Renewable Heating & Cooling
European Technology and Innovation Platform

100% RHC Event

From Insights to Action: Digitalisation and AI as Enablers for RHC Technologies

16 April 2026

11.00 > 12.30

Messecongress Graz (Austria)

Organised in collaboration with

ISEC 4th INTERNATIONAL SUSTAINABLE ENERGY CONFERENCE 2026
14 – 16 April 2026 | Messecongress Graz, Austria

#100RHC

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Renewable Heating & Cooling

European Technology and Innovation Platform

From Insights to Action: Digitalisation and AI for Next-Generation Renewable Heating & Cooling Systems

Dominik Rutz & Andrej Misech (RHC-ETIP Secretariat)

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Renewable Heating & Cooling
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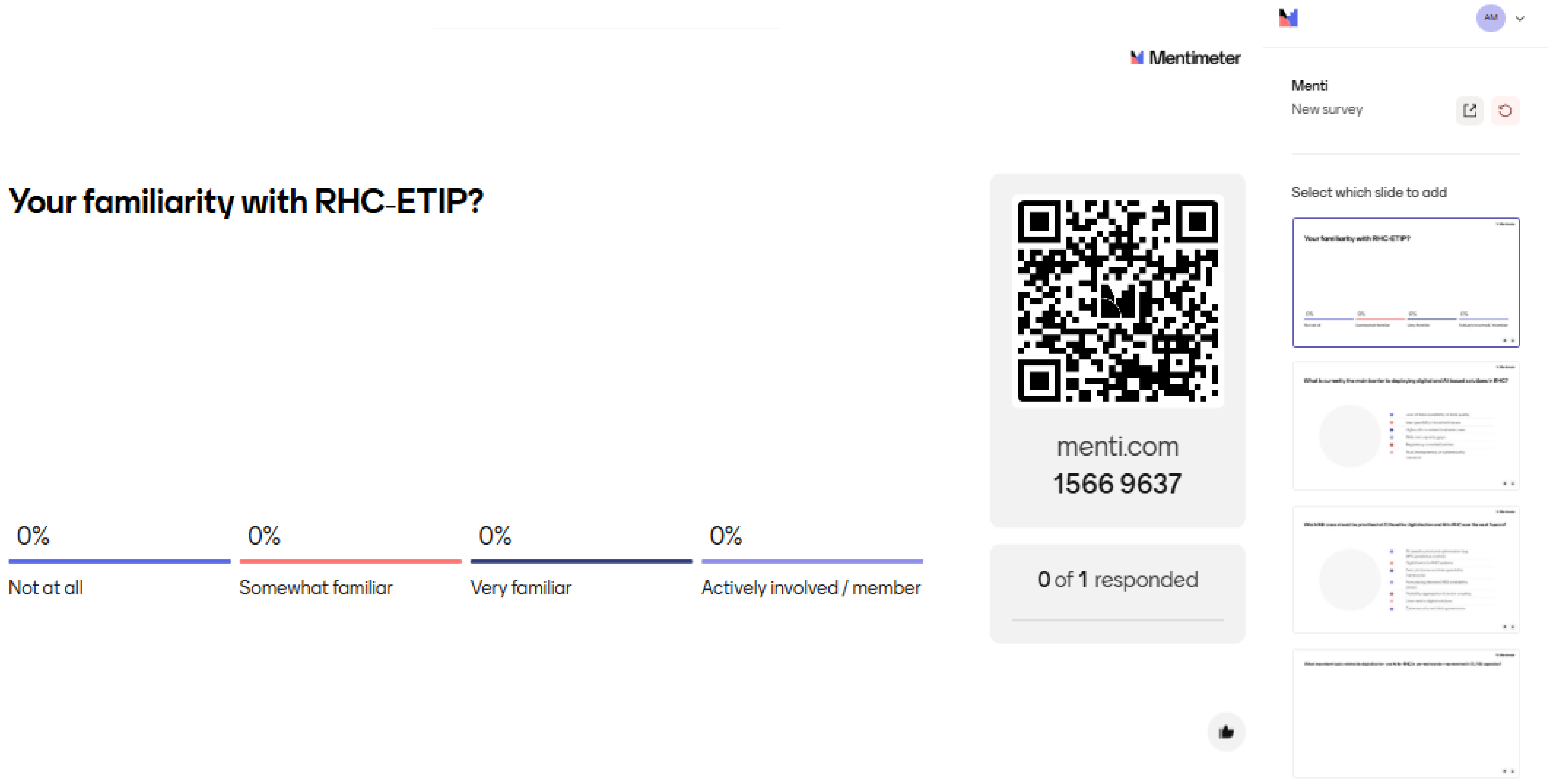


Renewable heating and cooling at a critical moment

Limited RES share

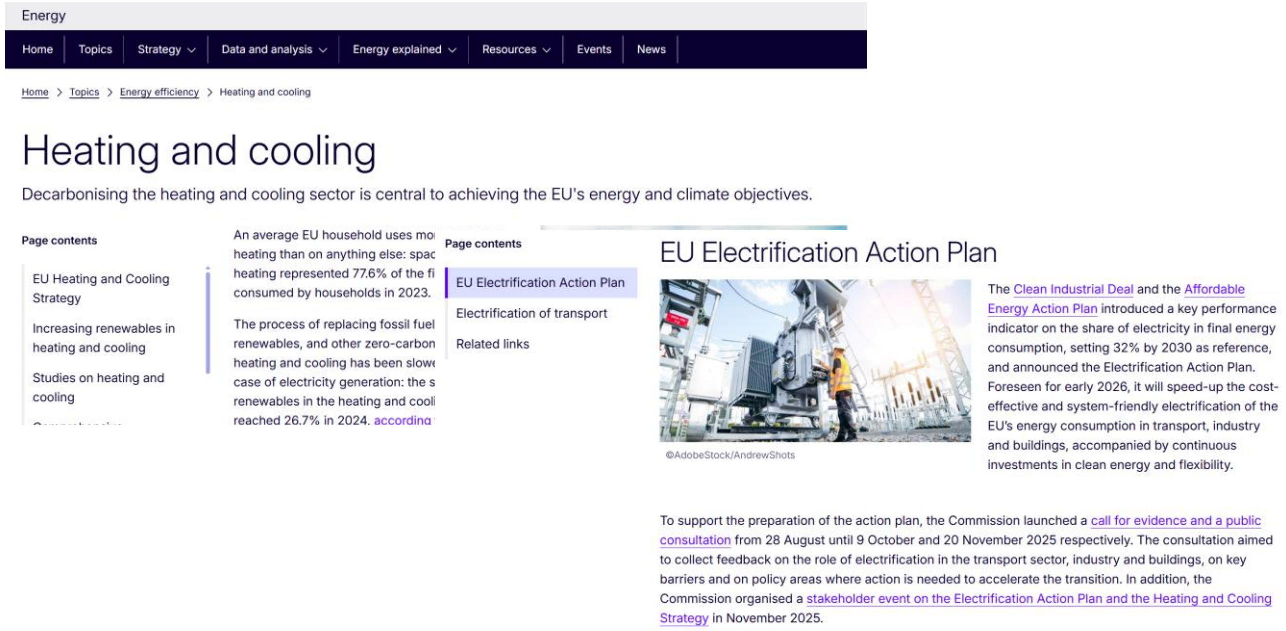
- *The use of renewable energy sources in heating and cooling continues to increase in the EU, with the share reaching 26.7% in 2024, the highest value since the time series started in 2004 (11.7%).* (Eurostat)

Renewable heating and cooling strategy

- Publication expected by May/June 2026

Electrification Action Plan

- Publication expected by May/June 2026



Renewable Heating & Cooling
European Technology and Innovation Platform

The European Technology and Innovation Platform on Renewable Heating & Cooling (RHC-ETIP)

What is RHC-ETIP?

- The RHC-ETIP is a European stakeholder platform bringing together research organisations, industry, and other experts to accelerate innovation and deployment of RHC technologies.

What does it do?

- Develops and regularly updates the Strategic Research and Innovation Agenda (SRIA)
- Identifies research, innovation, and deployment priorities across the RHC value chain
- Provides a structured interface between:
  - R&I communities
  - Industry and market actors
  - EU and national policymakers and funding bodies

Why it matters to you

- The platform offers a channel to translate project results and market needs into policy-relevant input
- The SRIA helps shape EU and national funding priorities (e.g. Horizon Europe)
- Enables collaboration and alignment across technologies and system integration

Renewable Heating & Cooling
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The European Tec  newable Heating & Cooling (RHC-ET

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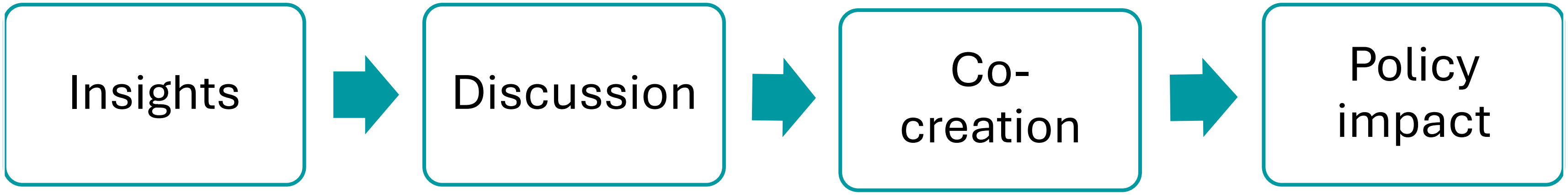
Key strategic outputs of RHC-ETIP

- Preparation and publishing of 2050 Vision for 100% renewable heating and cooling in Europe
- Preparation and publishing of SRIA for climate-neutral heating and cooling in Europe
- Preparation of Implementation and deployment report for renewable heating and cooling sectors in Europe
- Position paper on «Coupling of Heating/Cooling and Electricity Sectors in a Renewable Energy-Driven Europe»
- Position paper on «Renewable hydrogen: Opportunities, limitations and threats of hydrogen for energy transition in Europe»
- RHC-ETIP‘s priority topics or the Horizon Europe‘s Work Programme 2025

From Insights to Action: Digitalisation and AI for Next-Generation RHC Systems

- Expert workshop focusing on applied digitalisation and AI in Renewable Heating & Cooling
- Bridging research outcomes, industrial deployment, and system integration
- Organised under the RHC-ETIP framework, linking technical insights to EU-level strategy
- Session designed to capture expert knowledge and practical experience → participants are not just listeners – they are contributors



Digitalisation & AI: A Lever for Performance, Scalability, and Competitiveness

- Increasing complexity of RHC systems:
  - Hybrid systems, sector coupling, flexibility services, large-scale deployment
- Digital tools and AI enable:
  - Advanced control strategies (e.g. MPC, predictive optimisation)
  - Improved system design, commissioning, and lifetime operation
  - Data-driven performance monitoring, fault detection, and O&M optimization
- Digitalisation is a **key enabler for cost reduction, scalability, and market uptake**

SRIA as a Strategic Interface Between R&I and Funding Frameworks

- The Strategic Research and Innovation Agenda (SRIA):
  - Defines priority research topics, innovation gaps, and deployment needs
  - Reflects input from research organisations, industry, and stakeholders
- SRIA outcomes influence:
  - Horizon Europe calls and topics
  - National and EU funding and policy orientations
- Updating the digitalisation R&I priorities ensures that:
  - Current R&I challenges and opportunities are accurately represented

Objective: Co-shaping future digital RHC research & innovation priorities

Core objective:
👉 Jointly identify and prioritise digitalisation and AI R&I needs for RHC systems

What this means in practice:

- Assess state-of-the-art in research
- Real deployment and market challenges
- Identify:
  - Missing topics
  - Cross-cutting digital enablers
  - Barriers to implementation and scale-up
- Translate experiences from projects and products into strategic guidance

What Do You Gain from Contributing?

For researchers:
- Position emerging research topics in a **policy-relevant framework**
- Increase visibility of results, methods, and approaches
- Help shape future **Horizon Europe research directions**

For industry:
- Highlight real-world bottlenecks and market needs
- Influence R&I priorities to better support **commercialisation and scale-up**
- Connect with research partners and innovation pipelines

Interactive format focused on technical priorities

Session approach:

- Short, targeted expert inputs:
  - Concrete solutions, methods, and lessons learned
- Moderated discussion supported by live polling (Mentimeter) as the co-creation exercise to:
  - Collect priority R&I topics
  - Identify gaps and overlaps
  - Capture concise, actionable inputs

Turning technical input into strategic impact

Session outputs will:

- Feed directly into the updated SRIA digitalisation chapter
- Be consolidated by RHC-ETIP experts

Results will inform:

- Policy dialogue with the European Commission
- Future RHC-relevant funding opportunities

Your contribution here helps ensure that future R&I programmes support robust, scalable, and deployable digital RHC solutions.

Become a member of the European Technology and Innovation Platform Renewable Heating and Cooling!

- **EU-level policy insights** through regular newsletters and updates
- **Influence on strategy and policy**: contribute to the SRIA and future policy documents
- **Access to expert webinars** on renewable heating and cooling technologies and trends
- The **100% RHC events, brokerages** and **matchmakings** for proposals

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Thematic presentations

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Renewable Heating & Cooling

European Technology and Innovation Platform

From Data to Value - Digitalisation for Efficient and Flexible District Heating and Cooling Networks

Ralf-Roman Schmidt & Edmund Widl;
AIT Austrian Institute of Technology GmbH

ISEC 2026, 14 – 16. April 2026, Graz, Austria; workshop “From Insights to Action: Digitalisation and AI as Enablers for RHC Technologies”

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This presentation is based on:

- IEA DHC Annex TS9, AIT receives national funding from the Federal Ministry Innovation, Mobility and Infrastructure, Republic of Austria
- DeRiskDH: funded by the Climate and Energy Fund of the Federal Government of Austria within the framework of the Energy Model Region "Green Energy Lab"

Agenda

- **Part I - Value**
  - digitalization in DHC: use cases
  - Value of smart supply temperature control
  - Value of reduced return (and supply) temperatures

- **Part II – Data**
  - Challenges for Data Handling
  - Data Spaces: The Future of Data Handling
  - Common European Energy Data Space

- **Summary and Conclusions**

Part I - Value

digitalization in DHC: **use cases**

- **Operation optimization**: Cost-efficient dispatch and el. grid balancing, smart supply temperature control

- **Monitoring & fault detection**: Network maintenance and identification of system/substation issues (e.g. leakages or high return temperatures)

- **User integration & flexibility activation**: end-user participation, implementation of improved DH tariffs and activation of demand-side flexibilities

- **Planning & system design**: Data-driven demand/supply analysis and DHC network planning / adaptation

Based on:

- RHC-ETIP's priority topics for the Horizon Europe's Work Programme 2026-2027; https://www.rhc-platform.org/content/uploads/2025/05/RHC-ETIP_HE-WP2026-2027recommended-topics-vFINAL.pdf
- Dietrich Schmidt, et. al, *The current state and future outlook of digitalization for the operation of district heating systems: A review*, Energy, Volume 344, 2026, https://doi.org/10.1016/j.energy.2026.140086

digitalization in DHC: **use cases**

- **Operation optimization**: Cost-efficient dispatch and el. grid balancing, smart supply temperature control
- **Monitorin** system/su ification of tures)

What is the (monetary) value / benefit of these use cases?

- **User integration & flexibility activation**: end-user participation, implementation of improved DH tariffs and activation of demand-side flexibilities
- **Planning & system design**: Data-driven demand/supply analysis and DHC network planning / adaptation

Based on:

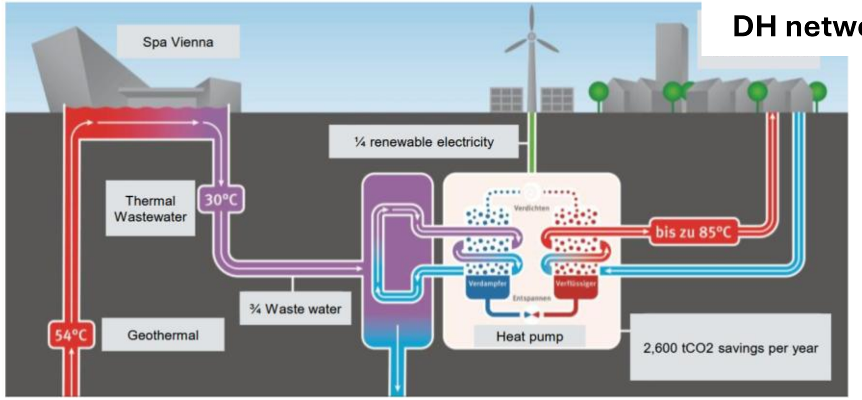
- RHC-ETIP's priority topics for the Horizon Europe's Work Programme 2026-2027; https://www.rhc-platform.org/content/uploads/2025/05/RHC-ETIP_HE-WP2026-2027recommended-topics-vFINAL.pdf
- Dietrich Schmidt, et. al, *The current state and future outlook of digitalization for the operation of district heating systems: A review*, Energy, Volume 344, 2026, https://doi.org/10.1016/j.energy.2026.140086

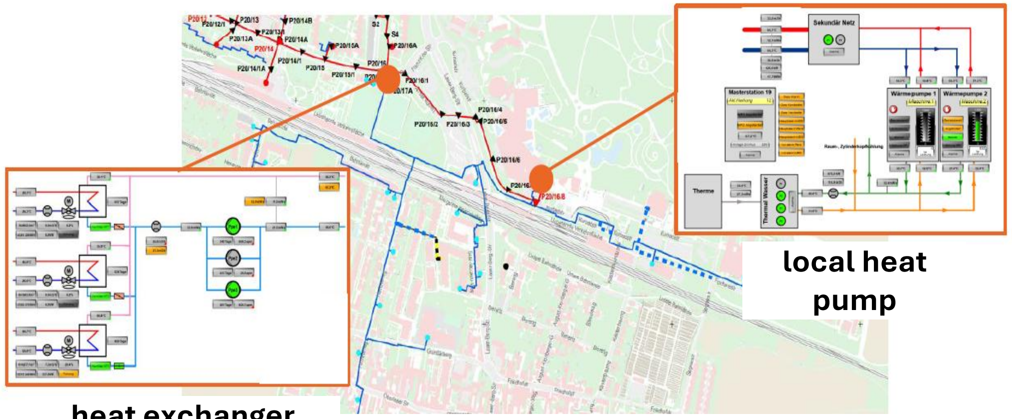
Example: Value of smart supply temperature control

Digital twin application

- **Case study:** a secondary DH network in Vienna
  - heat demand (2023): 19,4 GWh
  - Heat supply (2023):
    - 90% main DH network (via a heat exchanger),
    - 10% a local HP (source: geothermal energy from a spa)
- **Challenge**: high supply temperatures
- **Method**: digital twin implementation for smart supply temperature control (start: 2023)
  - Gradyent created a digital copy of the network that runs in real-time, combining geographical, weather, and sensor data with physics-based models and AI.

secondary DH network





local heat pump

heat exchanger (supply from main DH network)

https://www.gradyent.ai/resources/customer-stories/wien-energie-reducing-forward-temperature-by-5-degrees
https://www.gradyent.ai/resources/news/wien-energie-kicks-off-heat-pump-optimisation-with-gradyent
https://heatpumpingtechnologies.org/project57/case-studies/waste-heat-utilization-spa-vienna/

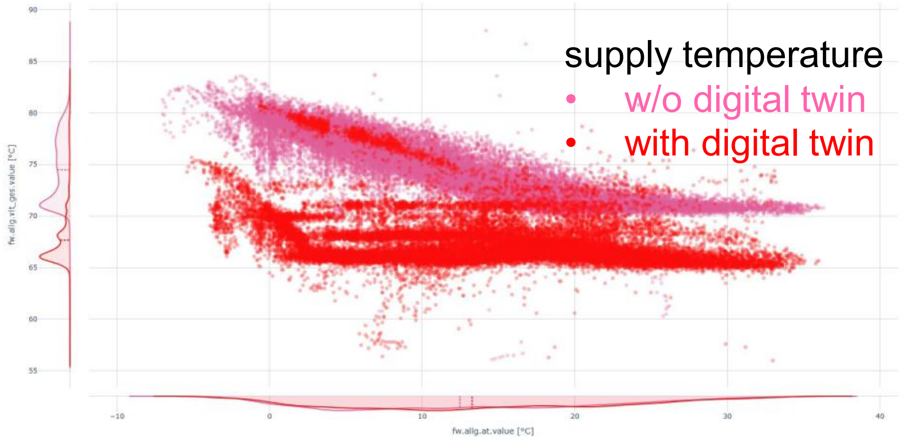
(preliminary) **Results**

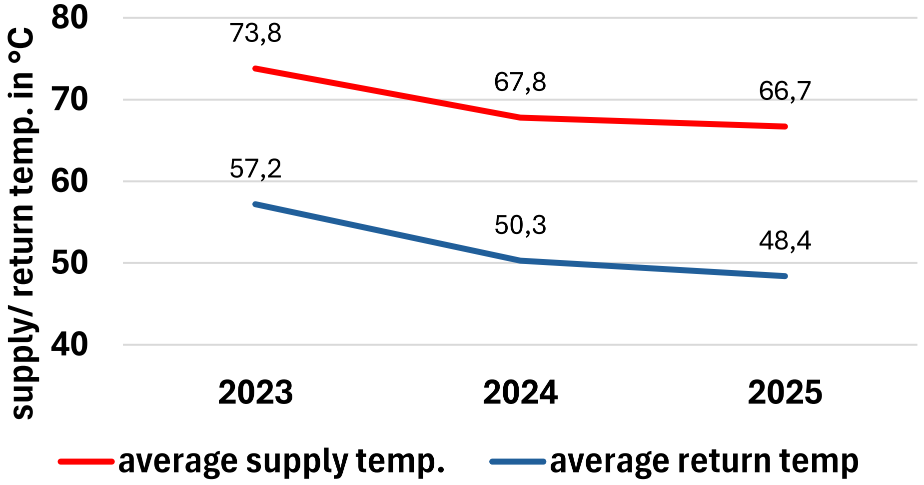
- The optimization led to a **reduction of the average supply and return temperatures by <u>7,1K and 8,8K</u>** respectively (from 2023 to 2025)

- This resulted in two effects:
  - **Reduction of heat losses by 308 MWh**
    → saving = 17 000 €/year
    (<u>assumption</u>: average heat generation price of 55 €/MWh)
  - **Increase of the COP of the HP from 3.6 to 4.1 →** reduction of the el. demand by 12.8%.
    → saving = 23 800 €/year
    (<u>assumption</u>: (average) electricity price = 100 €/MWh; (improved) share of heat supply by the HP = 35%)

- **Total savings* = 40 800 €/year → 2.18 €/MWh**

*costs for new heat meters, setting up and operating the digital twin etc. are not considered

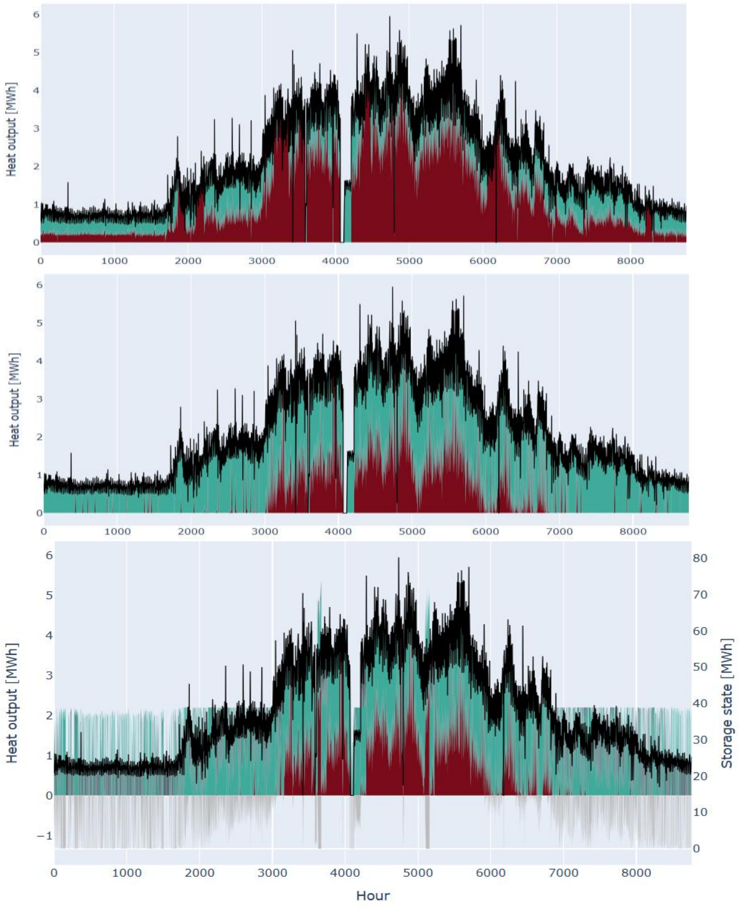


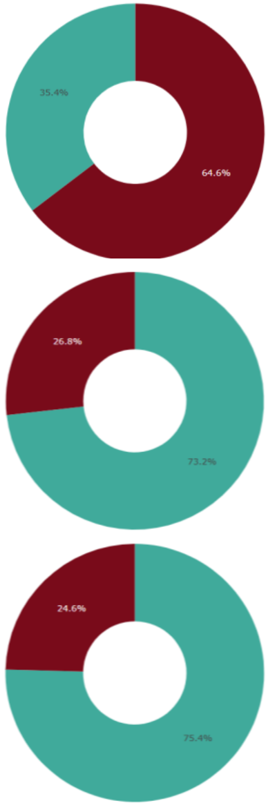


Outlook: optimization

Method: Investment and operational optimization (perfect foresight) and dynamic simulation for testing/ validating the operational behaviour

- current situation
- Optimized operation (el. price)
- Optimized operation (el. price) + storage investment





levelized cost of heat = 100%

-20,3%

levelized cost of heat = 79,7%

-26,9%

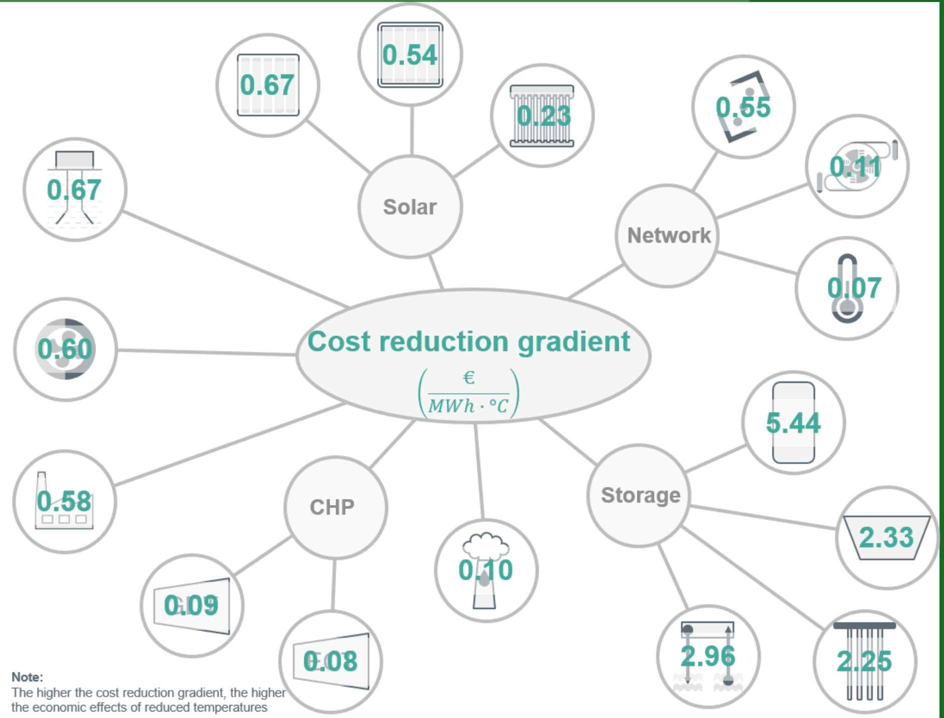
levelized cost of heat* = 73,2%

- Heat exchanger (supply from main DH network)
- Local Heat Pump

*including annualized CAPEX of the storage

Source: Jerik Catal, Nyasha Grecu et. al: D2.1 Report on the analysis and optimization of the performance of buildings in DH networks, Project DeRiskDH (publication expected Q4/2026)

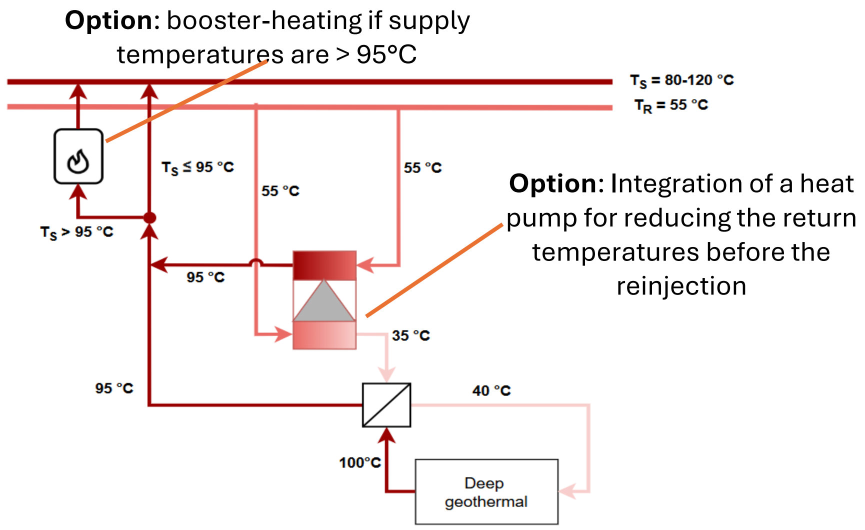
Example: Value of reduced return (and supply) temperatures

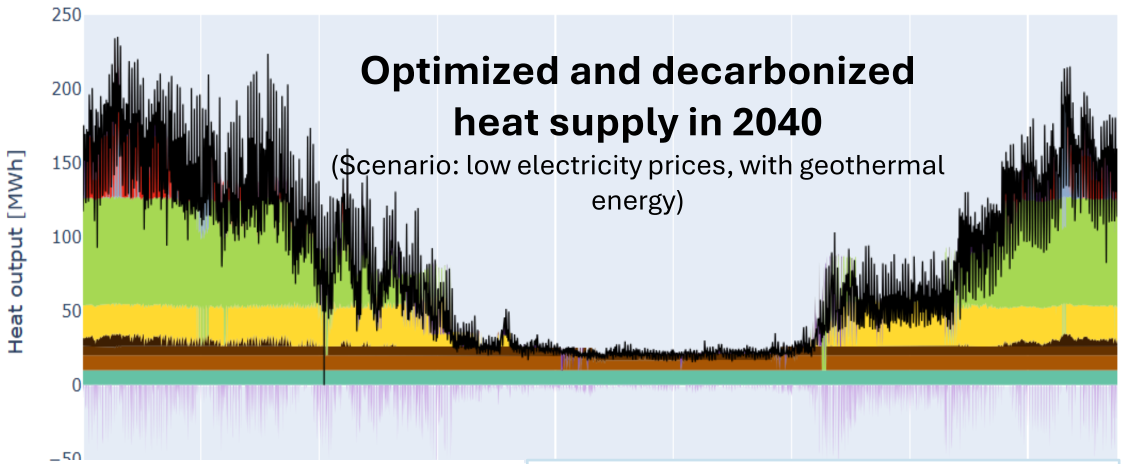


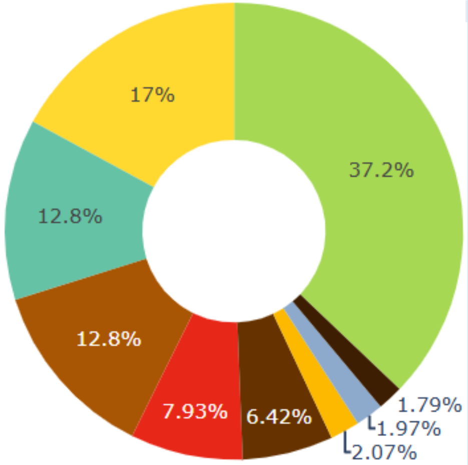
Roman Geyer, Jürgen Krail, Benedikt Leitner, Ralf-Roman Schmidt, Paolo Leoni, Energy-economic assessment of reduced district heating system temperatures, Smart Energy, Volume 2, 2021 https://doi.org/10.1016/j.segy.2021.100011

Case study: decarbonization of DH

- **Case study:** a medium size DH network in Austria, heat demand: ~ 428 GWh
- **Challenge:** Decarbonizing and optimized integration of heat pumps and deep geothermal energy
- **Method:** Investment and operational optimization for 2040





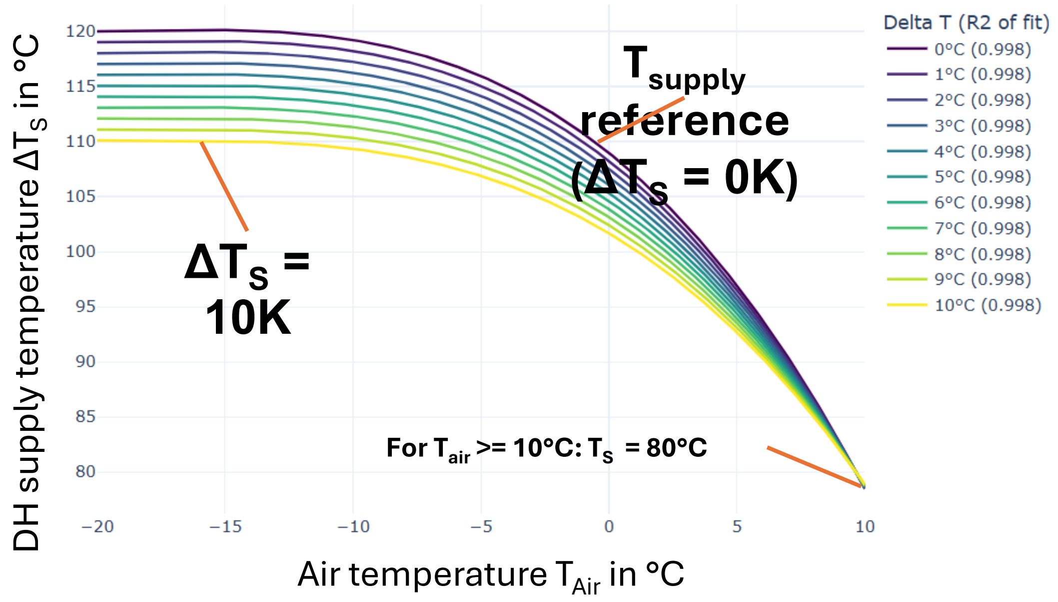


- **Baseload:** biomass boiler & deep geothermal
- **Peak load:** electric & biomethane boilers
- **Majority share:** biomass CHP & air HP due to low biomass and electricity cost
- **Storage** used mainly in the transition period and winter

Grecu, Schmidt, Strömer, Dahash, Haslinger: "DEKARBONISIERUNG DER FERNWÄRME UNTER ZUKÜNFTIGEN UNSICHERHEITEN: DIE ROLLE VON GEOTHERMIE, SAISONALEN SPEICHERN UND REDUZIERTEN NETZTEMPERATUREN";EnInniov, 19. Symposium Energieinnovation 11.-13.2.2026, Graz; https://www.tugraz.at/fileadmin/user_upload/Events/Eninnov/EnInnov2026/files/pr/655_PR_Grecu.pdf

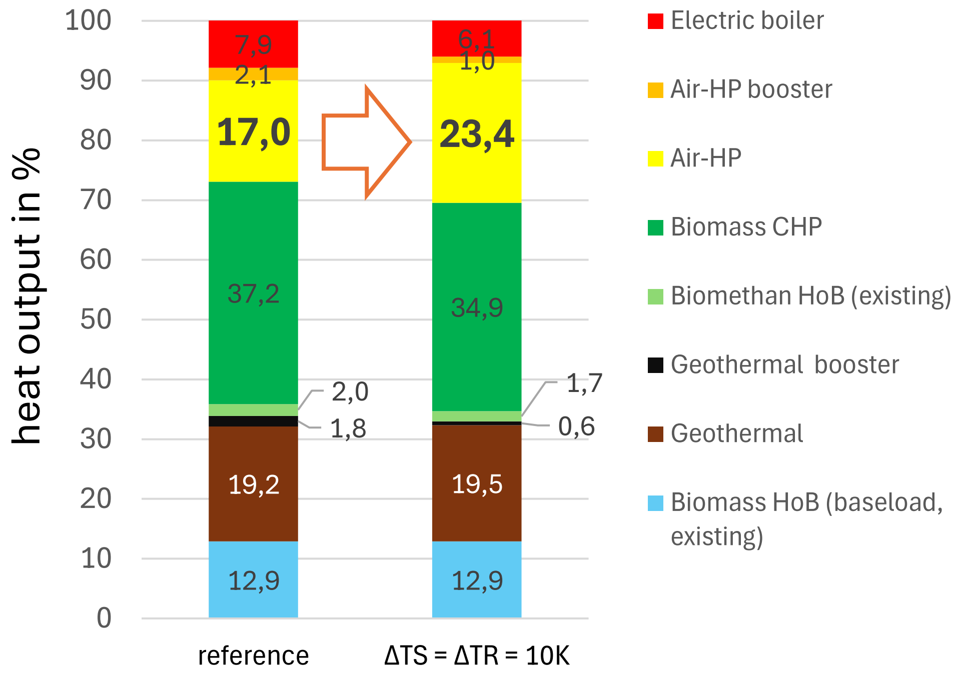
Analysis of temp. reduction scenarios

- **Analysis of different temperature reduction scenarios** for the
  - return temperature → ΔT_R and/or
  - maximum supply temperature → ΔT_S



Effects of reduced temperatures :

- Reduced network losses
- Improved heat pump performance
- Increased storage range



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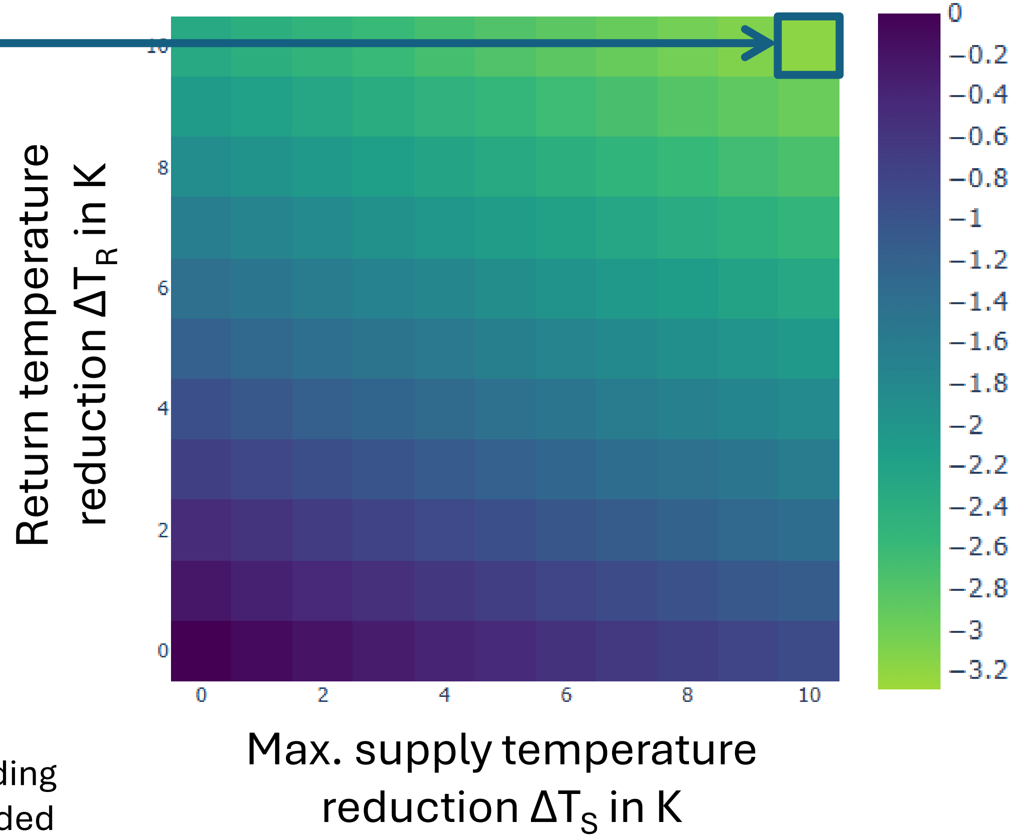
Result: Effect of reduced temp.

- **A reduction of the supply <u>and</u> return temperatures by 10°C saves**
  - **3.18 €/MWh,** amounting to
  - **2.17 M€/year**

- To achieve this reductions, either **investments are required**:
  - in network extensions → T_S reduction without reducing T_R or
  - Buildings adaptations → T_R reduction and T_S reduction[1]
- **Or, alternatively, digitalization measures can be cost-efficient!**

Savings in LCOH* when reducing return and/ or supply temperatures in €/MWh



[1]or connection of new customers

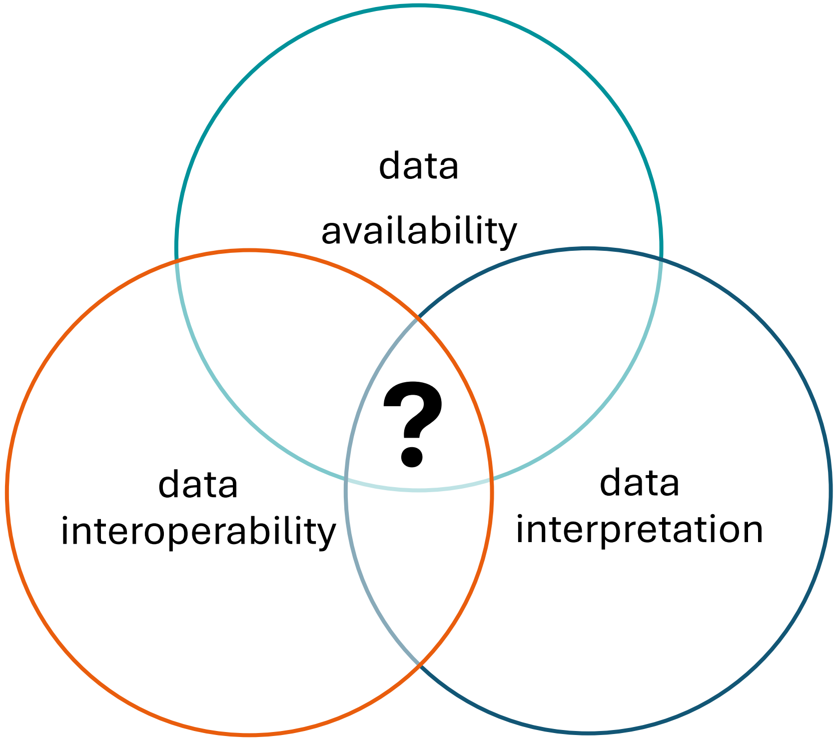
*costs for network extension or building adaptation/ retrofitting are not included

Grecu, Schmidt, Strömer, Dahash, Haslinger: "DEKARBONISIERUNG DER FERNWÄRME UNTER ZUKÜNFTIGEN UNSICHERHEITEN: DIE ROLLE VON GEOTHERMIE, SAISONALEN SPEICHERN UND REDUZIERTEN NETZTEMPERATUREN";EnInniov, 19. Symposium Energieinnovation 11.-13.2.2026, Graz; https://www.tugraz.at/fileadmin/user_upload/Events/Eninnov/EnInnov2026/files/pr/655_PR_Grecu.pdf

Part II – Data

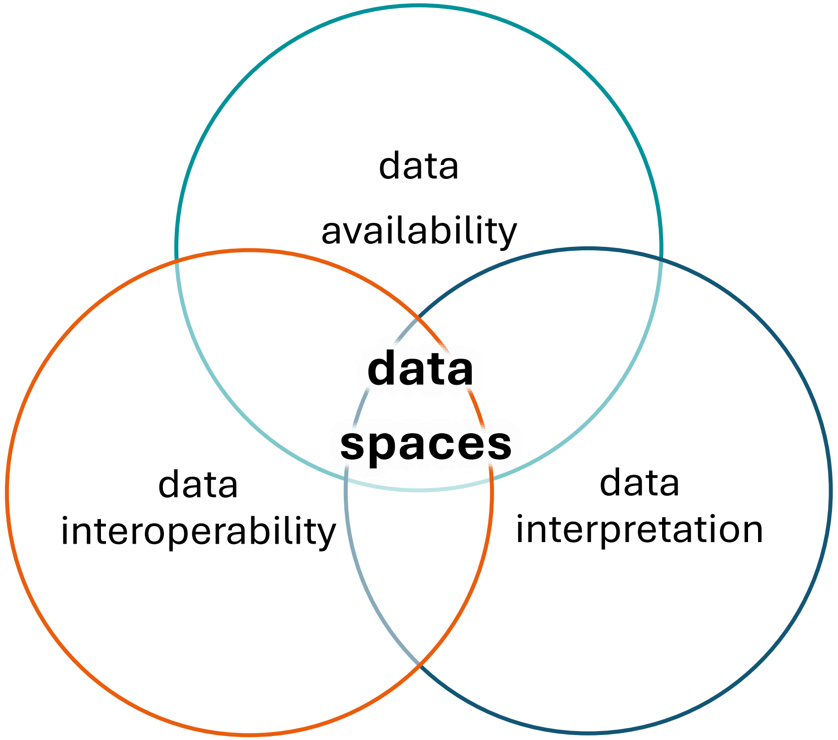
Challenges for Data Handling

- **Availability of data**
  - technical: data stored in different sources (utilities, smart home solutions, etc.), ...
  - non-technical: GDPR, data sovereignty, privacy, compliance with regulations, ...
- **Interoperability of data**
  - no uniform data standards or naming conventions
  - avoid vendor lock-in
- **Interpretation of data**
  - semantic data models / ontologies for heat sector (infrastructure, assets, metering, operation, ...)



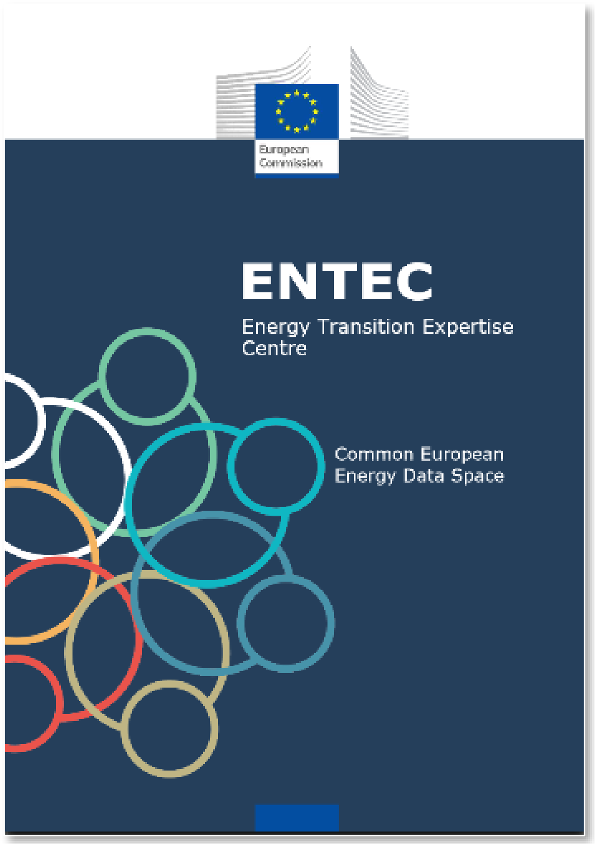
Data Spaces: The Future of Data Handling

- European Commission announced the **European Strategy for Data**:
  - create single market for data to be shared and exchanged
  - data spaces will facilitate data sharing, while protecting sensitive data and simplifying regulatory compliance
- Data spaces are expected to become ubiquitous within the EU across all sectors (similar to clouds today)
  - transport, finance, health, governance, ...



Common European Energy Data Space

- **Common markets** for energy and data are intended to facilitate the **energy transition**
- Digital technologies and access to data are key to **integrating renewable energies**
- Currently there is a focus on the electricity sector, but access to standardized device data from heat sector is seen as an opportunity to improve **flexibility services**



„Common European Energy Data Space ": https://doi.org/10.2833/354447

Summary and Conclusions

Summary and Conclusions

- **Digital applications for optimizing DHC systems have become mature**
  →exploit state-of-the-art digital technologies: AI/ML, cloud/edge/IoT, digital twins, ...
  →transition from prototypes to products has already taken place
- **Key to all these digital applications is data!**
  →transition to data economy is the logical next step
  →DHC stakeholders gather, organize, and exchange data to create (economic) value
  →data spaces will become the EU's primary infrastructure for handling data
- **Challenge: Build vs. buy trade-off and vendor selection complexity**
  →Open-source software enables full control; but requires in-house expertise and resources
  →Expertise can be outsourced to commercial service – but which one? + vendor-lock-In + costs
- **Chicken and egg problem**
  →Positive impacts of digitalization measures are maximized in a fully decarbonized system,
  →However, digitalization is a prerequisite for a cost-efficient decarbonization of DHC networks.

THANKS FOR YOUR ATTENTION!

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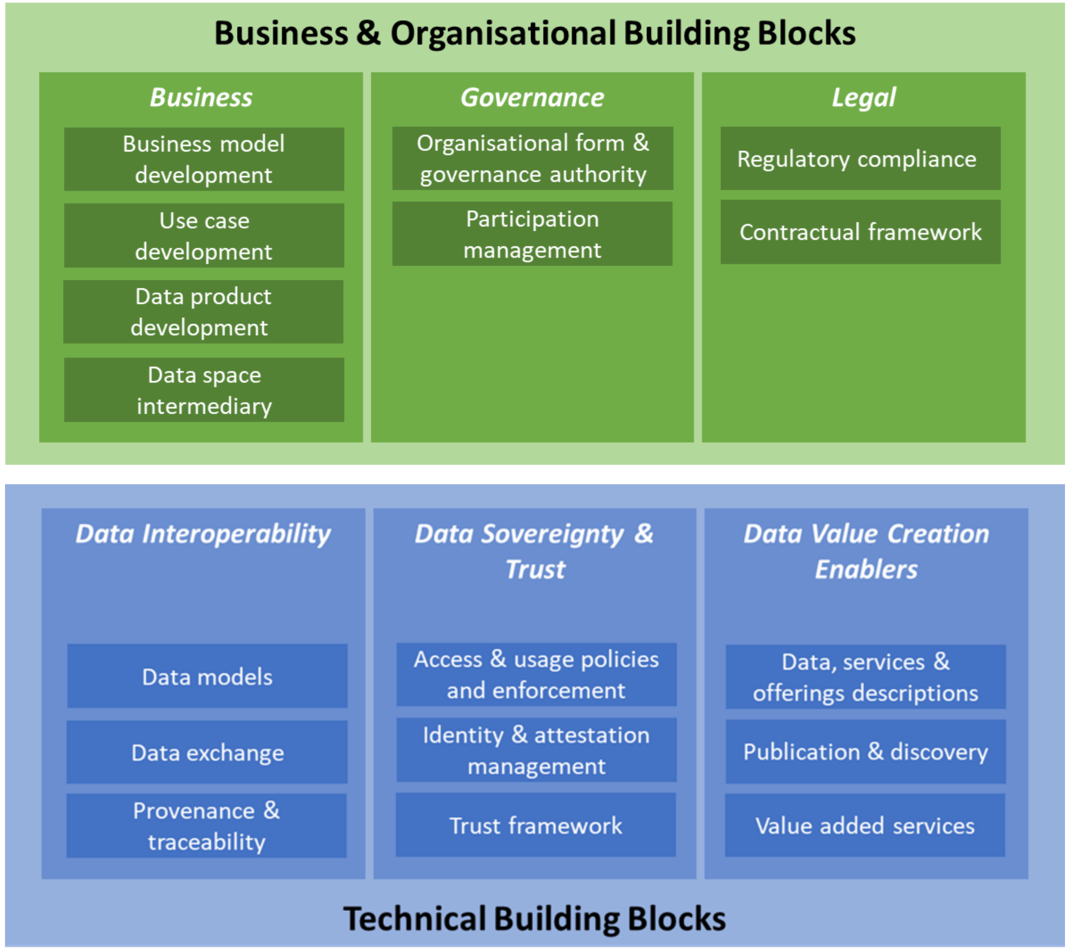
Open-source vs Commercial software

Open-source software:

- Enables building monitoring platforms in-house
- Full control over the system and implementation
- Requires in-house software engineers and data scientists, dependency on one or a few key internal individuals
- Resource-intensive and time-consuming setup and operation

- **Commercial software:**
  - Access to provider expertise
  - Long-term availability, maintenance, and updates
  - Easier implementation of improvements (depending on provider)
  - Availability of advanced features (e.g., simulation with limited data, digital twin capabilities, optimization of systems)
  - Data and expertise are outsourced to provider servers
  - Dependency on external company
  - Ongoing costs

BACKUP: Data Space Building Blocks

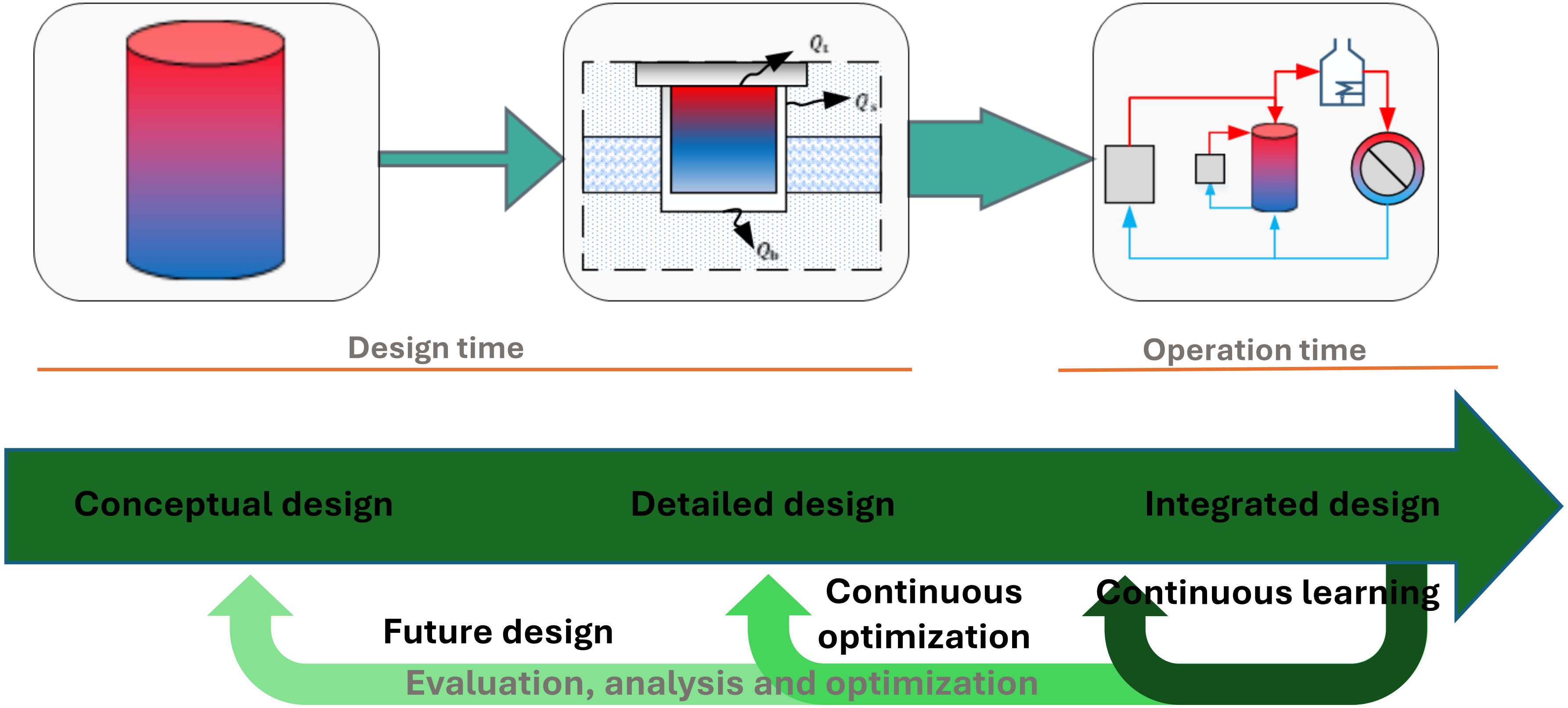


From „*Data Spaces Blueprint v1.0*“: https://dssc.eu/space/BVE/357073006/Data+Spaces+Blueprint+v1.0

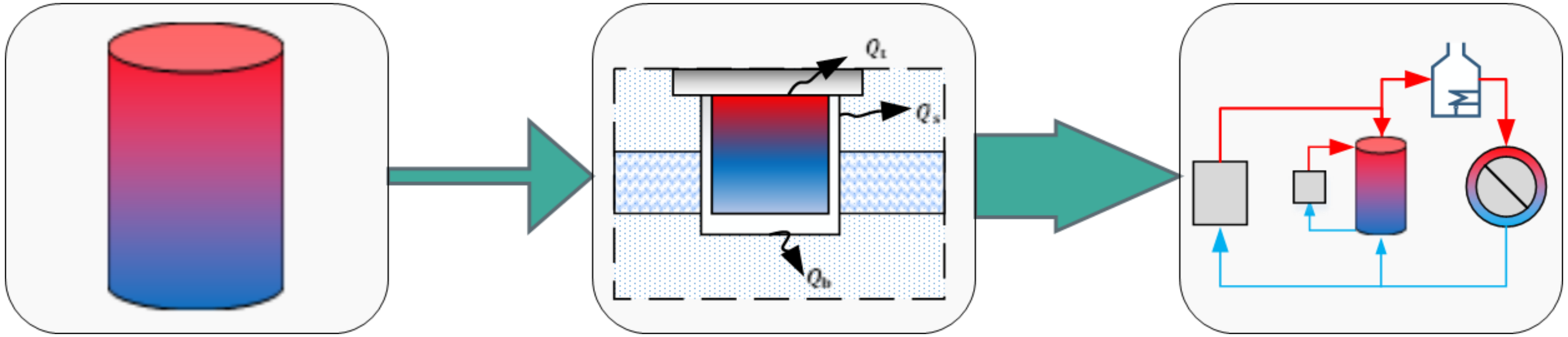
Value of optimized storage operation

Seasonal thermal energy storage

Insight throughout sTES lifecycle



SEASONAL THERMAL ENERGY STORAGE
Insight throughout sTES lifecycle



Design time

Operation time

Digital thread

Data

Renewable Heating & Cooling

European Technology and Innovation Platform

Affordable, sustainable and resilient heating and cooling: Powered by physics-based MPC

Dr. Lucas Verleyen (KU Leuven)

Prof. Dr. Lieve Helsen (KU Leuven)

Energy Ville

THERMAL SYSTEMS SIMULATION

KU LEUVEN

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Next-generation renewable heating and cooling systems

Affordability

Access for everyone through a
- ✓ <u>low</u>,
- ✓ <u>fair</u>, and
- ✓ <u>predictable</u>

system cost

Minimising operational costs

Sustainability

- ✓ <u>Efficiency</u>: supplying same heating and cooling services with fewer resources
- ✓ <u>Consistency</u>: aligning with nature and (local) context
- ! <u>Sufficiency</u>: reducing consumption to stay within planetary boundaries

Minimising climate impact

Resilience

Ensuring continuity under extreme conditions through
- ✓ <u>flexibility</u> and
- ✓ <u>adaptability</u>

Maximising synergies and inherent system flexibility

Smart operation = smart control

Next-generation renewable heating and cooling systems

= Affordable, sustainable, and resilient heating and cooling

Minimising operational costs

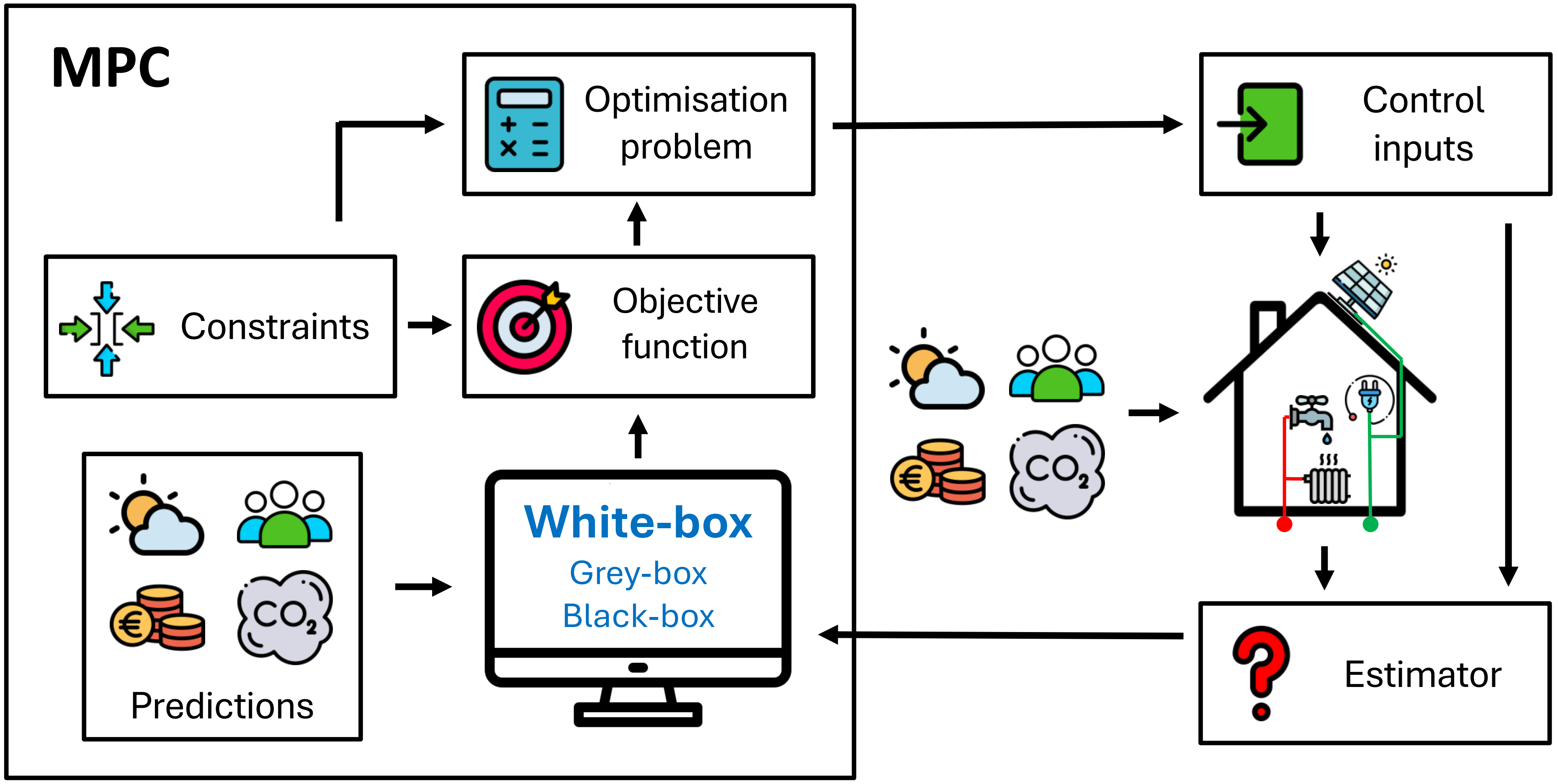
Minimising climate impact

Maximising synergies and inherent system flexibility

powered by

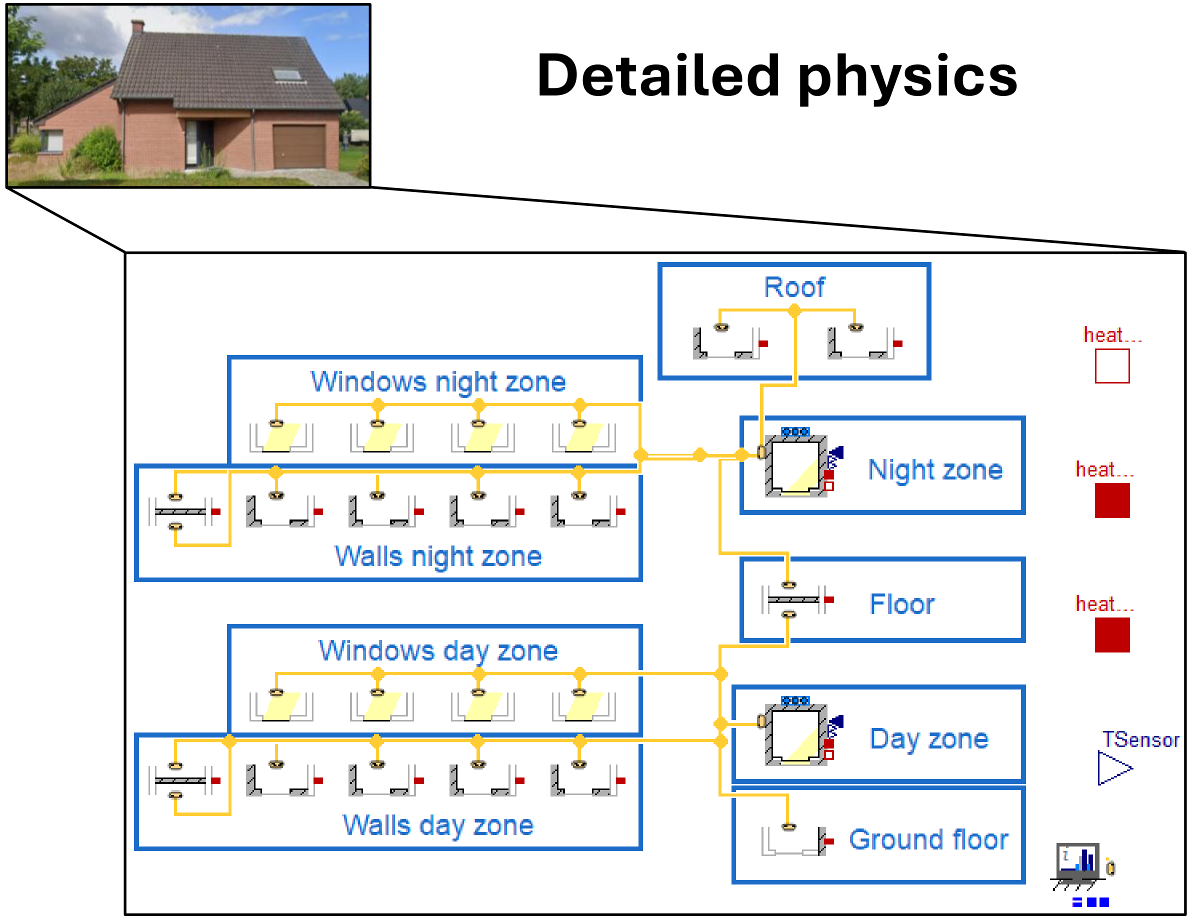
Model Predictive Control (MPC)

Model Predictive Control (MPC)



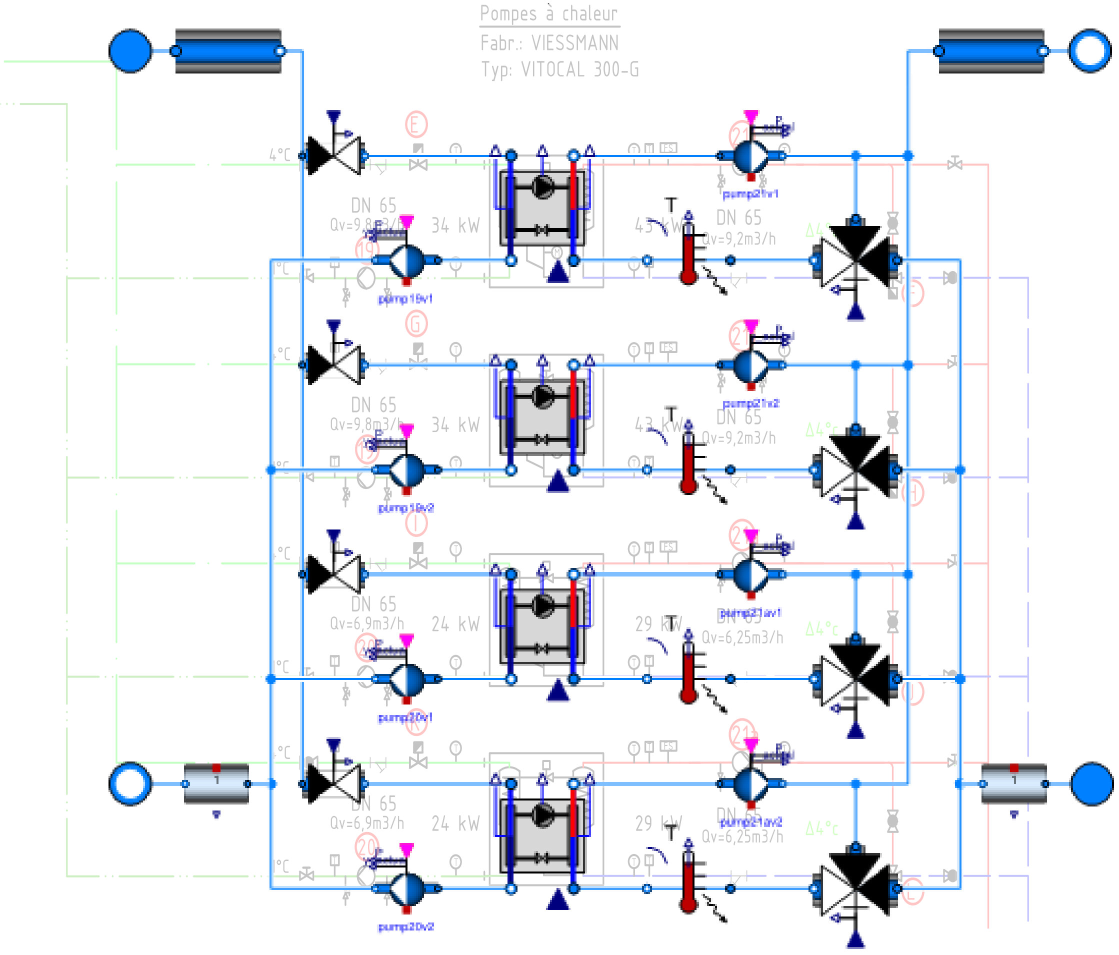
Physics-based white-box models

Detailed physics



→ Conduction, internal and external convection, longwave and shortwave radiation

One-to-one mapping



Open-source Modelica libraries

README

Modelica IBPSA library

International Building Performance Simulation Association

build passing

This is the development site for the *Modelica IBPSA Library* and its user guide.

Instructions for developers are available on the wiki.

Library description

The Modelica *IBPSA* library is a free open-source library with basic models that codify best practices for the implementation of models for building and community energy and control systems.

The development of the IBPSA library is organized through the IBPSA Modelica Working Group (https://github.com/ibpsa/modelica-working-group). The development was organized from 2017 to 2022 through the IBPSA Project 1 (https://ibpsa.github.io/project1) of the International Building Performance Simulation Association (IBPSA), and from 2012 to 2017 through the Annex 60 project (http://www.iea-annex60.org) of the Energy in Buildings and Communities Programme of the International Energy Agency (IEA EBC).

This library is typically not used directly by end-users. Rather, it is integrated by developers of other Modelica libraries for building and community energy systems, who then distribute it to end-users as part of their respective library. Currently, the *IBPSA* library is used as the core of these libraries:

README Contributing

EBC | Institute for Energy Efficient Buildings and Indoor Climate

E.ON Energy Research Center

RWTH AACHEN UNIVERSITY

OpenModelica Readiness 0.84

AixLib

AixLib is a Modelica model library for building performance simulations.
The library contains models of HVAC systems as well as high and reduced order building

README BSD-3-Clause license

BuildingSystems

Universität der Künste Berlin

This is the development site for the Modelica BuildingSystems library and its user guide.
Instructions for developers are available on the wiki.

Library description

The Modelica BuildingSystems library is a free and open-source library for energy-related building and plant simulation.

README

Modelica Buildings library

BERKELEY LAB Lawrence Berkeley National Laboratory

build canceled

This is the development site for the Modelica *Buildings* library and its user guide.

Stable releases including all previous releases are available from the main project site at http://simulationresearch.lbl.gov/modelica.

Instructions for developers are available on the wiki.

README

IDEAS v4.0.0

KU LEUVEN

IDEAS is a *Modelica* library for Integrated District Energy Assessment Simulations. This free and open-source library enables simultaneous transient simulation of integrated thermal and electrical energy systems including buildings at both individual (building) and collective (district) level.

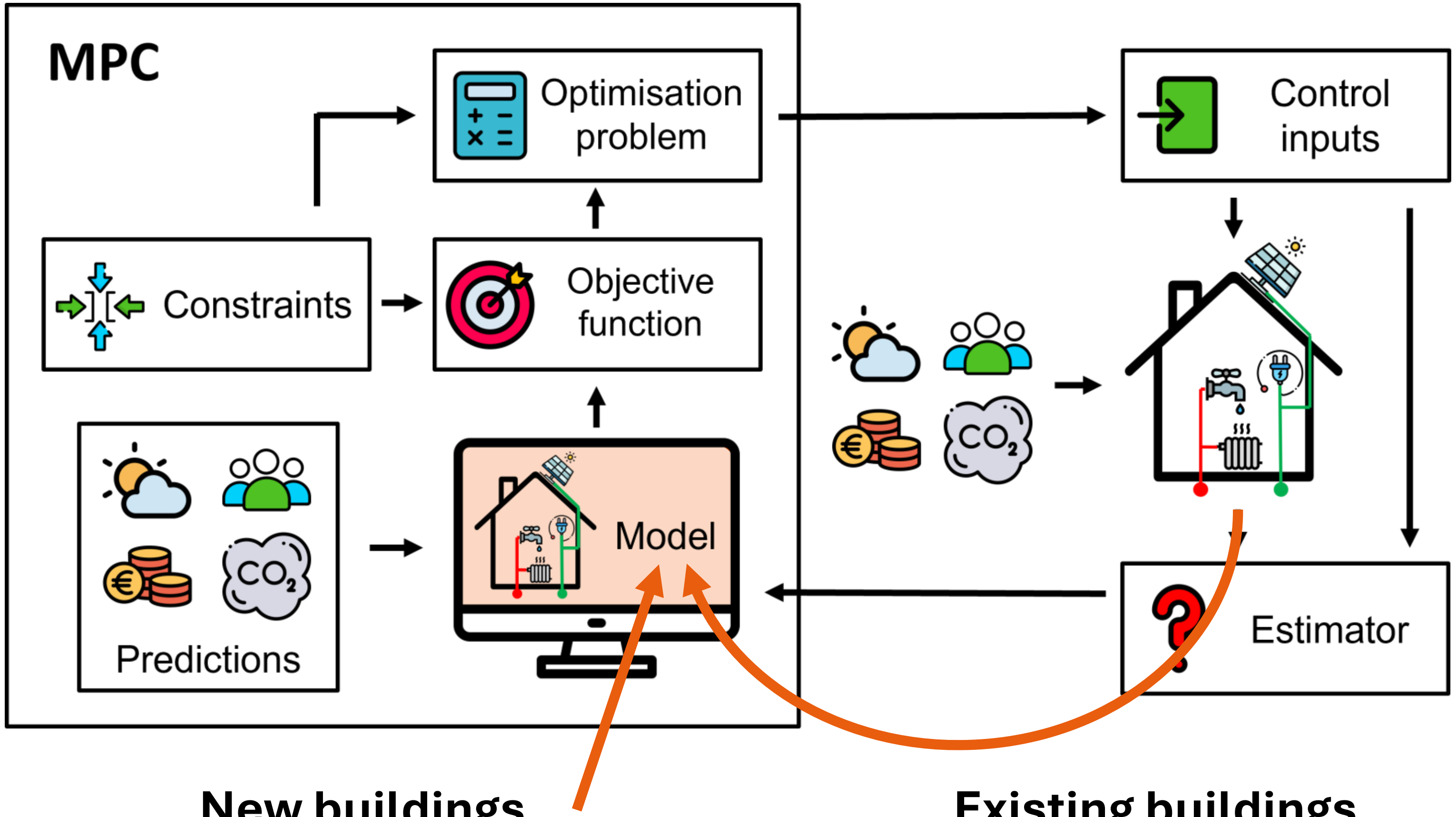
EBC Energy in Building and Communities Programme

IBSPA Project 1

IBSPA Modelica Working Group

→ International collaboration and peer review

Data-enriched physics-based models



New buildings
Automated model generation
Data are known

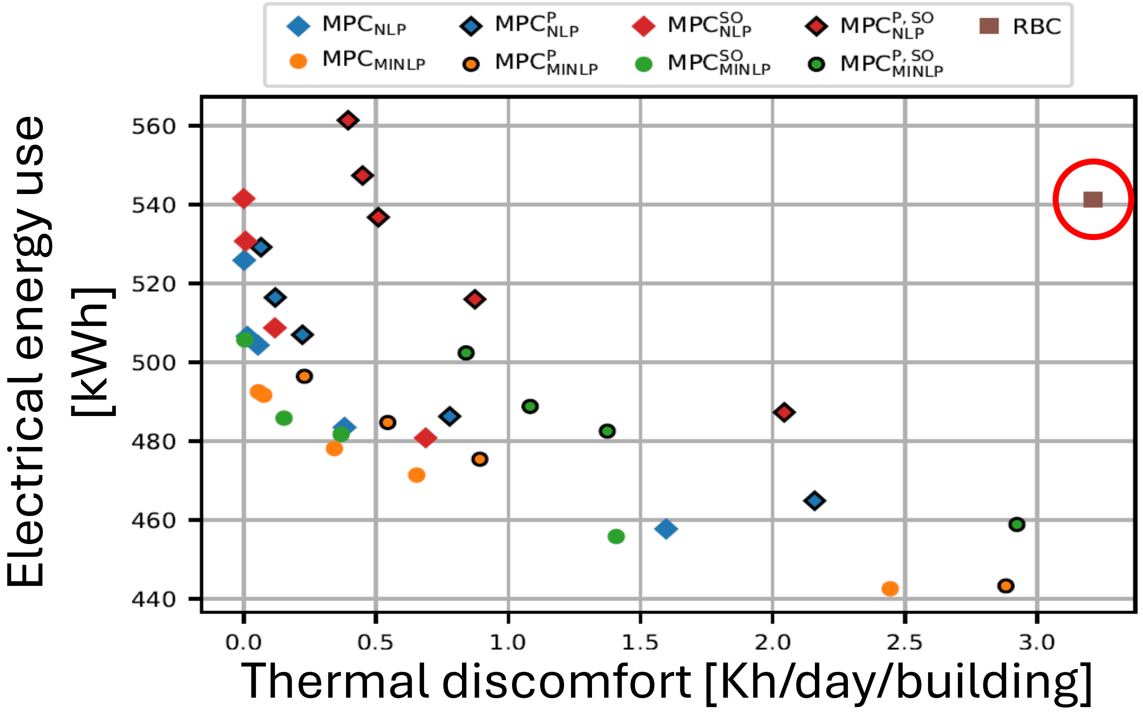
Existing buildings
Measured data for calibration

cf. keynote Prof. L. Helsen

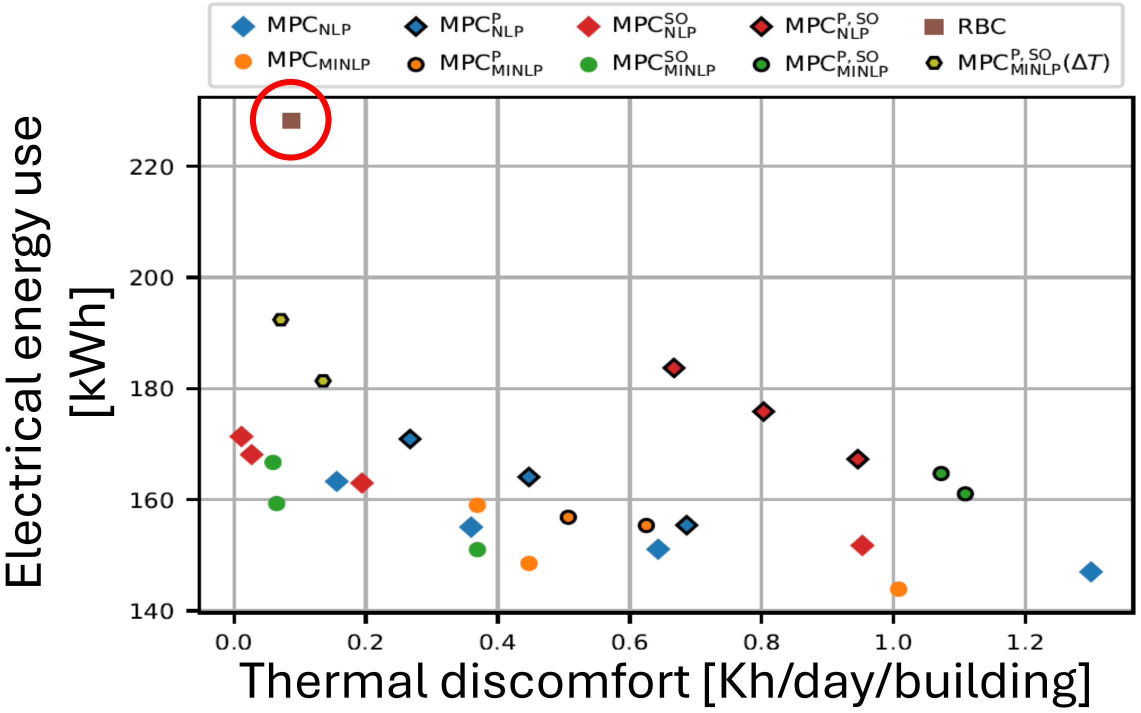
MPC as physics-based intelligence

All MPC formulations outperform **RBC**

<u>Variations</u>: NLP vs. MINLP, prediction uncertainties, state estimator



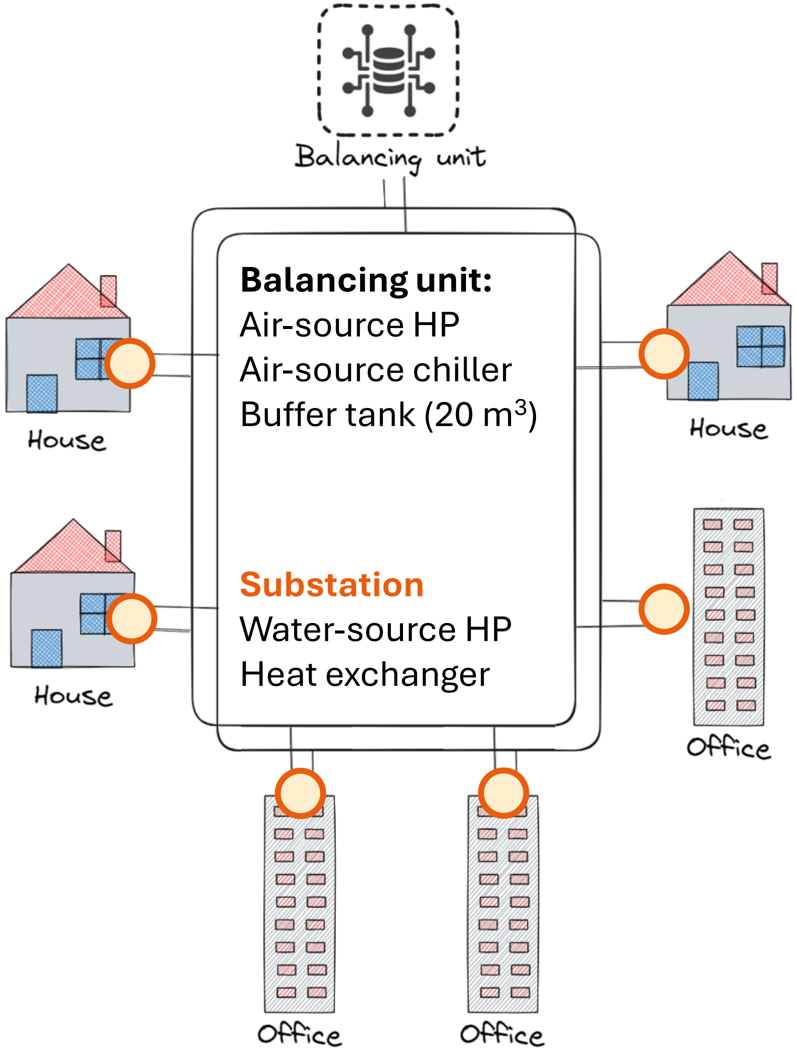
Winter



Spring

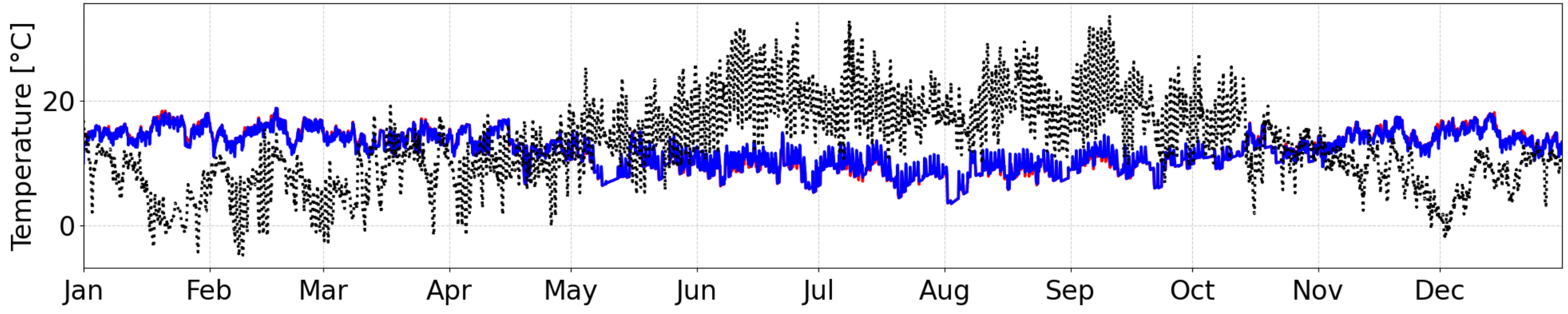
cf. keynote Prof. L. Helsen

MPC as system integrator – 5GDHC



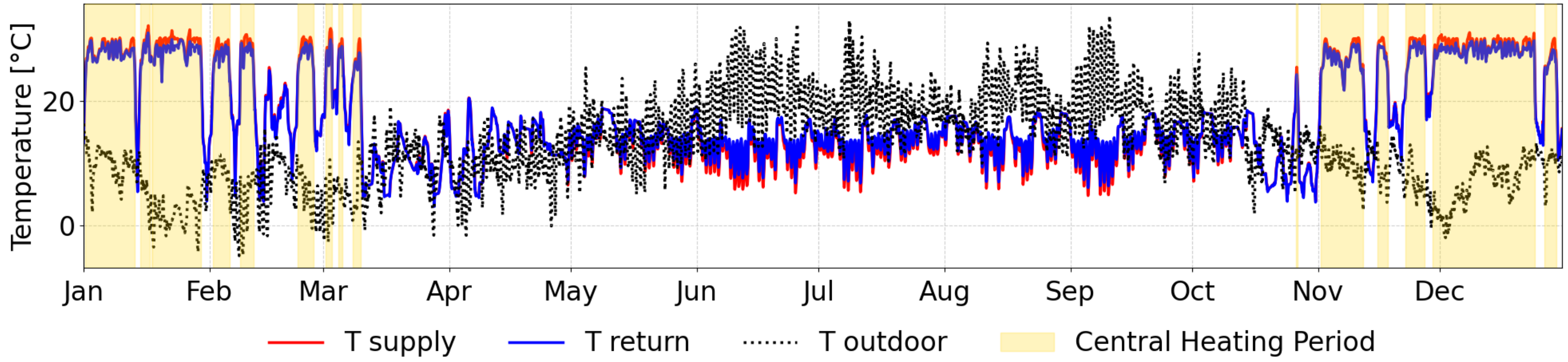
RBC

Total energy use: 29.7 MWh/year – Discomfort: 6337 Kh/year



MPC

Total energy use: 16.1 MWh/year – Discomfort: 652 Kh/year



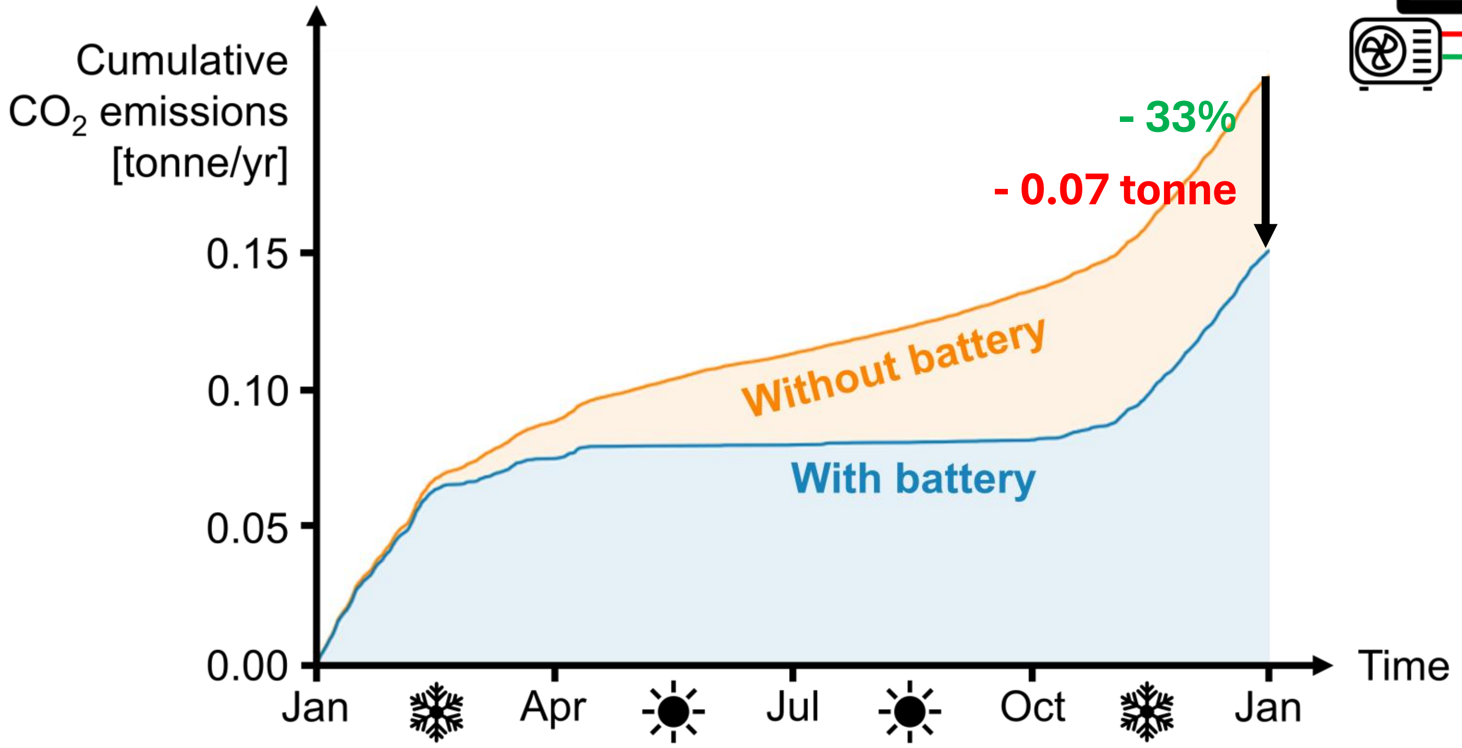
A complex system needs an advanced controller

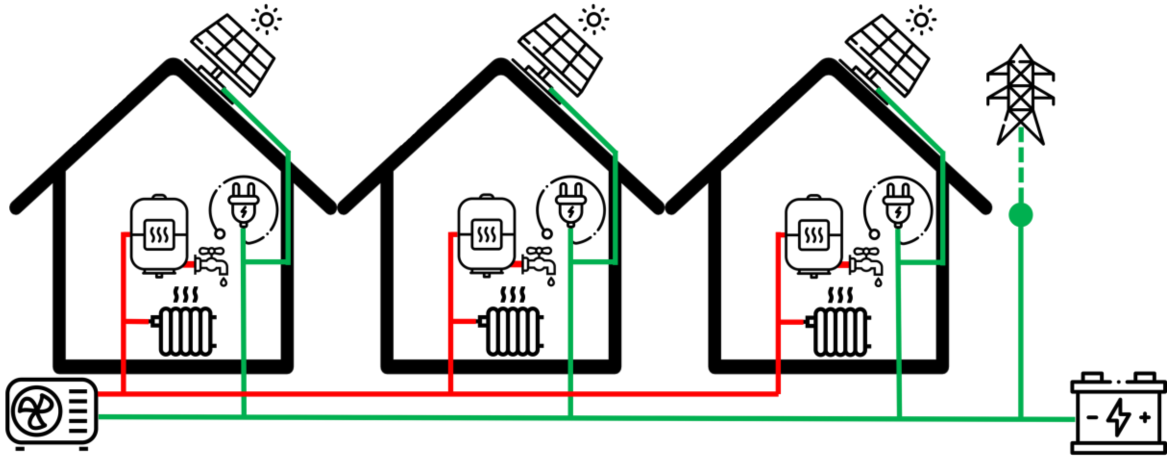
cf. keynote Prof. L. Helsen

MPC as system integrator – Multi-vector

CO_2 emission reduction cost

Battery energy storage:	> 5000 EUR/tonne CO_2
Electrifying heating:	~ 200 EUR/tonne CO_2
EU ETS2:	~ 50 EUR/tonne CO_2





Importance of dynamic models

Inherent thermal system flexibility

170 kWh/K

Electrical flexibility (battery)

14 – 38 kWh

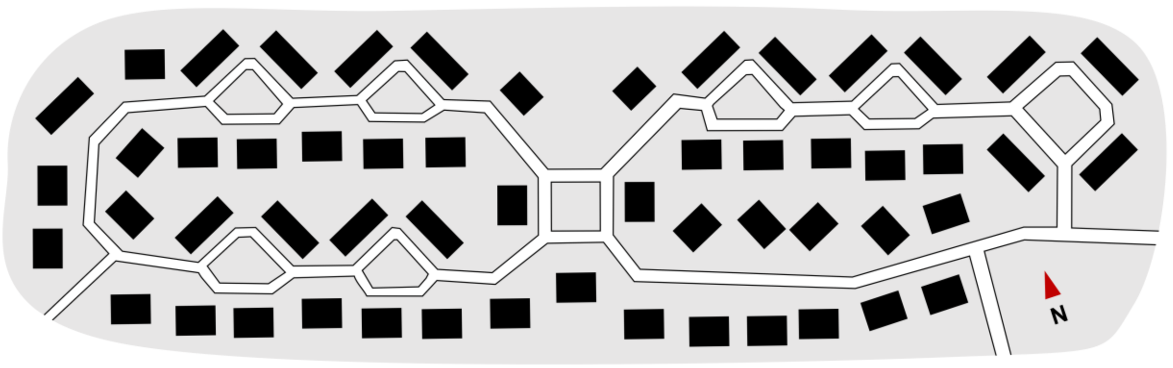
Used flexibility (excl. battery)

Electricity saving: 3 MWh

Thermal flexibility: 2 MWh

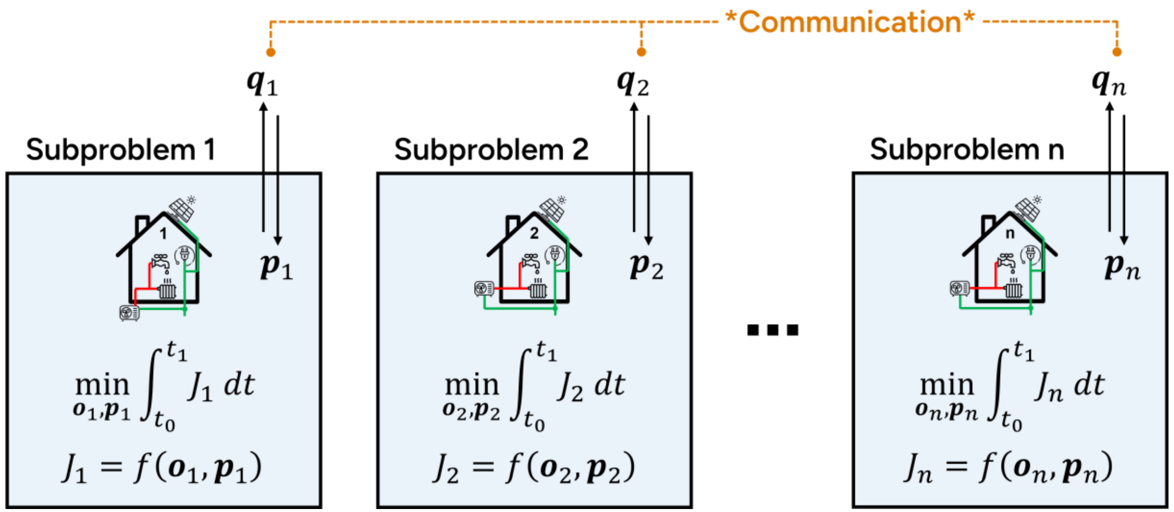
Distributed MPC enabling scalability

Neighbourhood of 120 houses
with a district heating network



22 000	States
1.9 million	Differential-algebraic equations
361	Optimisation variables
360	Communication variables
35 040	Control intervals *1 year @ 15-min. intervals*

Cooperative, parallel, sensitivity-based distributed optimisation



23 hours → Feasible for real-time MPC with 15-min. control intervals

Next-generation renewable heating and cooling systems

= Affordable, sustainable, and resilient heating and cooling

Minimising ~~operational costs~~

Total life cycle cost

Minimising ~~climate impact~~

Total environmental impact

Maximising synergies and inherent system flexibility

powered by

Model Predictive Control (MPC)

Integrated optimal control and design

cf. keynote Prof. L. Helsen

Power of physics-based MPC

Constrained optimisation down to the lowest level
Optimise what is finally controlled

Perfect system integrator for complex systems
Aiming at the global optimum

Data-enriched
Adaptive, fault detection, …

Automated workflow
Easy to use by non-experts, scalable

One model for multiple purposes
Design, control, commissioning, …

Future-proof
Enabler for an all-inclusive and sustainable energy transition

Acknowledgements

IBPSA Modelica Working Group

EBC
Energy in Building and Communities Programme

IBPSA Project 1

IBPSA Project 2

KU LEUVEN

vito

AGENTSCHAP INNOVEREN & ONDERNEMEN

TECHPED
Technically feasible positive energy districts

HeriTACE

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mintus
zorg met een plus

boydens engineering

SWECO

BUILTWINS
Sustainable Building Control

DAIKIN

CLIMADRILL

Fluves

MICROTHERM
THERMAL INSULATION SOLUTIONS

VIESSMANN

UNIVERSITEIT GENT

Renewable Heating & Cooling

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Thank you!

EUREC The Association of European Renewable Energy Research Centres

EGEC GEOTHERMAL

Solar Heat Europe

Euroheat & Power

ehpa

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Energy Ville

THERMAL SYSTEMS SIMULATION

KU LEUVEN

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Renewable Heating & Cooling

European Technology and Innovation Platform

Predictive Energy Management in Office Buildings - Harnessing Flexibility to Reduce Costs and Improve Efficiency and Comfort

Valentin Kaisermayer
(BEST – Bioenergy and Sustainable Technologies GmbH)

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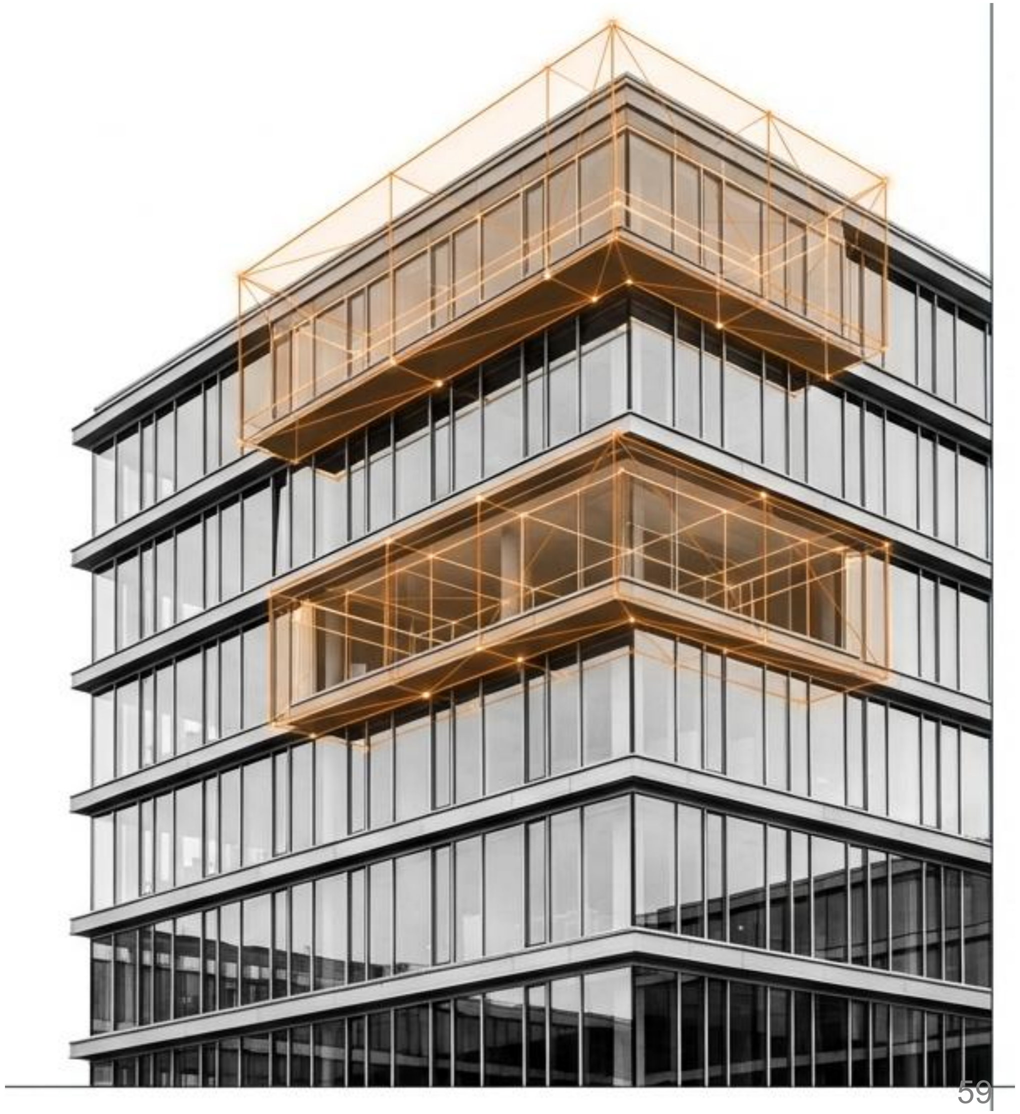
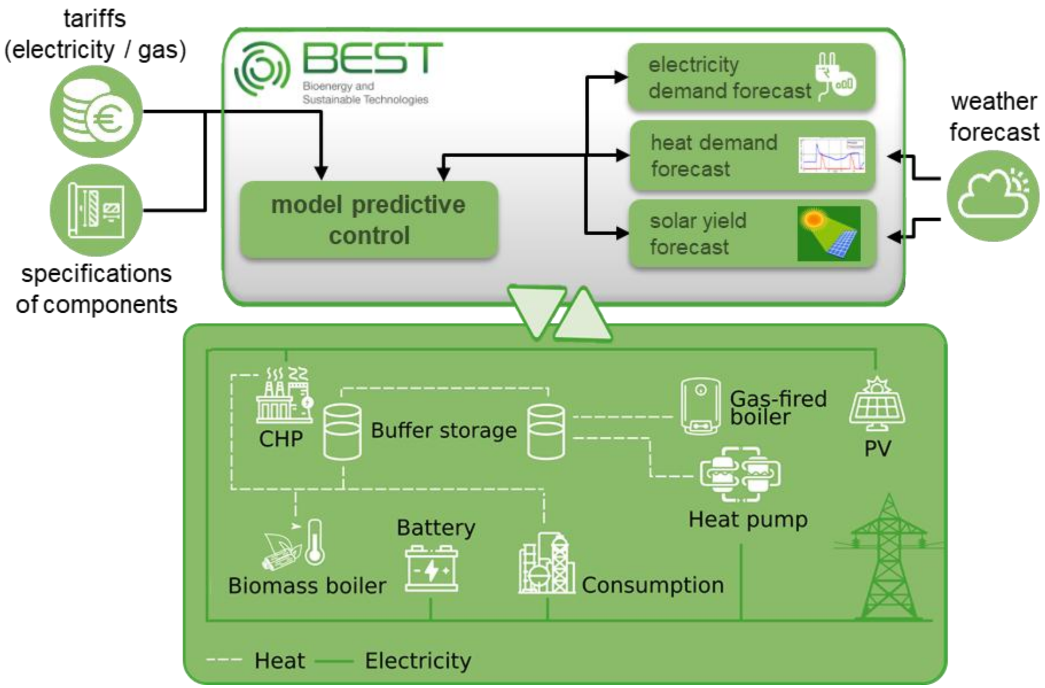
Introduction: The Challenge of Building Dynamics

- Buildings as **complex thermal systems** (long time constants, high thermal inertia, disturbances) → Real-time Model Predictive Control (**MPC**)
- The **Hidden State** problem: We measure air temperature, but the "energy" is stored in unmeasured walls/mass → **State Observers**
- Keep **modelling effort** low → Grey-box
- Need to **calibrate** models → machine learning



The Digitalization Engine: Modular MPC & AI

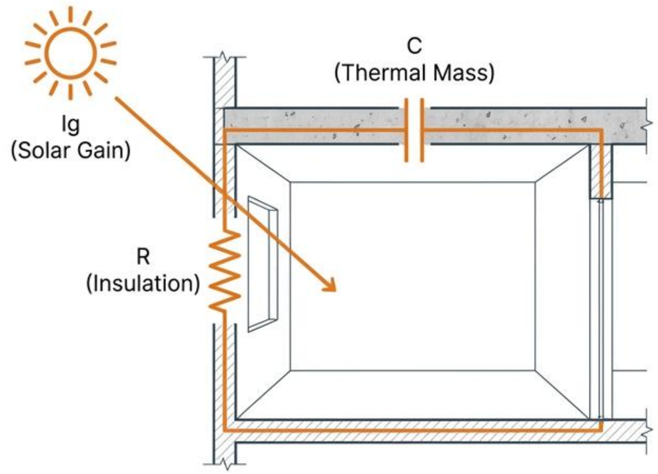


- Component view: Objective and equations/constraints
- Algorithms for state estimation, forecasting and model calibration

[1] Kaisermayer, V., et al. (2022). Smart control of interconnected district heating networks on the example of “100% Renewable District Heating Leibnitz.” Smart Energy, 6. https://doi.org/10.1016/j.segy.2022.100069
[2] Kaisermayer, V., et al. (2024). Predictive building energy management with user feedback in the loop. *Smart Energy*, 100164. https://doi.org/10.1016/J.SEGY.2024.100164

Estimate the Unmeasurable

- MPC needs **state information**
  - In the case of buildings temperatures of walls, air, ...
  - We might only measure the air temperature
  - Or even worse, only the return temperature
- A Kalman filter (KF) as **observer for hidden states** (wall and floor temperature)



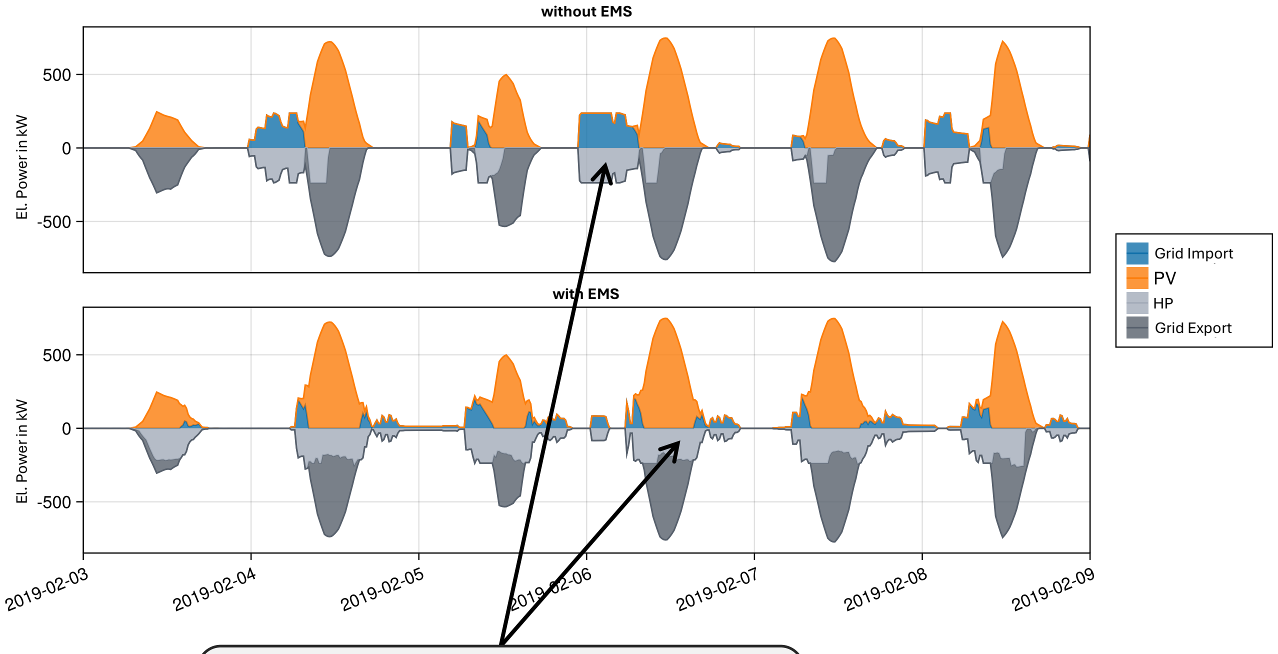
- Grey-box models need to be **parameterized**
- Physics informed neural net. (PINN) to estimate parameters
- Or formulation as a state-parameter problem for KF

Harnessing Flexibility for Renewable Integration

Flexibility comes from some form of **energy storage**

- TES, BESS or
- **Building's thermal mass** is a storage as well
  - High for concrete core activation (CCA)
  - Lower for buildings with floor heating
  - Other building types, such as cooling warehouses offer large flexibility as well

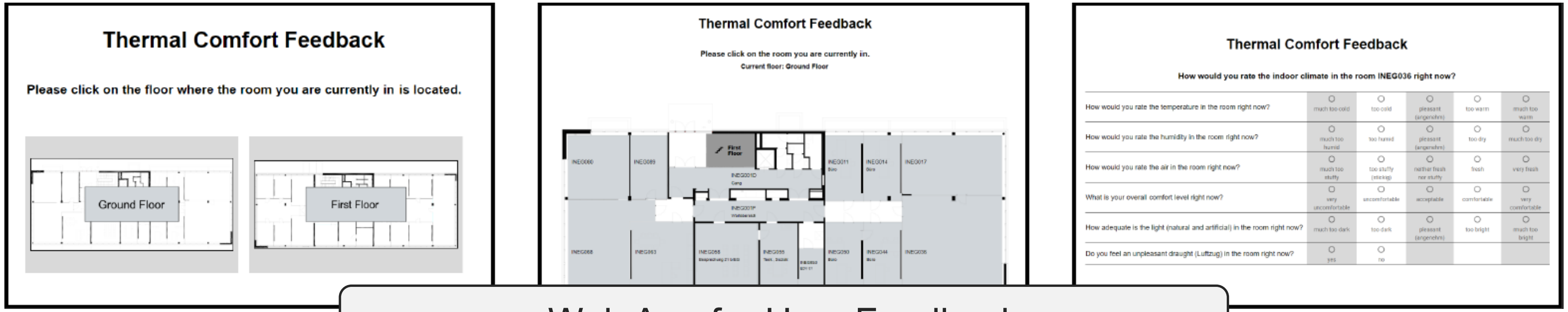
Simulation study



Shift HP operation to cheap hours. → same **comfort**!

The Human in the Loop: Occupancy Feedback as Virtual Sensors

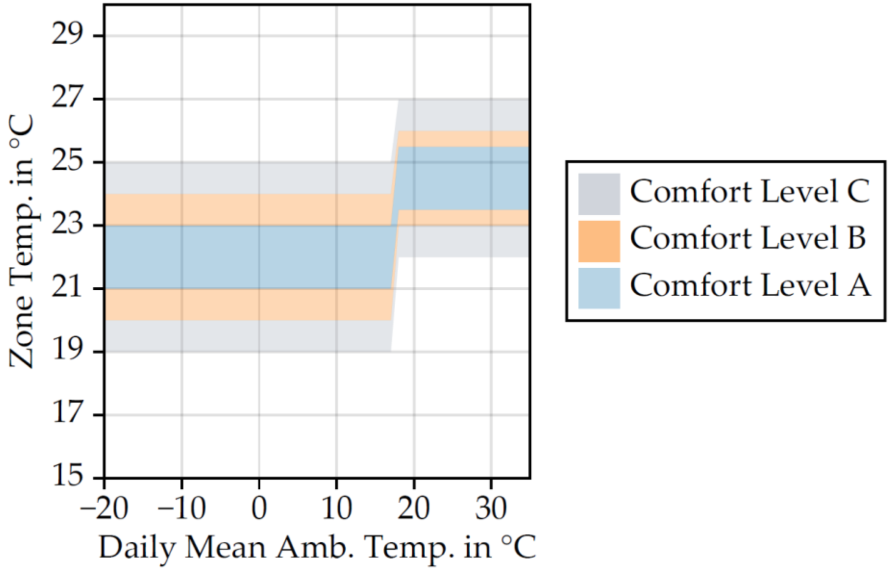
- Comfort is subjective, so static models fail. Need to bridge the gap between digital systems and human occupants.
- **Idea:** parameterize a comfort model to feedback of the users

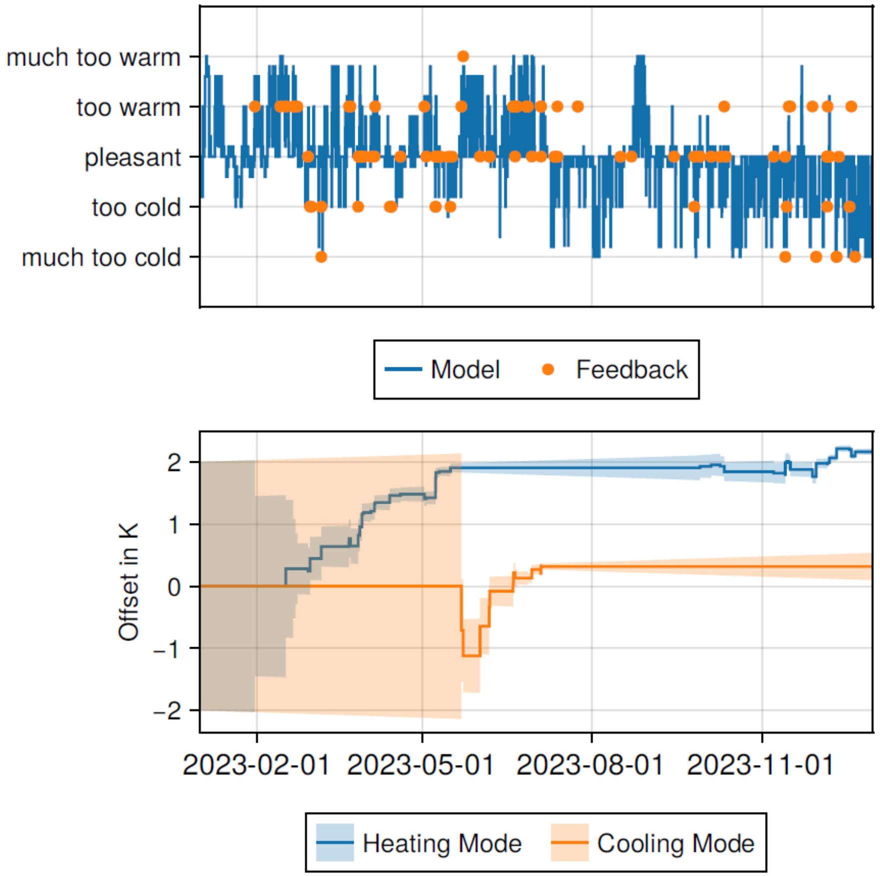


Web App for User Feedback

Occupancy Feedback as Measurement

- Each vote is a measurement
- Internal **comfort model** is updated using Kalman filter





Case Study: Office Building Inffeldgasse

Source: Google Earth

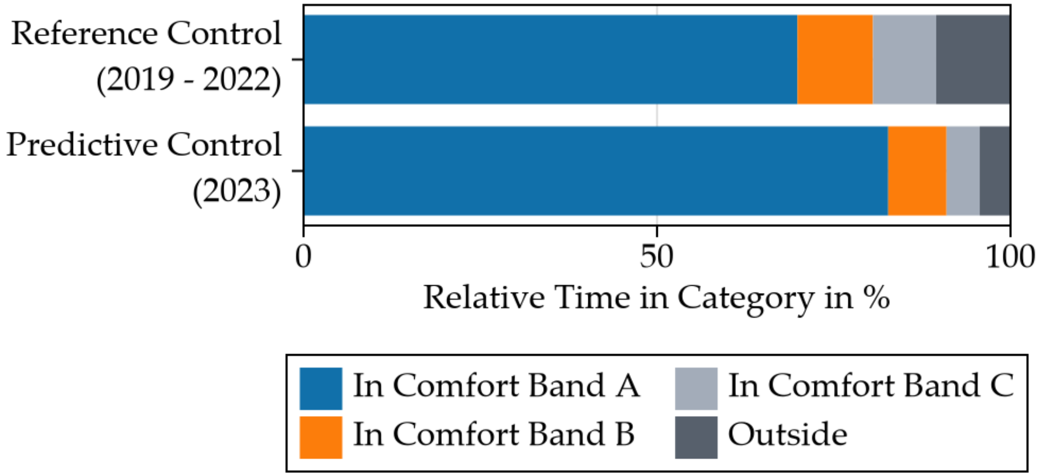
Facts

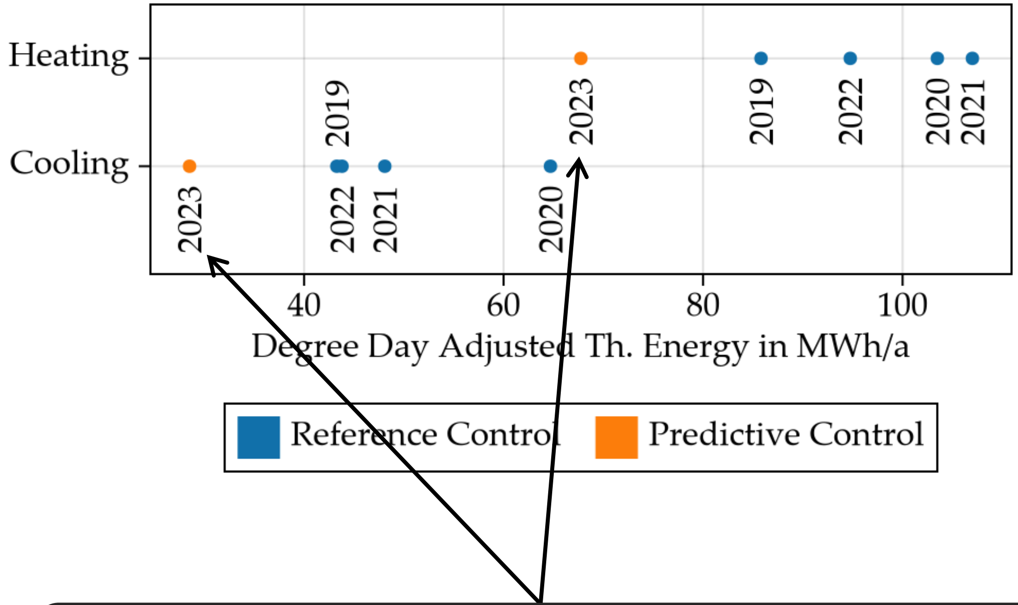
- **Location:** Graz University of Technology, Austria
- **Area:** 2,480 m^2 Office Space
- **System:** Concrete Core Activation (CCA)

2019-2020: Reference Period

2023: Predictive Period (MPC + User Feedback)

Result: Increased Comfort and Decarbonized Operations





Overall comfort improvement (all zones)
70 % → 82 % at comfort level A (blue)
11 % → 4% outside of comfort level C (grey)

Reduction by **21% to 37 %** for heating
34% to 56 % for cooling (depending on the year)

Kaisermayer, V., et al. (2024). Predictive building energy management with user feedback in the loop. *Smart Energy*, 100164. https://doi.org/10.1016/J.SEGY.2024.100164

Conclusion & Outlook

- Flexibility of buildings can be utilized while keeping the comfort
- Complex control problem → MPC
- Estimate hidden states and parameters → KF and PINN

Future:

- **Decomposition** of the MPC problem for large-scale cooperative control; multiple buildings → ongoing project
- **Reduce modeling effort:** Chose the right grey-box model from data via statistical tests

> ! Roadblock
> Digital methods need a high degree of **digitalization**.

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Thank you!

EUREC The Association of European Renewable Energy Research Centres

EGEC GEOTHERMAL

Solar Heat Europe

Euroheat & Power

ehpa

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‘Digital tools to optimise the design, operation and maintenance of hybrid solar thermal systems’

DigiSolar HEU project

Dimitris Papageorgiou (TVP Sola SA)

Funded by the European Union

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Hybrid Solar Systems

Hybrid Solar

- Solar Thermal (ST)
- Thermal Energy Storage (TES)
- High Temperature HP
- Waste Heat (WH) recovery
- Absorption chiller
- Solar PV

Reasons for going Hybrid Solar

- ✓ Achieving deeper decarbonization of heat – independence from fossil fuels
- ✓ Flexibility (integration with TES)
- ✓ Serving applications at higher temperatures (HP integration)

Renewable Heating & Cooling
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DIGISOLAR

Digital Tools in ST & Hybrid Solar

Motivation – Expectations

- Design tools for non-experts
- Modelling engine for experts
- Minimise system down-time and optimal maintenance
- Optimisation of ST temperature setpoint
- Optimal operation at hybrid system level
- Automated environmental assessment

Innovations

- ✓ Digital Twin
- ✓ Model Predictive Control (MPC)
  - Physics-based
  - AI-driven
- ✓ Forecasting & operational optimisation
- ✓ Energy management at hybrid system level

TVP SOLAR

Digital Tools in ST & Hybrid Solar

Today at TVP Solar → DigiSolar vision

Today at TVP Solar

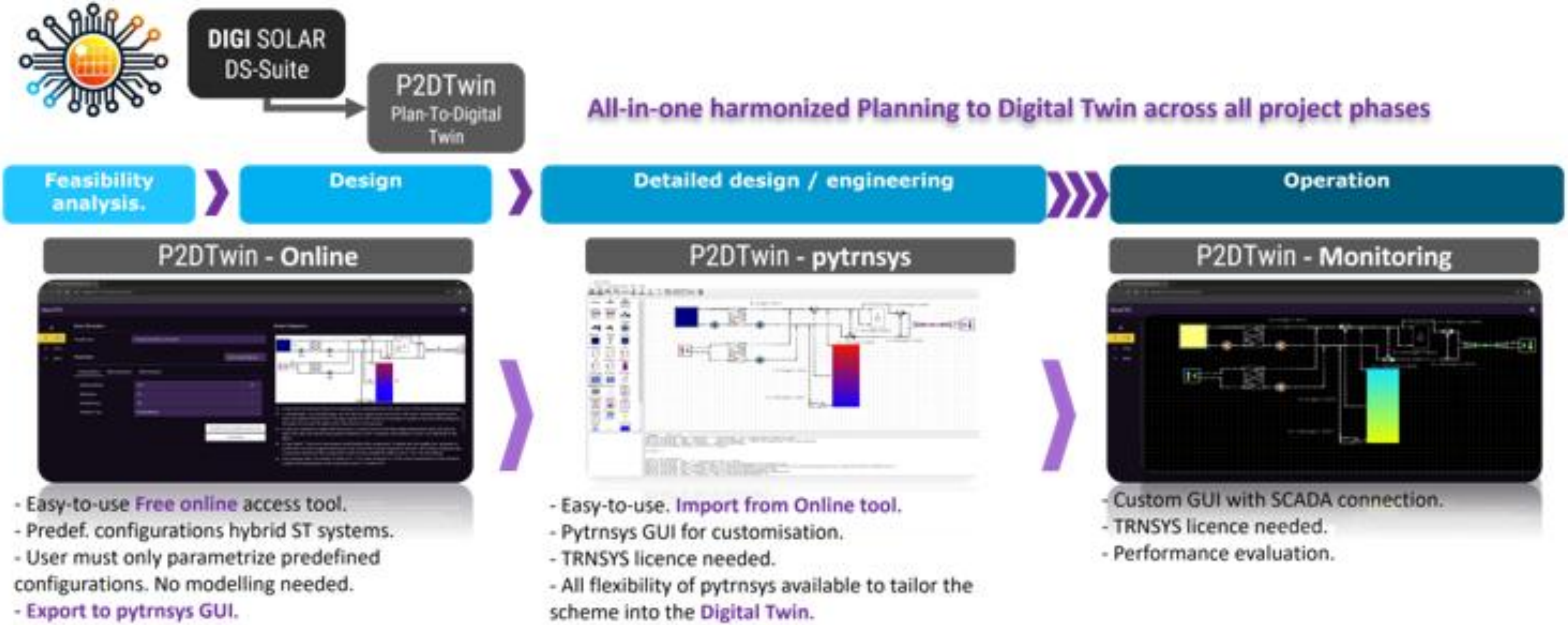
- **Design ST system**:
  - xls-based simplified energy & economic calculations
  - Energetic simulations (Polysun, Trnsys, etc.)
  - Engineer design: 3D & drawings (AutoCAD, etc.); hydraulic sizing (Hecos); Scada system
- **Operation ST system**:
  - Real-time monitoring & control (rule-based; PLC-Scada)
  - Performance assessment (ISO 24194)
  - Data-analysis, dashboards & decision support (Grafana)

DigiSolar vision

- **Design: ST & hybrid system**
  - Digital Twin: Planning to Operation
- Operation: ST & hydrid system
  - Performance verification (SunPeek)
  - Fault Detection & Diagnostics
  - Forecasting solar heat generation (weather forecasting)
  - Energy management (hybrid system)
  - LCA / LCC and CO_2 emissions avoidance

Digital Twin at system level

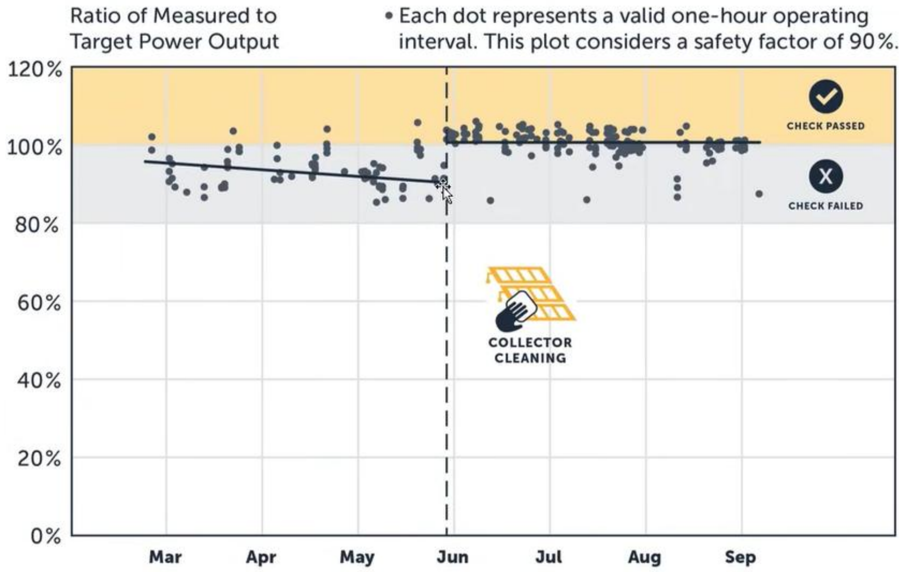
- Applicable across all project phases
- Using the same computational engine



FDD: Fault Detection & Diagnosis

Digital Twin:

- ❖ Runs simulations continuously
- ❖ Exchanges data with the real system that it's mirroring
- ❖ Assesses deviations, transmitting info to the FDD



FDD:

- ❖ Labels a deviation as fault or not
- ❖ Provides corrective guidance

Possible faults:

- ❖ Sensor faults,
- ❖ Pump failure,
- ❖ HX fouling
- ❖ Collector degradation,
- ❖ TES destratification
- ❖ Leakages,
- ❖ Flow balances,
- ❖ Shading,
- ❖ Soiling
- ❖ Supply temperatures anomalies,
- ❖ HTF degradation

Four Demonstration Cases (1/2)

❖ Case 1: Paper mill, Izmir, Turkey

- SOLITERM: Parabolic Through Collector (PTC)
- 4500 m2 (500 units) – 3 MWth; Hot water 170-180ºC
- TES: pressurised hot water 8m3 + 5m3
- Summer mode: absorption chiller 3.5MW; 80 % solar share
- Winter mode: 60 % heating requirements

❖ Case 2: DH in Racconigi, Italy

- DHN operator: ENGIE
- TVP Solar High Vacuum Flat Panels (HVFPs)
- 1030 m2 HVFP; 0.7 MWth; 920 MWh/year; 893 kWh/m2; Hot water 75ºC
- TES: Hot water 600m3
- HP: 147 kW
- CHP unit: 1.56MWe + 1.55MWth

Renewable Heating & Cooling
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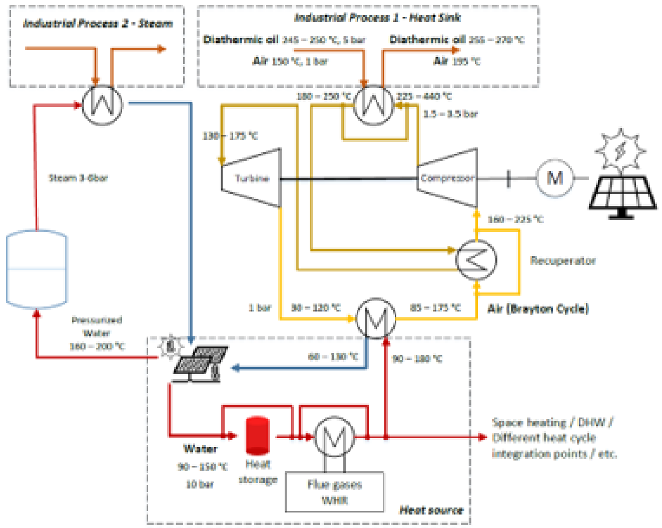
Four Demonstration Cases (2/2)

❖ Case 3: DH in Rappenau, Germany

- Flat plate collector: 28872 m2; 20 MWth
- Solar system operated by SOLENG: 12.8 GWh/year; 443 kWh/m2: Hot water 75 ºC
- TES: hot water 8’000 m³
- Biomass boiler: 16 MWth
- Biogas generation: 390 kWth
- CHP: 1.1 MWe
- PV: 650 kWp

❖ Case 4: Paper mill, Greece

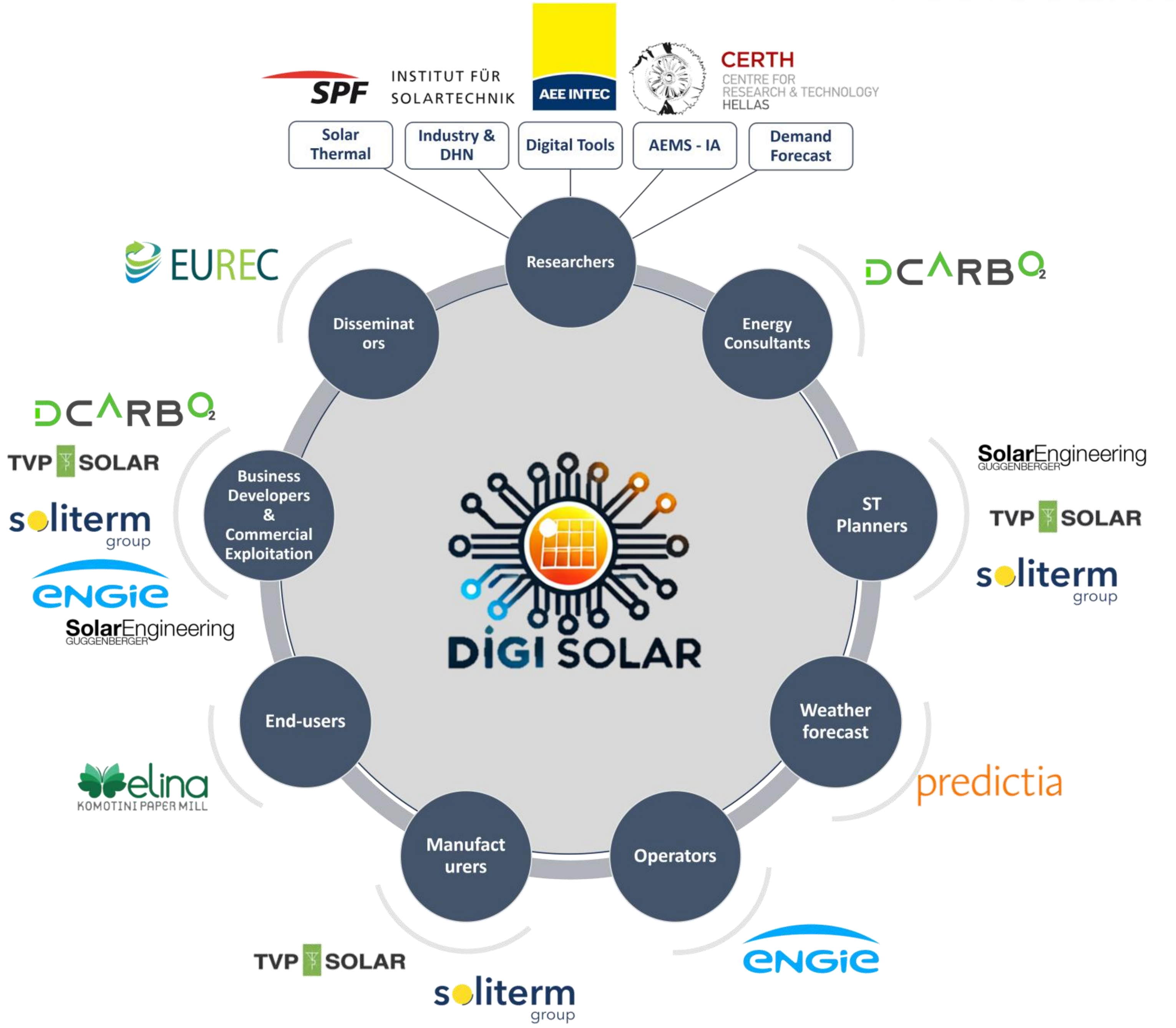
- TVP Solar High Vacuum Flat Panels (HVFPs)
- 700m2 HVFP; 0.4 MWth; 302 MWh/year; 604 kWh/m2; Hot water 160ºC
- TES: Pressurised hot water 15m3; 150C
- Biomass steam boiler: 7.6 MWth
- HP: 390 kW; Air Brayton cycle; 195 ºC
- PV: 100 kW



TVP SOLAR

DigiSolar: General data

- Budget: 5.7 M€
  - EU funding 2.9 M€
  - Swiss funding 2.0 M€
- Start 09.2025; End: 08.2029
- 11 partners, 7 countries
- https://digisolar-project.eu/



Operational data from ST fields

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DIGISOLAR

Stadtwerke Sondershausen, DE

TVP SOLAR SA
4,969 followers
3w • Edited •

🔥 Heat-for-Heat DH – EU Episode 1/4: 🇩🇪 Stadtwerke Sondershausen

📊 TVP SOLAR SA District Heat Project Report (2025)
Measuring the real impact of replacing natural gas with solar thermal

Here is TVP's measured 2025 performance at Stadtwerke Sondershausen:

• Energy delivered: 3,552 MWh/year
(584 kWh/m²/year) at >80°C

• Thermal efficiency:
47% yearly average (GHI: 1,250 kWh/m²/year)
69.7% peak

• System uptime: 99%

• ISO 24194 compliance: ≥1

➡️ Heat delivery is measured directly by the client at their heat exchanger.

🌱 Impact:
• Natural gas saved: 435,748 m³/year
• CO_2 avoided: 867 tons/year

SIG SDH, Geneva, CH

ENGIE SDH, IT

Published in Zenodo

Compagnie de Chauffage, FR

TVP SOLAR SA
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1w •

🔥Heat-for-Heat DH - EU Episode 4/4: 🇫🇷 Compagnie de Chauffage

📊 TVP SOLAR SA District Heat Project Report (2025)
Measuring the real impact of replacing natural gas with solar thermal

Here is TVP's 2025 measured performance CCIAG in Grenoble:
• Energy Delivered: 127 MWh/y (738 kWh/m²/y) at >74°C

• Thermal Efficiency: 54% yearly average (GHI: 1,362 kWh/m²/y); 72% peak

• System Uptime: 99%

• ISO 24194 Compliance: ≥1

➡️ Heat delivery is measured directly by the client,

🌱 Impact:
• Natural Gas Saved: 15,580 m³/y (150 MWh)

• CO2 Avoided: 31 ton/y

TVP SOLAR

TAKE OUR SURVEY

Are you involved in **industrial heating, district heating, or energy services**?
We are developing innovative digital tools to optimize hybrid solar thermal systems and we want your insights.
Your experience will help us design solutions that truly meet the needs of those who provide or sell, heat and heating installations. **Scan the QR code below** to take the survey (participating takes just 2 minutes of your time).

Follow us on
digisolar-project.eu

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RHC Renewable Heating & Cooling

European Technology and Innovation Platform

Thank you!

EUREC The Association of European Renewable Energy Research Centres

EGEC GEOTHERMAL

Solar Heat Europe

Euroheat & Power

ehpa

WIP RENEWABLE ENERGIES

papageorgiou@tvpsolar.com

TVP SOLAR

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Renewable Heating & Cooling
European Technology and Innovation Platform

ISEC 4th International Sustainable Energy Conference 2026
14 – 16 April 2026 | Messecongress Graz, Austria

100% RHC Event

16 April 2026
11.00 > 12.30

#100RHC
Messecongress Graz (Austria)

From Insights to Action: Digitalisation and AI as Enablers for RHC Technologies

Leonie Kuhlmann
RHC-ETIP Secretariat

Valentin Kaisermayer
BEST

Ralf-Roman Schmidt
Austrian Institute of Technology

Edmund Widl
Austrian Institute of Technology

Dimitrios Papageorgiou
TVP Solar

Lieve Helsen
KU Leuven

Lucas Verleyen
KU Leuven

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European Technology and Innovation Platform

Mentimeter

Menti
New survey

What is currently the main barrier to deploying digital and AI-based solutions in RHC?

Responses can be up to 200 characters and will appear here.

You can group responses if you get more than 10.

Turn on voting so people can flag their favorite responses.

menti.com
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0 of 1 responded

Select which slide to add

Renewable Heating & Cooling
European Technology and Innovation Platform

Mentimeter

Which R&I areas should be prioritised at EU level for digitalisation and AI in RHC over the next 5 years?

Responses can be up to 200 characters and will appear here.

You can group responses if you get more than 10.

Turn on voting so people can flag their favorite responses.

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Waiting for participants

AM

Menti
New survey

Select which slide to add

Your familiarity with RHC-ETIP?

0% 0% 0% 0%

What is currently the main barrier to deploying digital and AI-based solutions in RHC?

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European Technology and Innovation Platform

Mentimeter

What important topic related to digitalisation and AI for RHC is currently under-represented in EU R&I agendas?

Responses can be up to 200 characters and will appear here.

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