestbed *(Aurelien Bres, AIT)*
	Live demonstration of the DigitalEnergyTestbed *(Thomas Natiesta, AIT)*
	Conclusions and outlook *(Ralf-Roman Schmidt, AIT)*
16:15	*End of Block II, Coffee Break and switching from TEAMS to wonder.me*

Block III – Workshop and knowledge exchange *(wonder.me)*

16:35	*Testing of technical connections and the wonder.me online discussion tool*
16:40	**Introduction to the Workshop** *(Nicolas Marx, AIT)*
	The participants have the opportunity to discuss the lab infrastructures and software solutions with the presenters, as well as experience live demo results of the DigitalEnergyTestbed
17:30	*End of Block III*

All times in CEST

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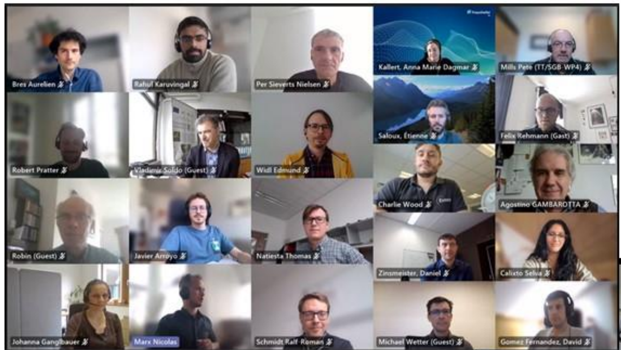

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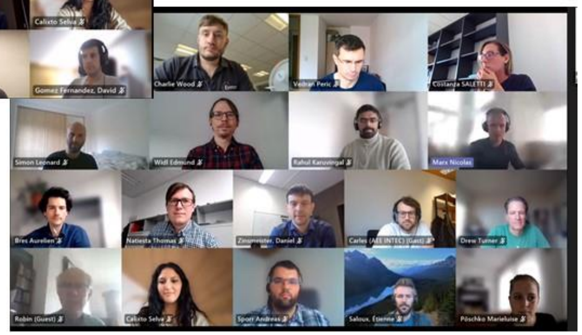
GROUP PICTURES

- In total up to 50 participants



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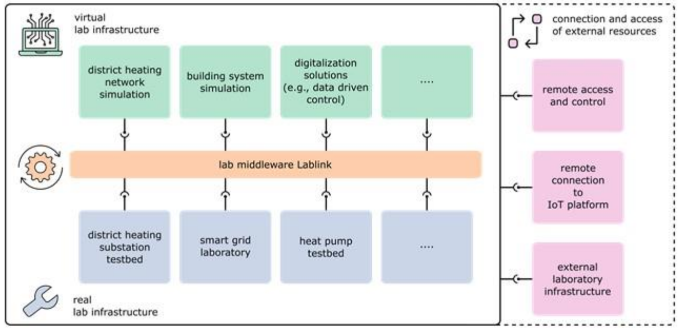
DIGITAL ENERGY TESTBED

THE AIT DIGITAL ENERGY TESTBED

→ An open test environment for the evaluation, (further) development and integration of digitalization solutions for integrated district heating networks

The AIT LabLink middleware is open source!

https://ait-lablink.readthedocs.io/en/latest/



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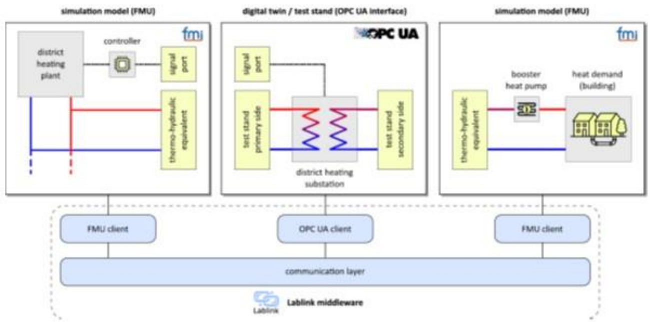
DIGITAL ENERGY TESTBED

CURRENT IMPLEMENTATION

- As a **proof-of-concept**, a testbed prototype has been implemented around an existing DH substation test stand
- **→ assess individual DH substations** and the overall system in response to remote control signals sent by the network operator.



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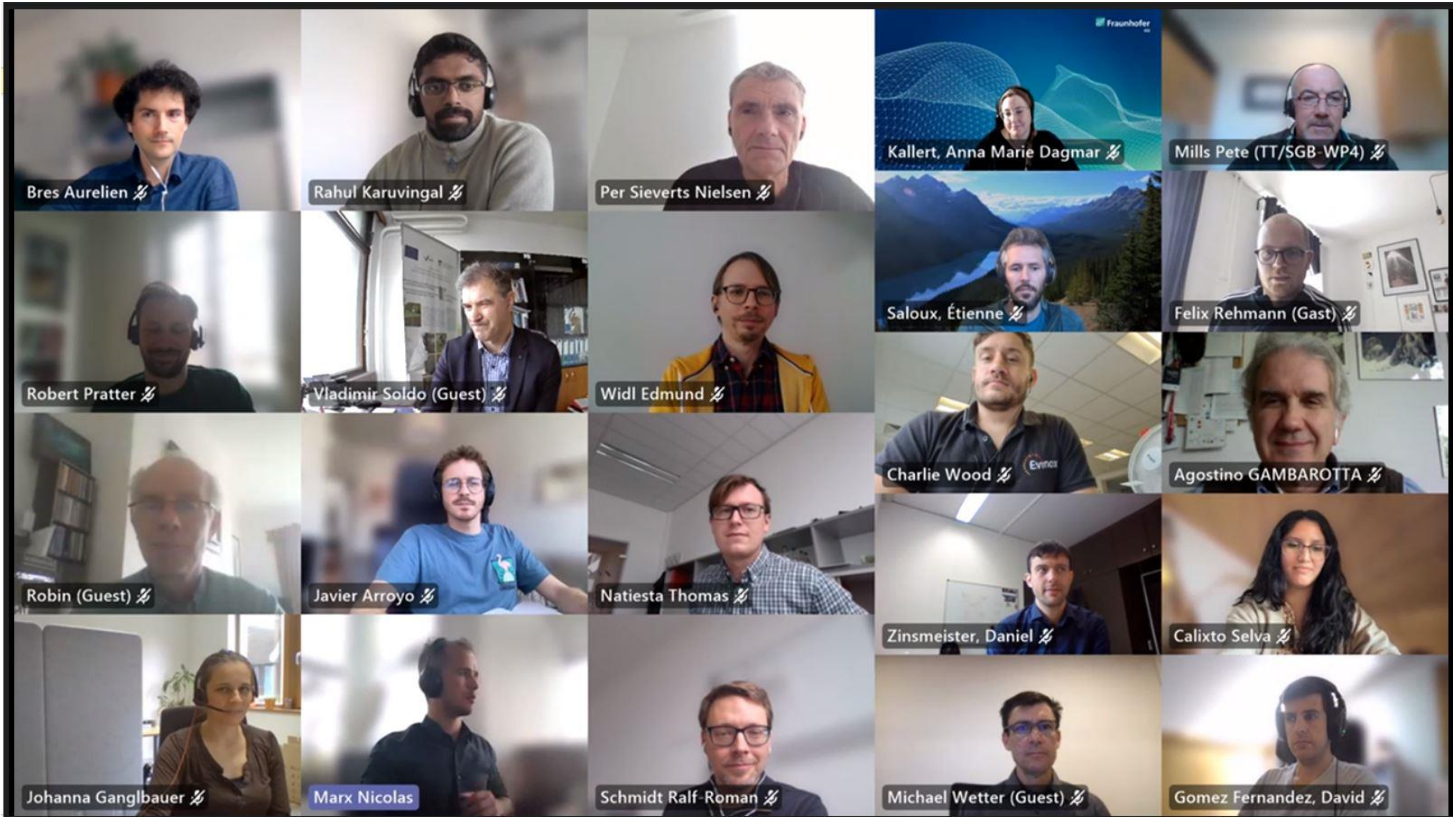
DIGITAL ENERGY TESTBED

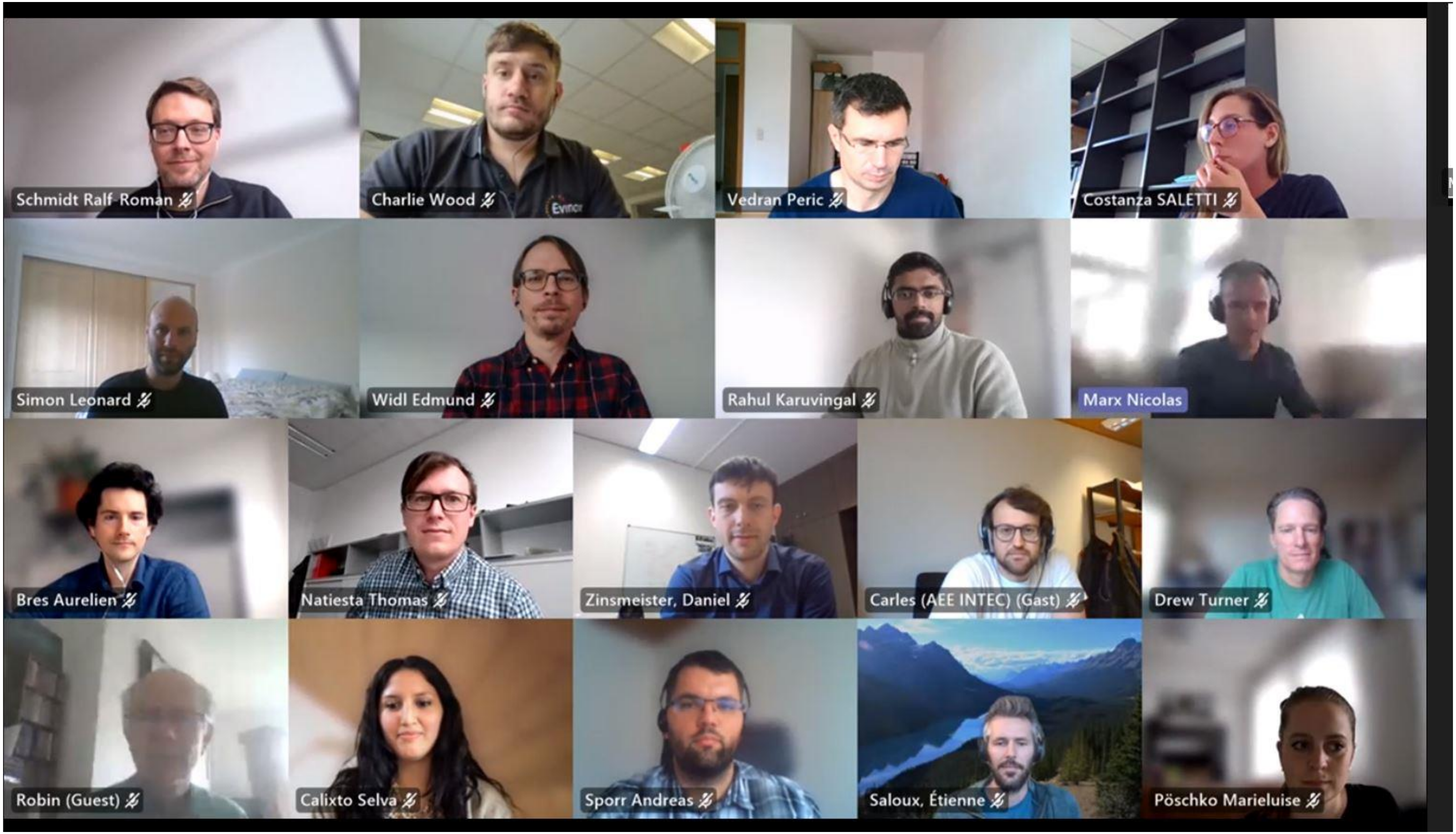
AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

THANKS FOR YOUR ATTENTION!

Dr.-Ing. Ralf-Roman Schmidt

AIT Austrian Institute of Technology GmbH
Giefinggasse 2 | 1210 Vienna | Austria
T +43(0) 50550-6695 | M +43(0) 664 235 19 01 | F +43(0) 50550-6679
Ralf-Roman.Schmidt@ait.ac.at | http://www.ait.ac.at


Bres Aurelien
Rahul Karuvingal
Per Sieverts Nielsen
Kallert, Anna Marie Dagmar
Mills Pete (TT/SGB-WP4)
Saloux, Étienne
Felix Rehmann (Gast)
Robert Pratter
Vladimir Soldo (Guest)
Widl Edmund
Charlie Wood
Agostino GAMBAROTTA
Robin (Guest)
Javier Arroyo
Natiesta Thomas
Zinsmeister, Daniel
Calixto Selva
Johanna Ganglbauer
Marx Nicolas
Schmidt Ralf-Roman
Michael Wetter (Guest)
Gomez Fernandez, David


Schmidt Ralf-Roman
Charlie Wood
Vedran Peric
Costanza SALETTI
Simon Leonard
Widl Edmund
Rahul Karuvingal
Marx Nicolas
Bres Aurelien
Natiesta Thomas
Zinsmeister, Daniel
Carles (AEE INTEC) (Gast)
Drew Turner
Robin (Guest)
Calixto Selva
Sporr Andreas
Saloux, Étienne
Pöschko Marieluise