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Transformation of the Building Sector – Technologies and Measures —

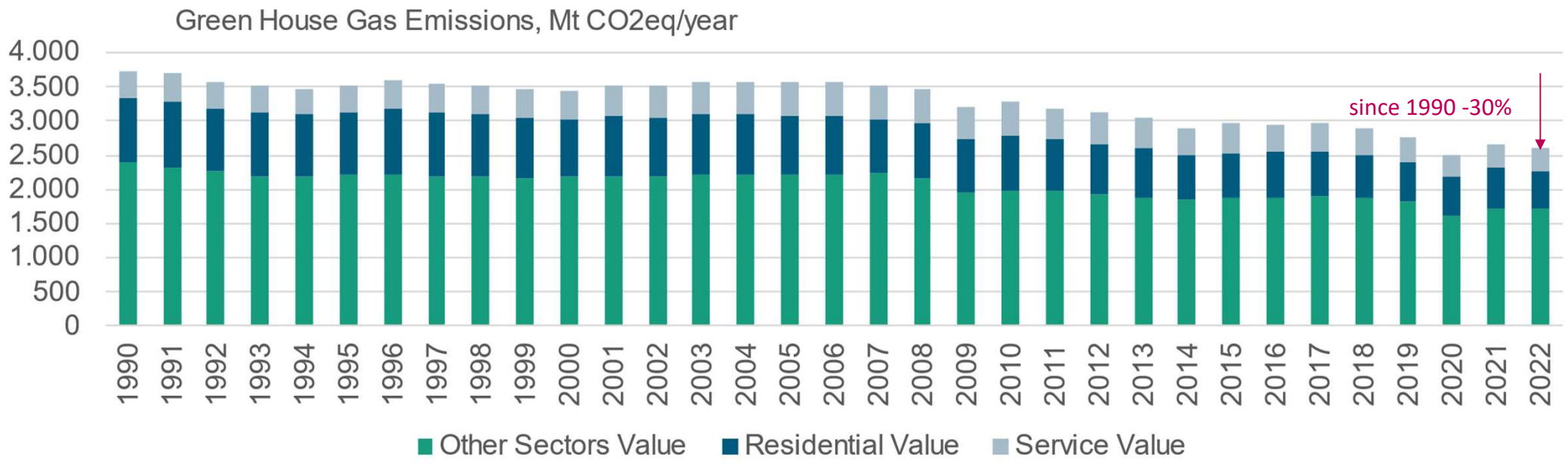
Sebastian Herkel

43rd Conference of Rectors and Presidents of European Universities of Technology - crp2025

Wroclaw University of Science and Technology
Poland, 19th September 2025

Where are We?

Some Figures on the European Building Stock - Green House Gas Emissions, Scope 1 and 2



Data Source: https://building-stock-observatory.energy.ec.europa.eu/database/

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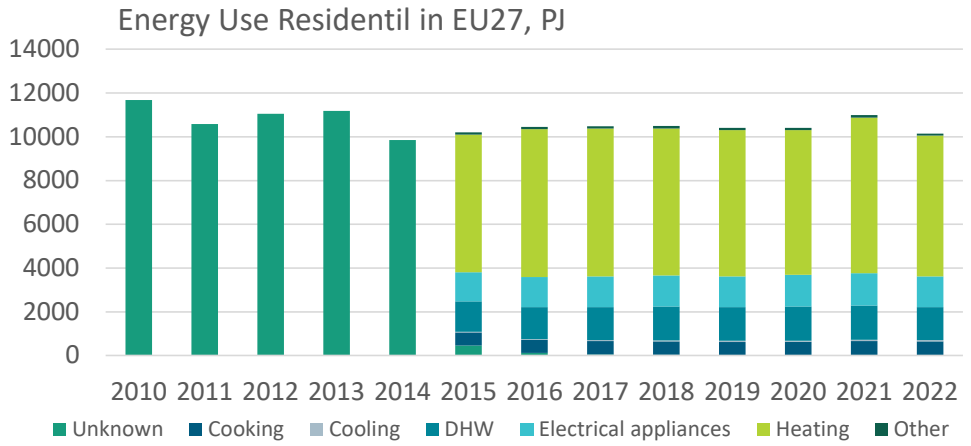
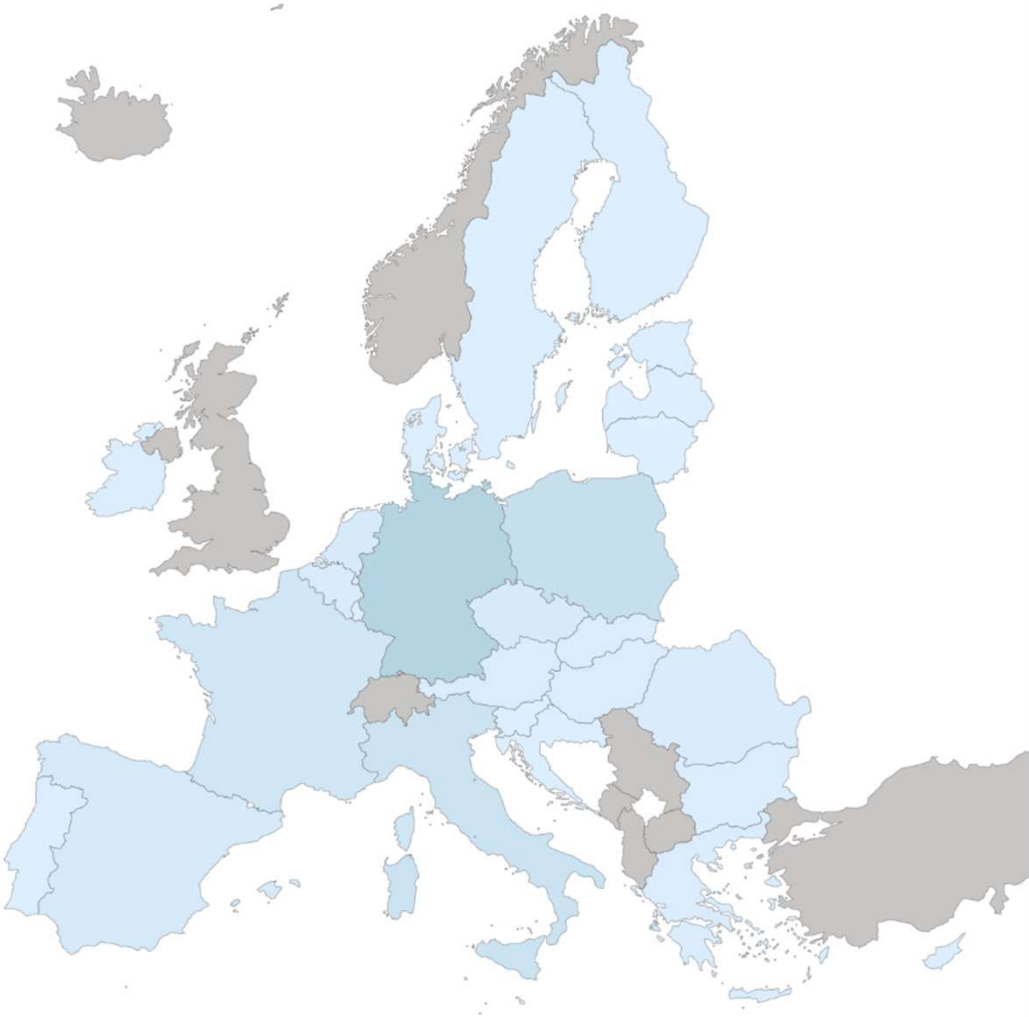
Where are We?

End Energy Use in Residential Buildings





3 Data Source: https://building-stock-observatory.energy.ec.europa.eu/database/

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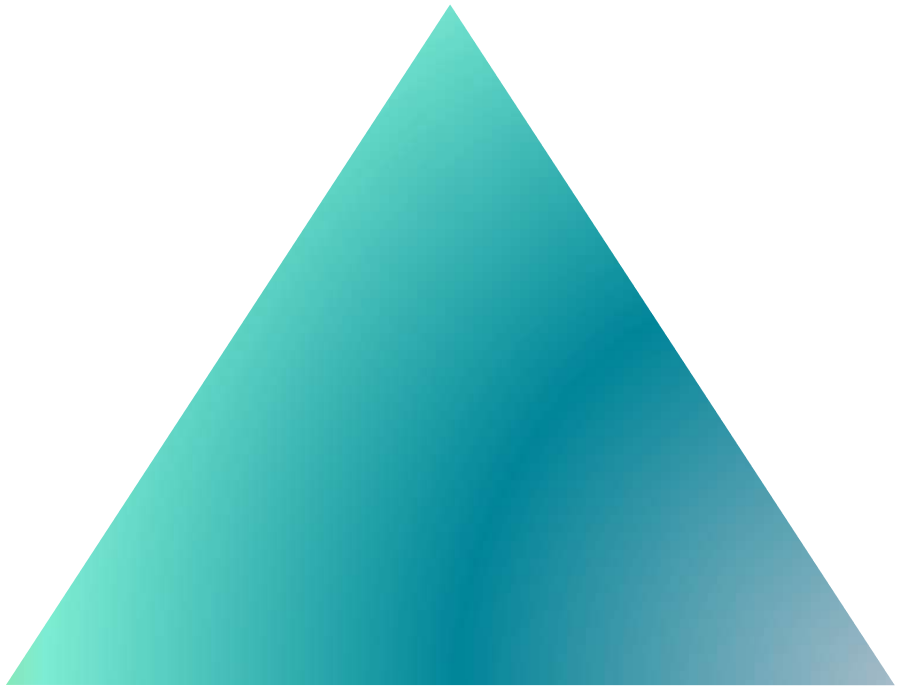
Goals for Climate neutral Building Stock

Aspects of Strategy Development

Reduction of GHG Emissions



Afordability
Acceptance
Energy Poverty
Unhealthy Conditions

Security
Availability
Independency
Infrastructure

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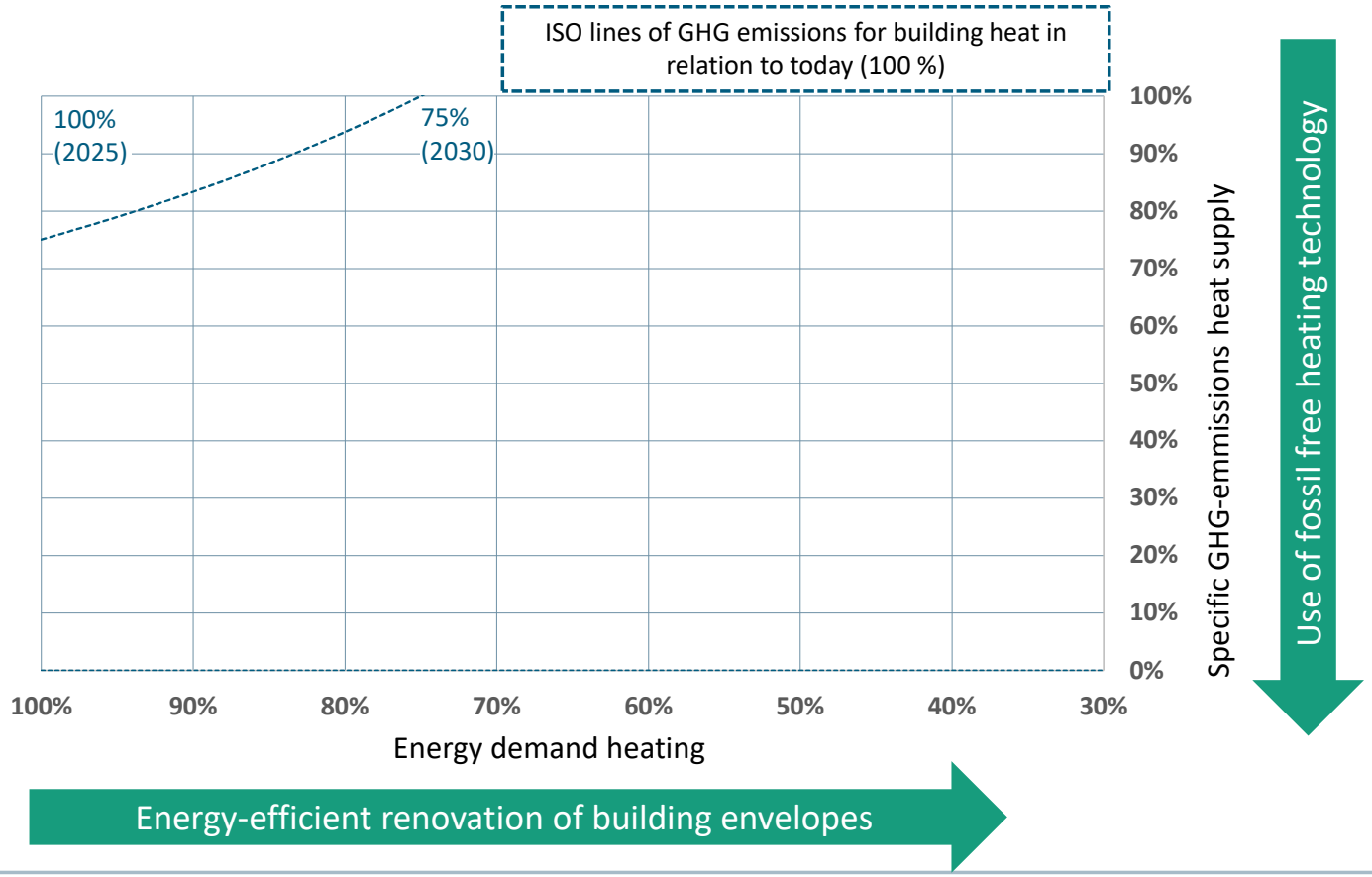
Solutions for a climate-neutral building sector

Target paths to climate neutrality (space heating and hot water)



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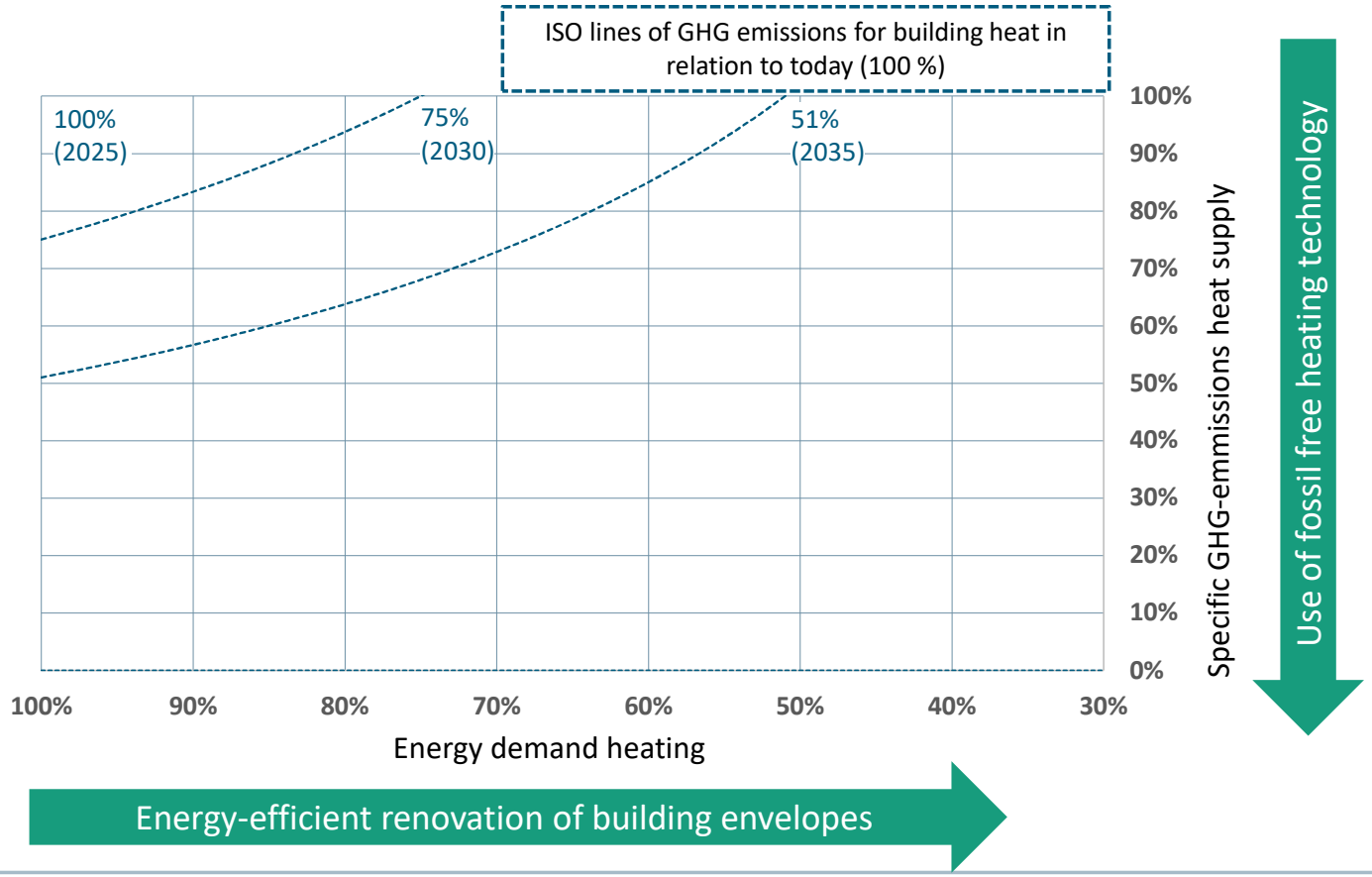

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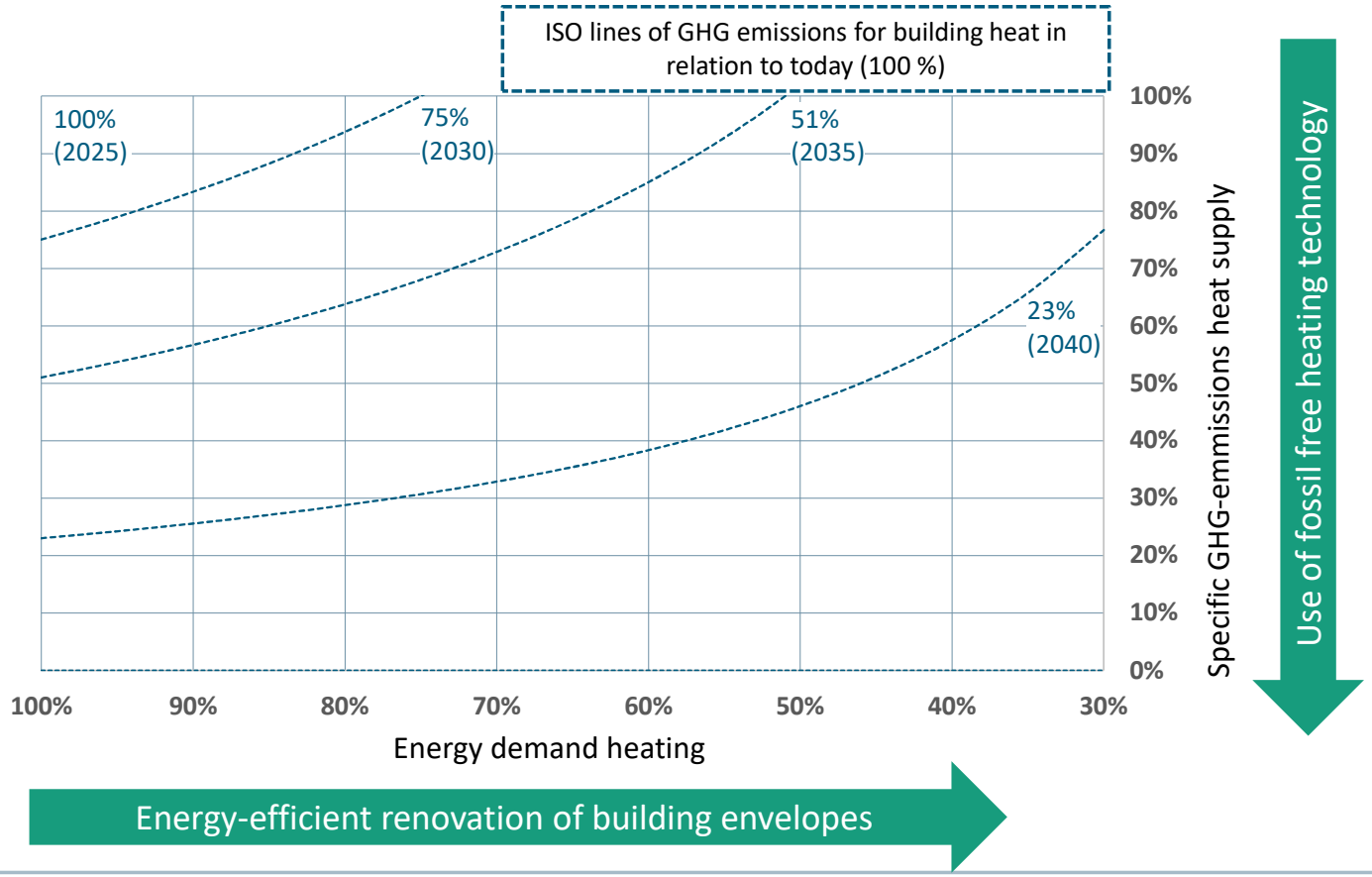

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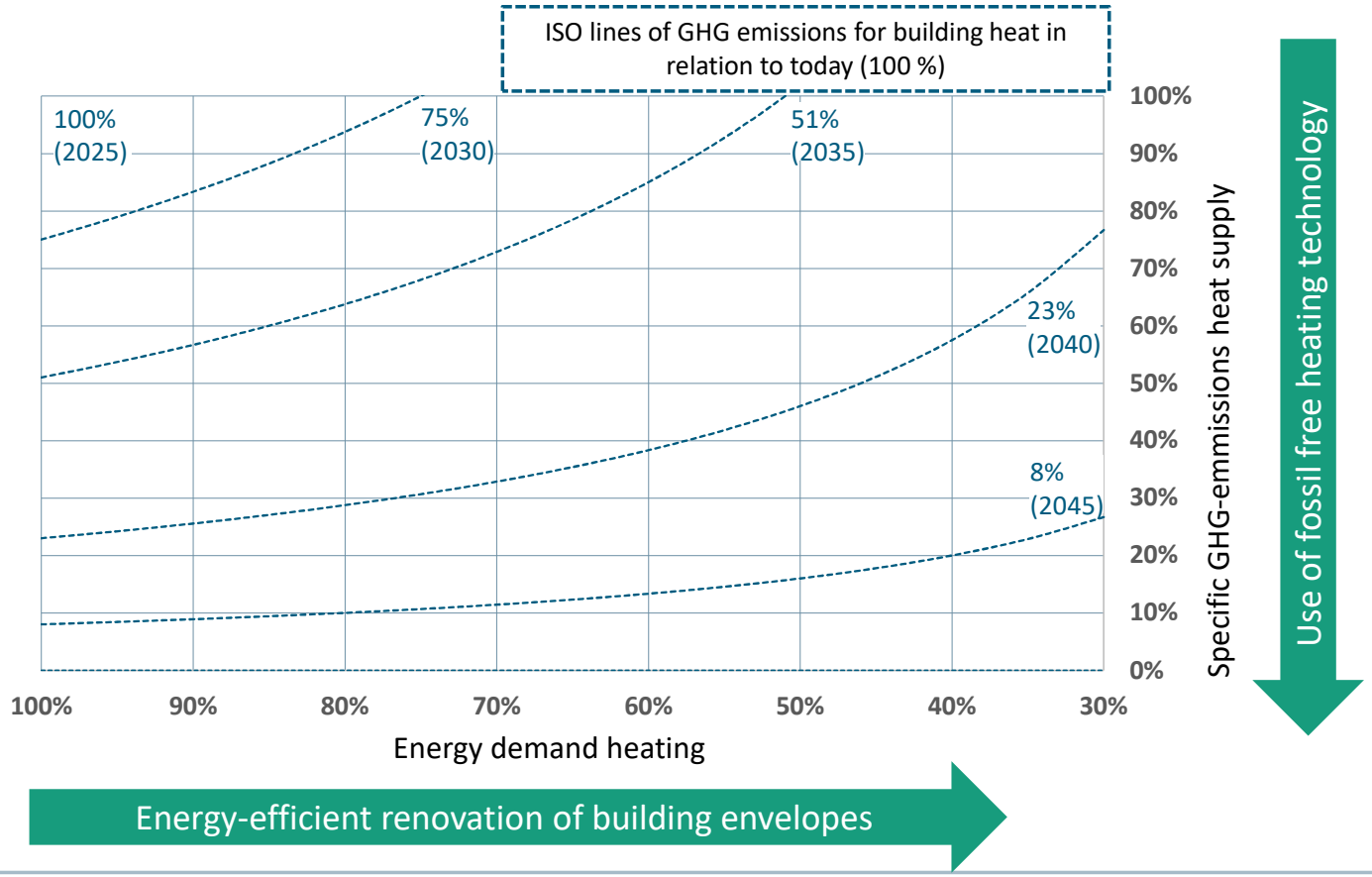

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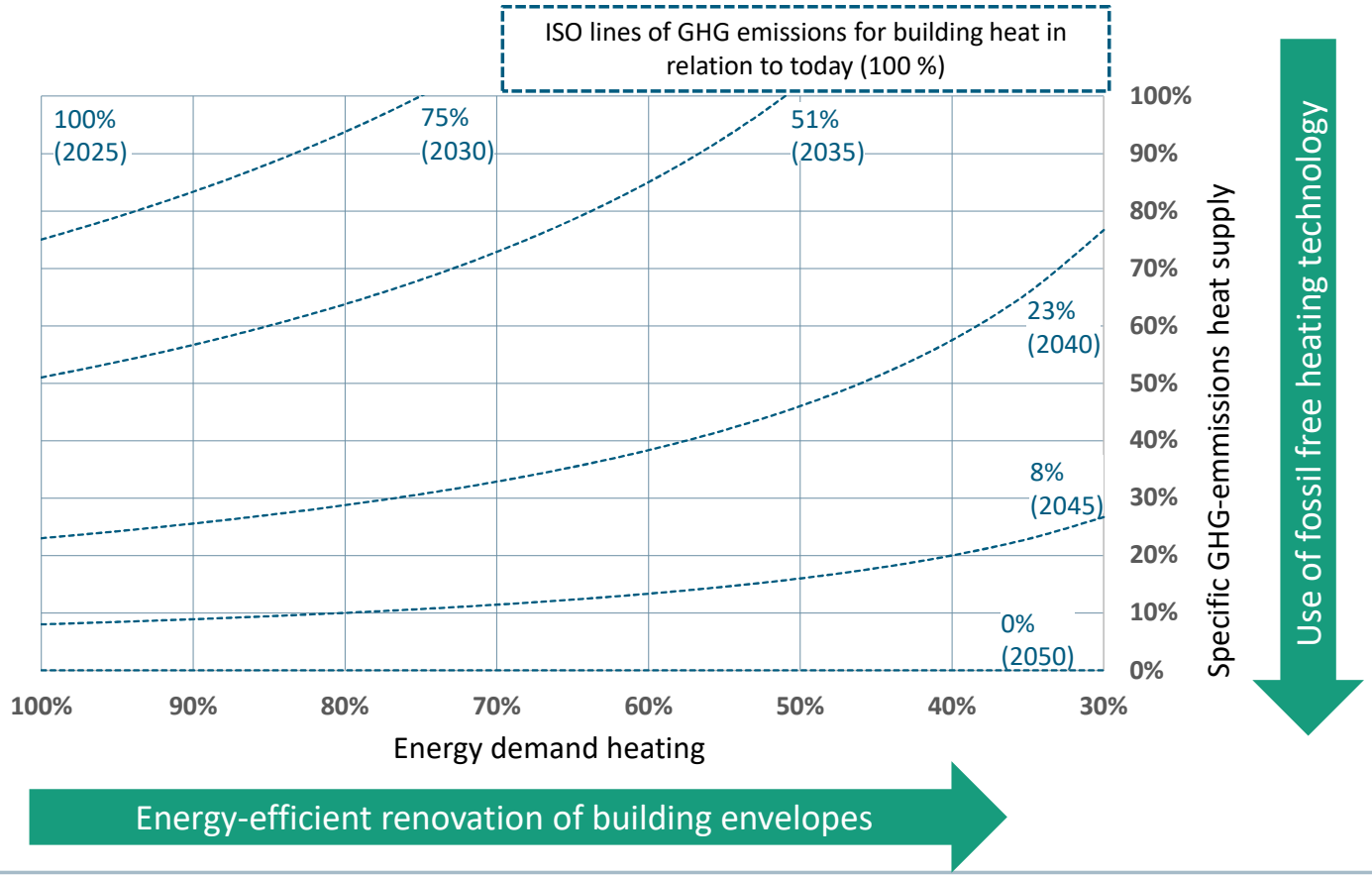

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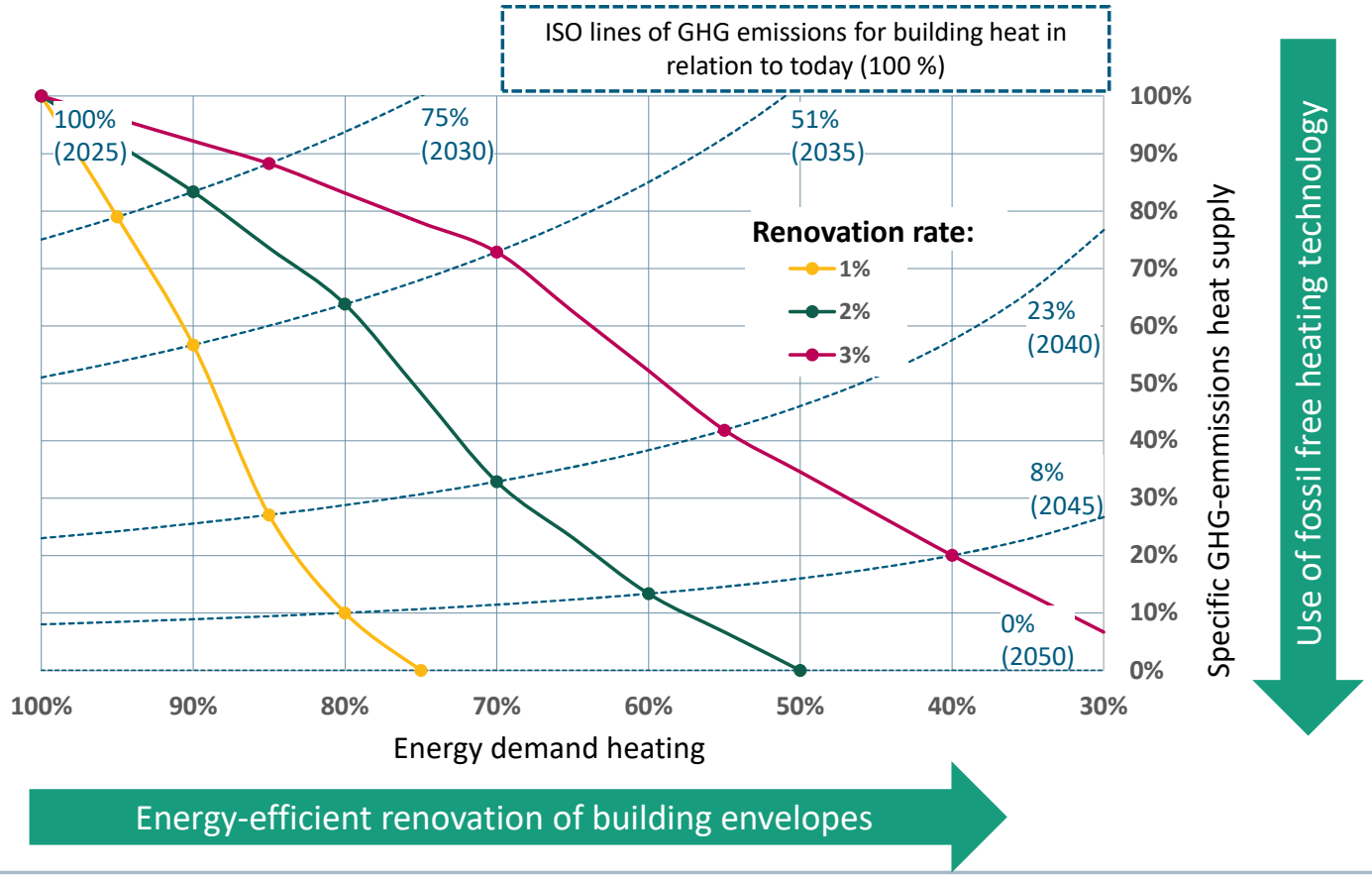

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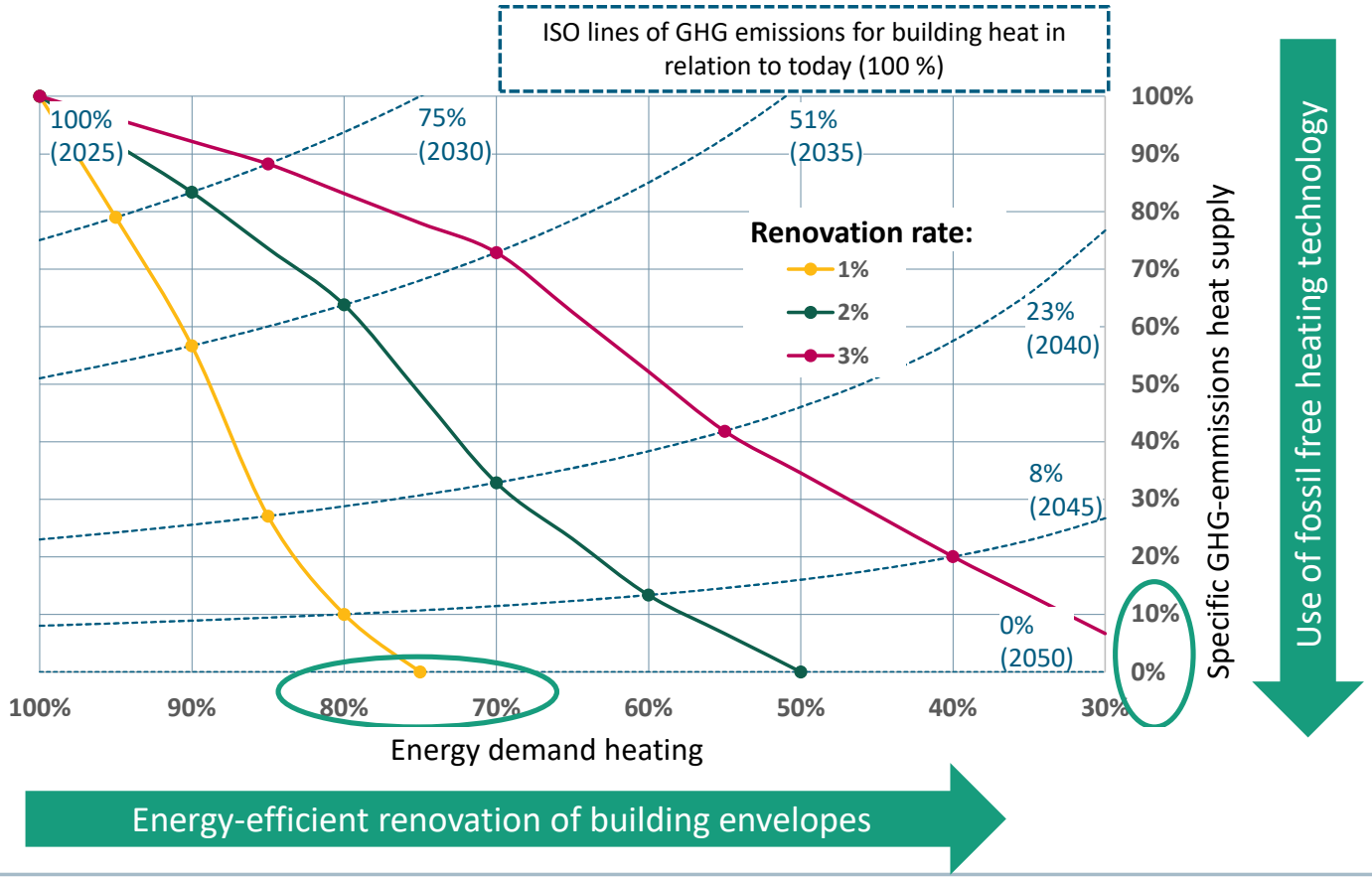

As an increase of the Renovation Rate is unlikely due to high costs, the use off fossil free heating technologies is a key element to achieve climate neutrality in the building sector

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Retrofit of High Rise Residential towards Passive House Standard

Freiburg Weingarten, Bugginger 50, 2009-2011

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Solutions for a climate-neutral building sector

Notes on energy-efficient renovation

Costs per ton of CO_2 saved increase disproportionately with high renovation depth

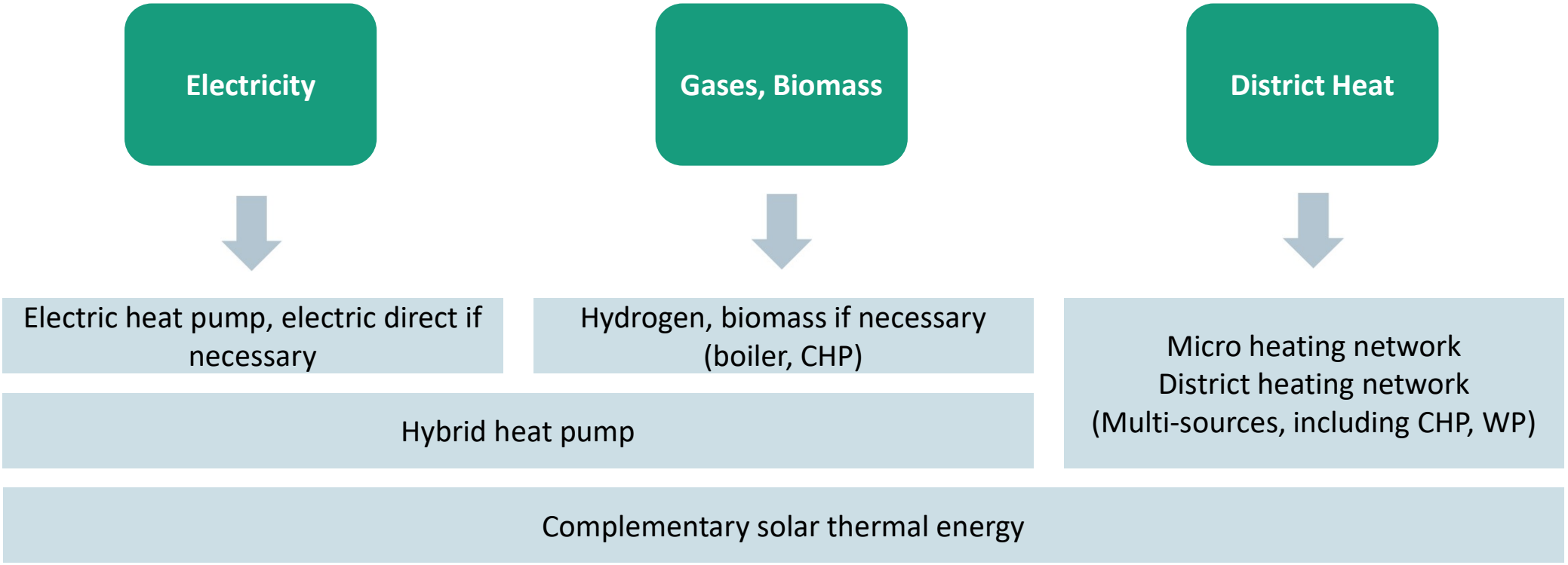
Renovation of existing buildings still necessary:

- Limiting energy demand and thus the use of renewable energies for space heating
- Reduction of heating temperatures (advantageous for the use of heat pumps and solar thermal energy)
- Reduced load on the power grids
- Burden on tenants in the event of excessive consumption costs

Ensuring sufficient energy-efficient renovation of the building stock by 2050

Solutions for a climate-neutral heat supply

Basic options



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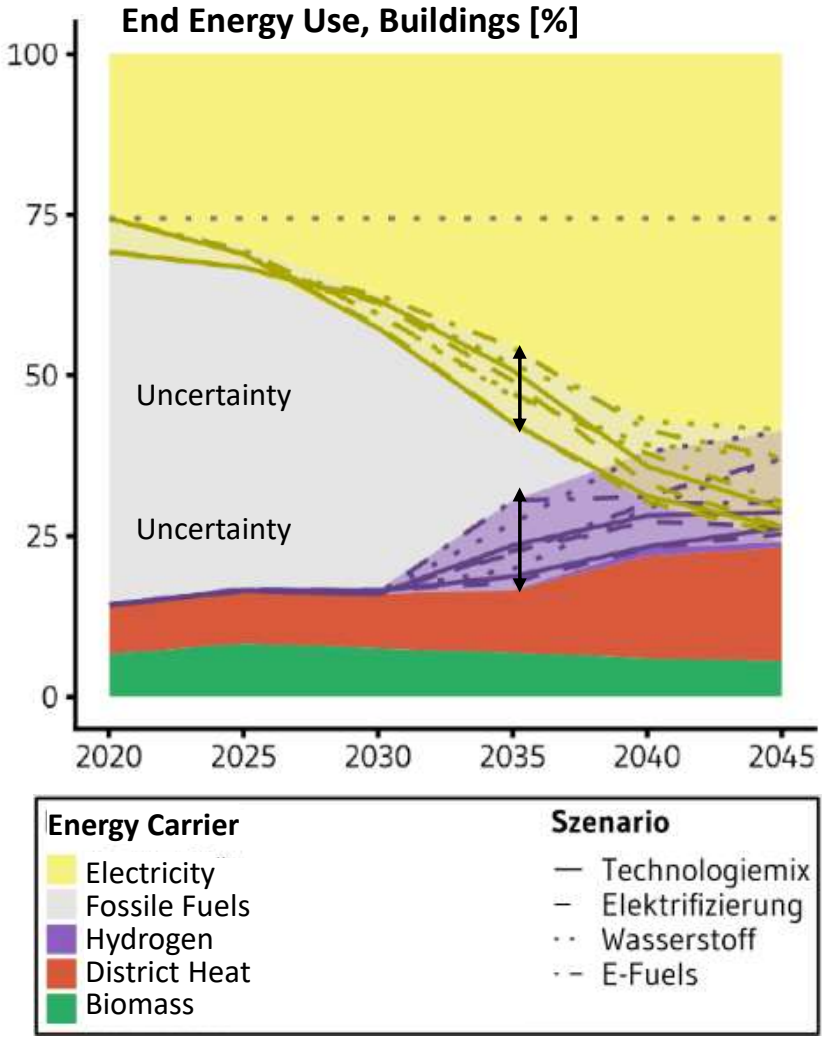
Energy sources in the building sector

Results of the Energy System Analysis, DE

- Direct electrification vs. hydrogen and e-fuels
- A comparison of current studies (Ariadne, BDI, DENA, Agora, long-term scenarios) consistently shows that indirect electrification will not play a role in the building sector until 2030
- There is also agreement that direct electrification (heat pumps) and heating networks are central components of the heating transition
- From 2030 onwards, there will be greater uncertainty:
  - Some scenarios assume that hydrogen and e-fuels play almost no role in the building sector
  - Other scenarios see relevant shares in 2045
- impact on infrastructures can only be derived in conjunction with a bottom-up view



Quelle: Ariadne Kurzdossier 2021: Durchstarten trotz Unsicherheit, 16.11.2021, https://ariadneprojekt.de/publikation/eckpunkte-einer-anpassungsfaehigen-wasserstoffstrategie/

KOPERNIKUS PROJEKTE Ariadne Die Zukunft unserer Energie

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Heat Pumps in Single Family Housing

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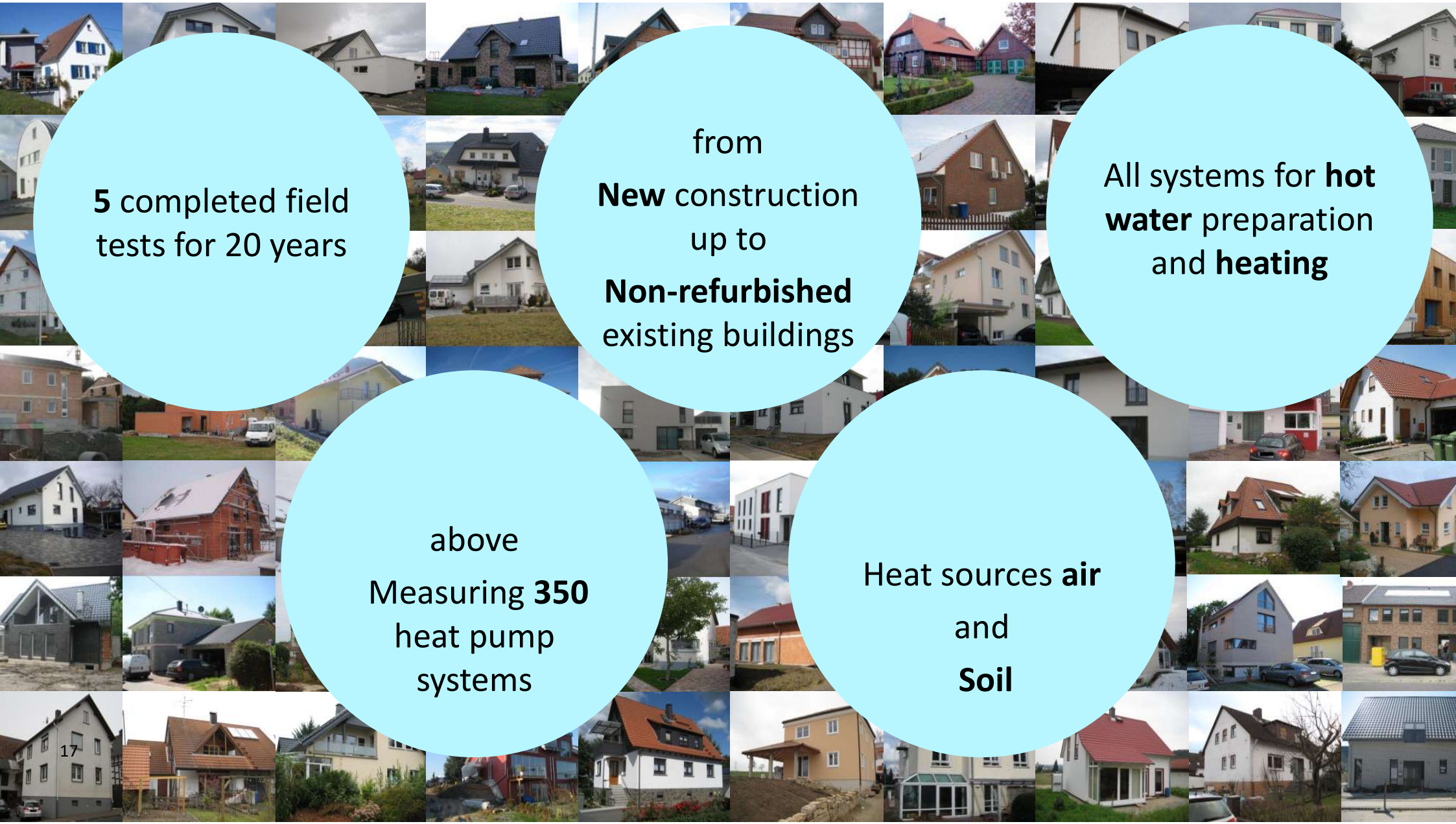
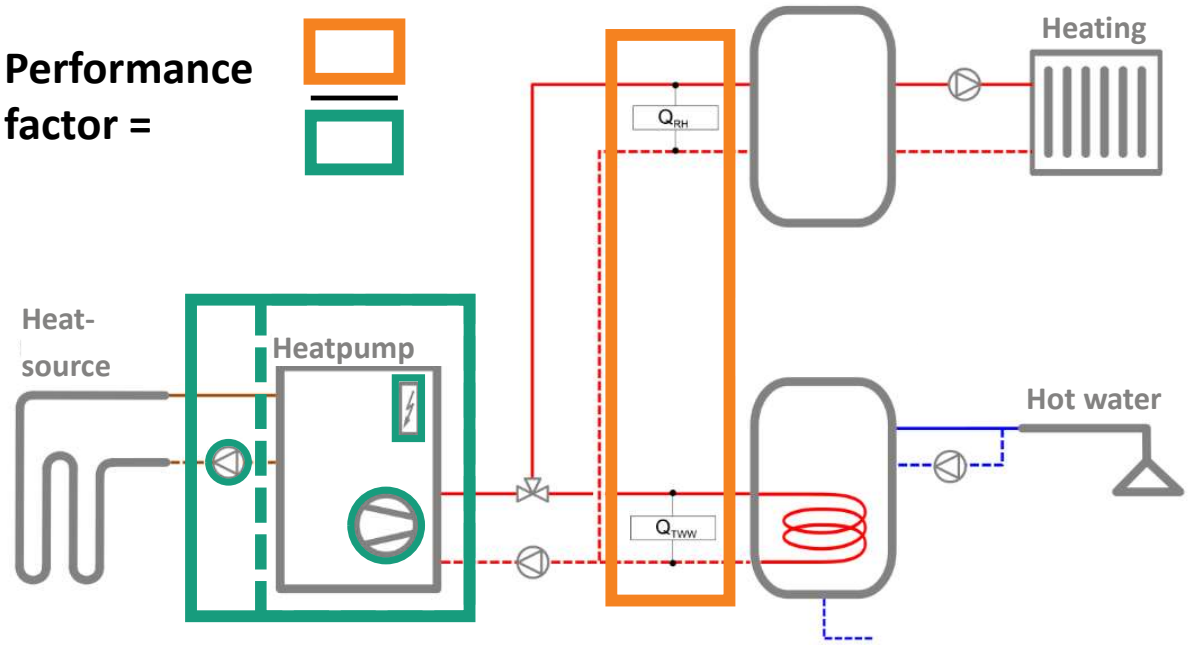

5 completed field tests for 20 years
from **New** construction up to **Non-refurbished** existing buildings
All systems for **hot water** preparation and **heating**
above Measuring **350** heat pump systems
Heat sources **air** and **Soil**

Efficiency Assessment in Field Measurements

System boundaries and determination of key figures

Performance factor =



- Uniform sensor technology for recording energy flows, uniform balancing and evaluation methodology
- Evaluation of transient operation (in contrast to (S)COP (= test bench))
- Consideration of different sources and transfer systems
- Measurements in new and existing buildings with different renovation statuses
- Inclusion of other heat generators (bivalent systems)

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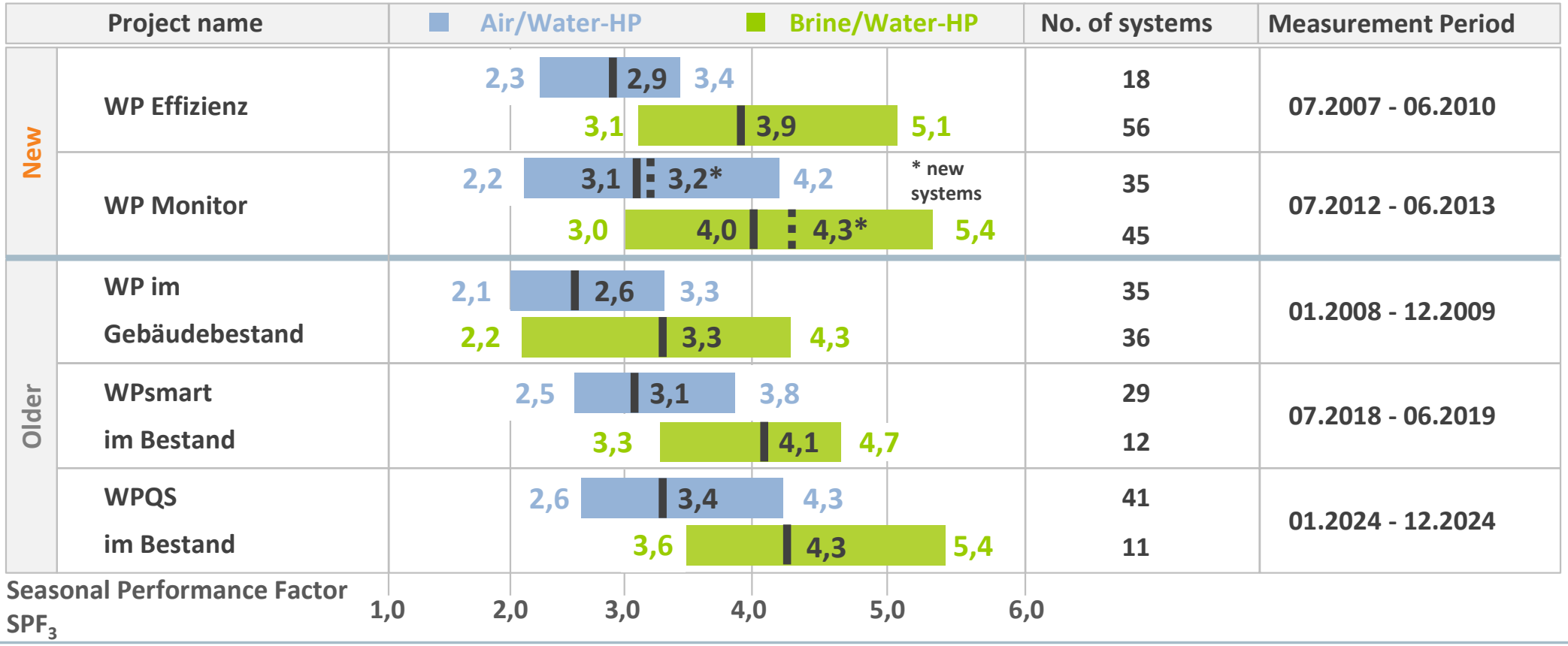
Heat Pumps – Monitoring

Seasonal Performance Factor: Results for detached and semi-detached houses



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

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Heat Pumps in Multi Family Housing

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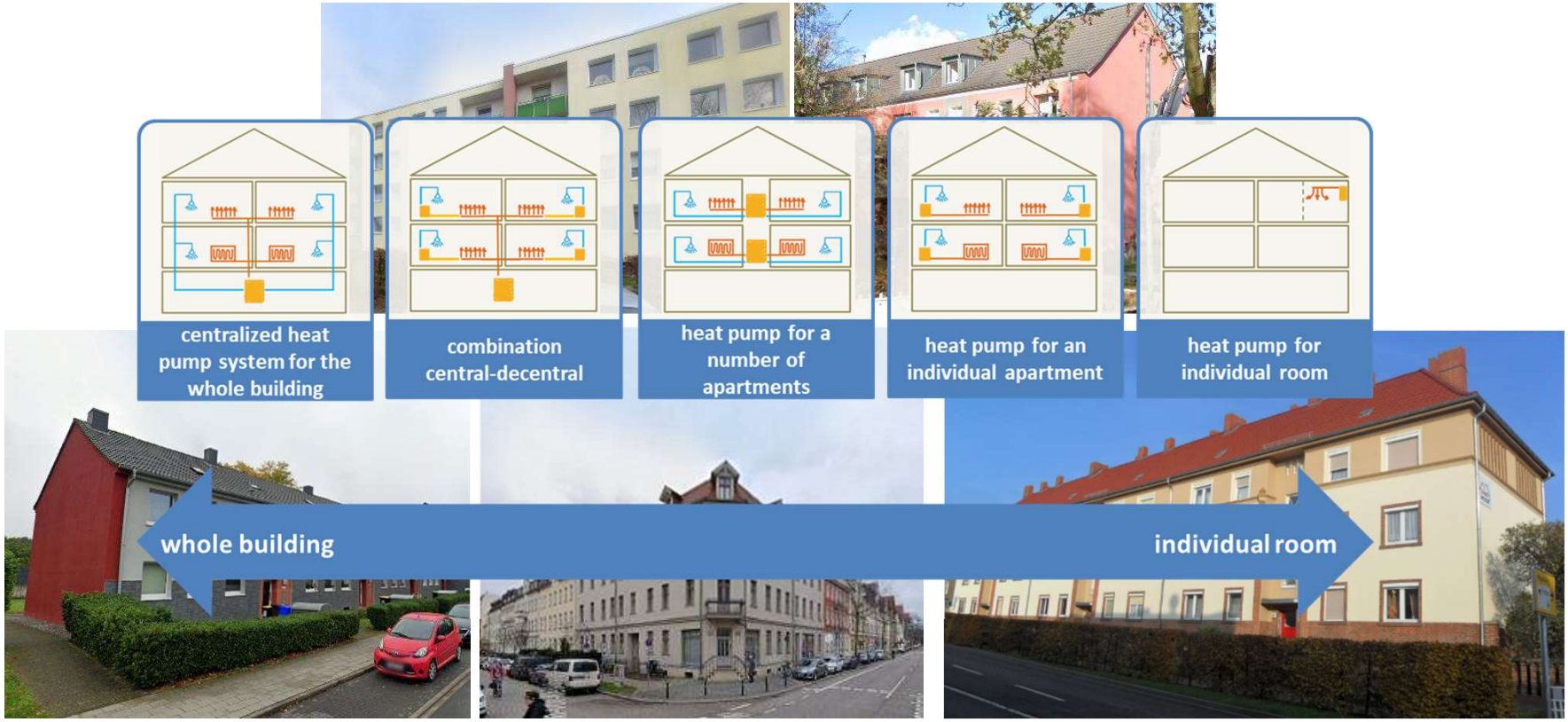
Heat pumps in Multi Family Houses

System Layouts



Quellen: google street view, IM Essen, WBG Schönebeck, KSG Hannover, WB Mönchengladbach, https://heatpumpingtechnologies.org/annex62

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Heat pumps in multi-family (existing) buildings

Challenges

Space requirements for plant technology and storage

Acoustics and Aesthetics: User Acceptance

Costs of plant engineering and installation (time)

Limited experience in installation operations

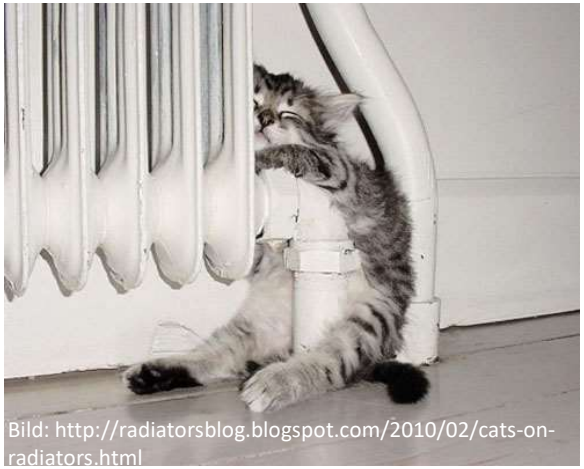

Bild: http://radiatorsblog.blogspot.com/2010/02/cats-on-radiators.html

Complex hydraulic systems

High temperatures in TWW systems

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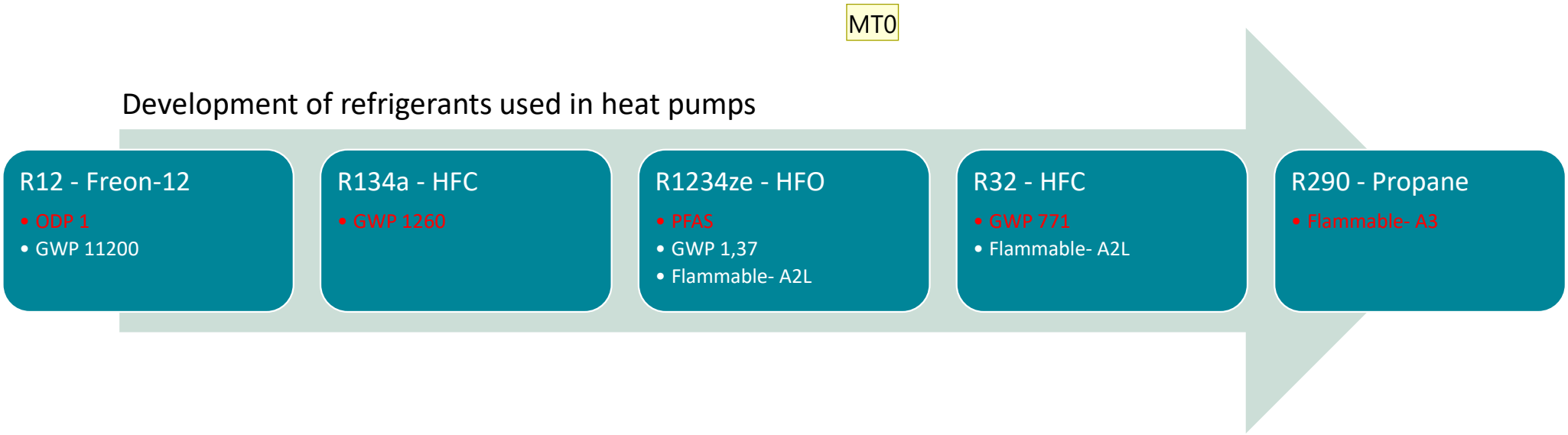
Refrigerant developments

Reducing the Global Warming Potential GWP

- Material properties of refrigerants determine areas of application



Funding reference number 03EN4046

LC R290
LOW CHARGE
HP SOLUTIONS

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

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Folie 23

MT0 Kondensations temepratur dominant, bekomme ich den bezug zur anwendung "kürzer/klarer"
Methler, Timo; 2025-05-23T10:11:07.006

Safety Aspects

Flammable Refrigerants

Propane (R290) will be one of the solutions or will be the solution.

- Propane is highly flammable
- Large amounts of propane can be very dangerous

Security guarantees are difficult to achieve, but not impossible

- Safety regulations apply from 152g R290
- Private individuals traditionally handle propane carelessly

190g Propan /Butan
Commercial Customary Size

11kg Propan
Commercial Customary Size

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Propane based Heat Pumps for Multi Family Houses

Detailed solution development

- Solutions include on sight installation (theoretical)
- Simulation based demand assessment
- Safety assessment local
- Building infrastructure assessment
- Lab scale example heat pump thermal assessment
- Lab scale example safety assessment
- Legal certification process testing

- strong space concerns
- strong noise concerns
- safety demands <150g R290

- Strong safety concerns
- Accessibility concerns
- Retrofit viable mandatory
- Heat capacity mandatory

- Location concerns legally
- Location concerns comfort (noise/ visual/ kids safety)
- Functionality concerns

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Propane based Heat Pumps for Multi Family Houses

Prototypes, Lab Condition

Small, flatwise	
Power @B0/W55	4,9 kW
SCOP 55	3,8
M. R290	150g
Size	45x75x35cm

Central, outside	
Power @A-10/W55	32 kW
SCOP 55	
M. R290	2000g
Size	80x250x120cm

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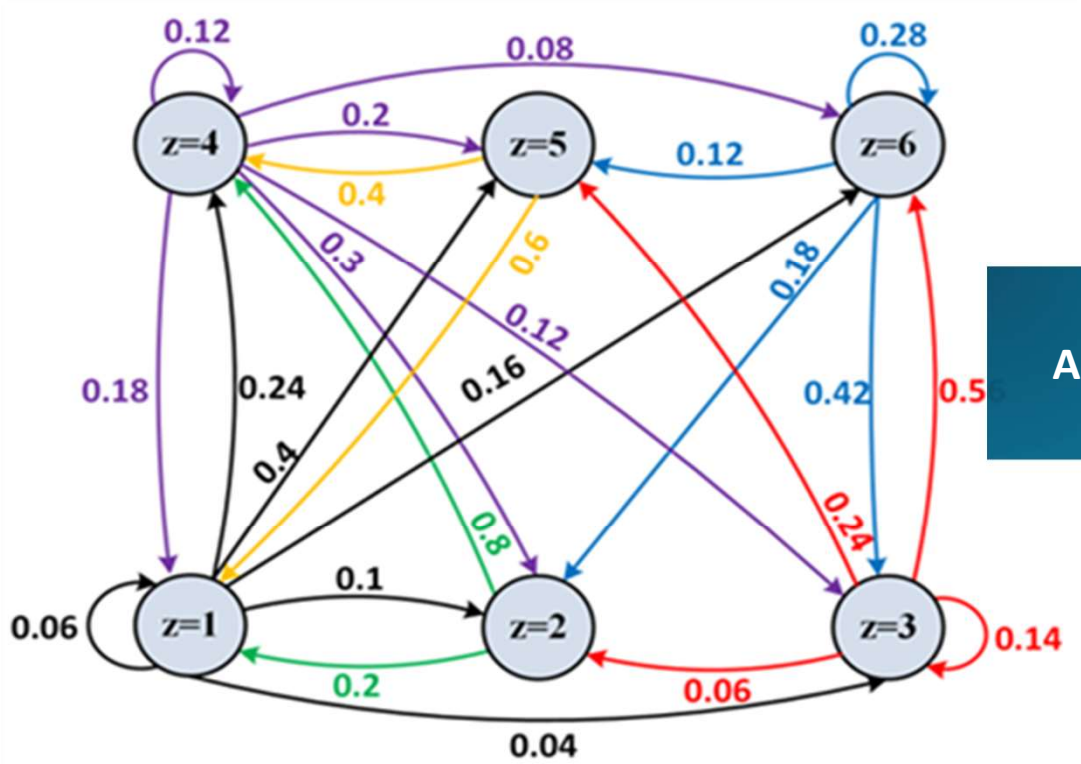

AI in the Building Domain

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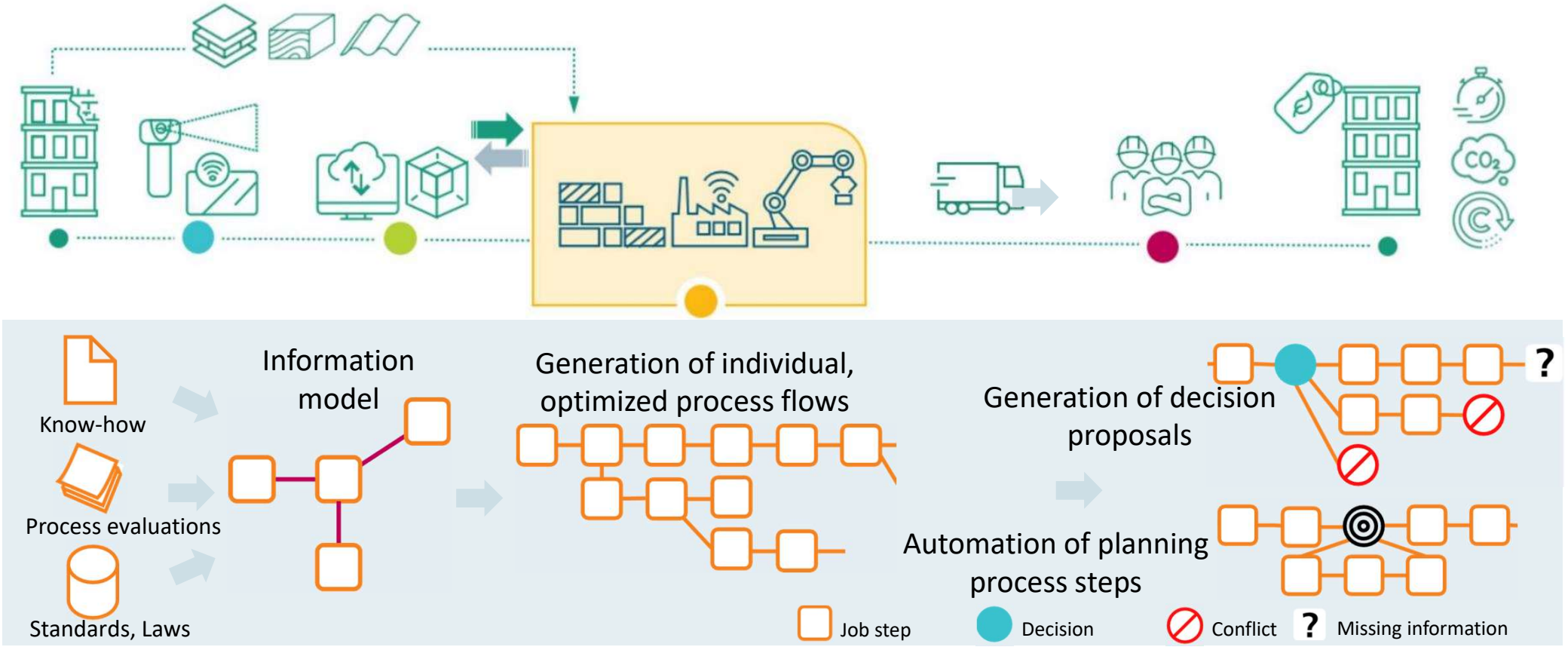
Optimization of the construction process

Field of application for artificial intelligence



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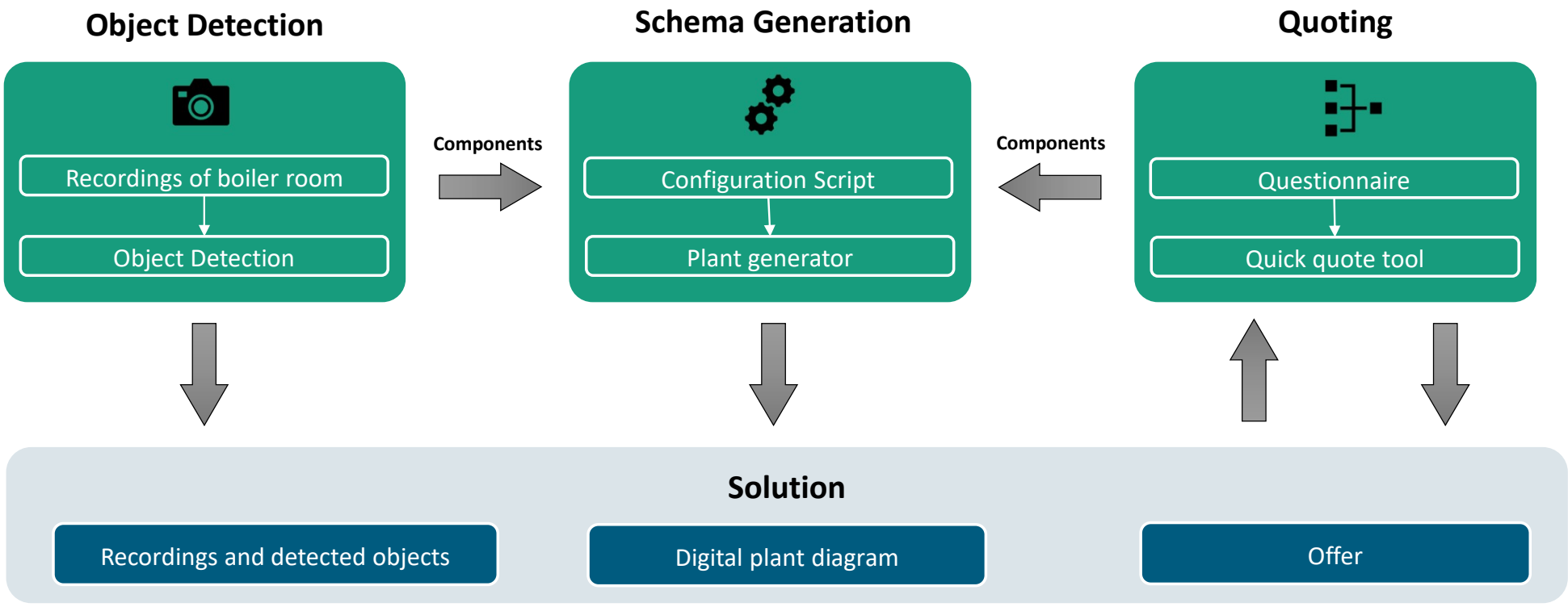
Digitization of inventory and quotation preparation

DiBeSan-SHK



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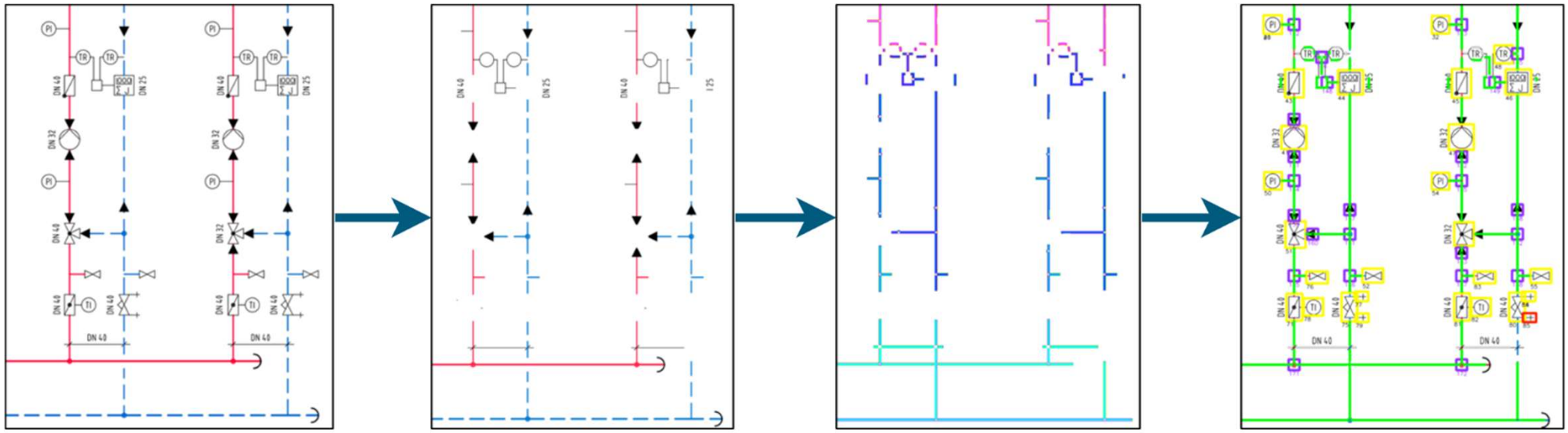
Digitization of plant schematics

AI-based scan of existing schemes



Schema → **Text and Component Detection** → **Line Detection** → **Junction Detection Transfer into a Graph**

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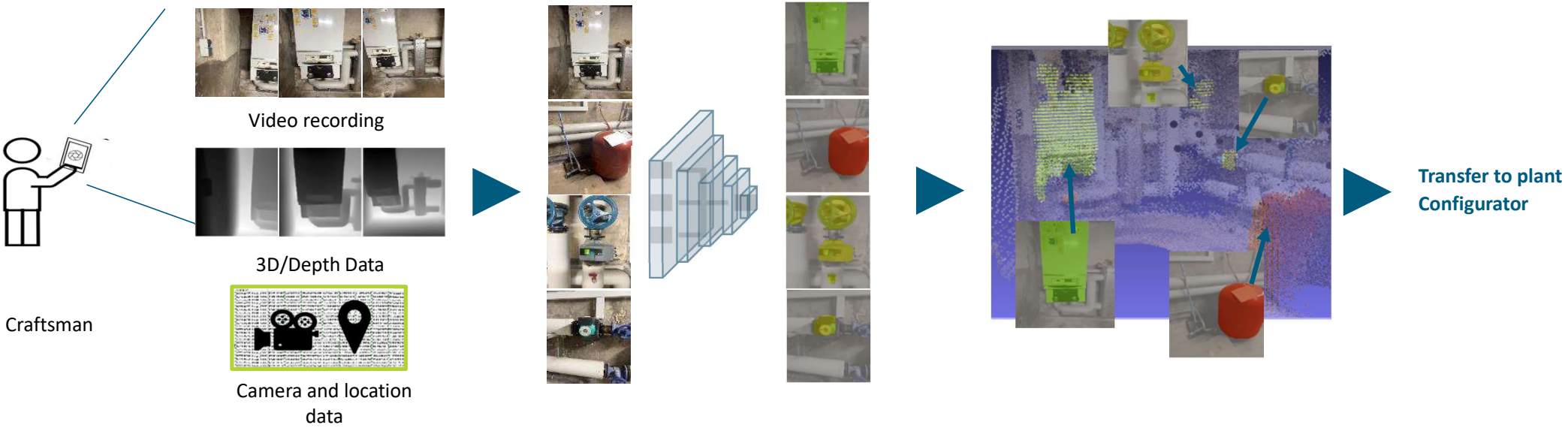
Method development for system recording

AI-based scan of Installations



Transactions made with smartphone Recording of the heating system

Segmentation of the system with neural networks

Merging, Scene Reconstruction via 3D data

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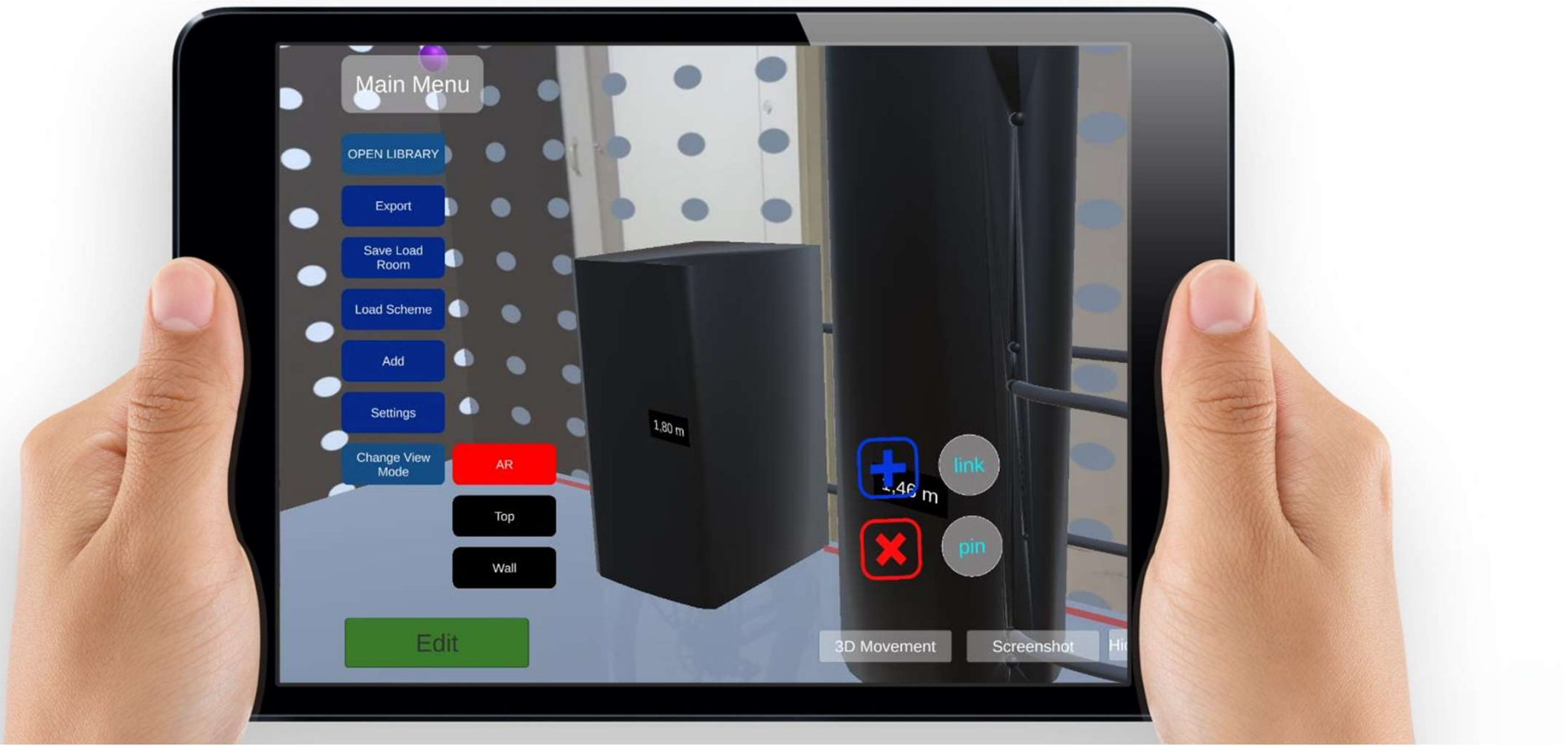
Heat pumps – Installation Support

Support of installation design



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Heat pumps – Installation Support

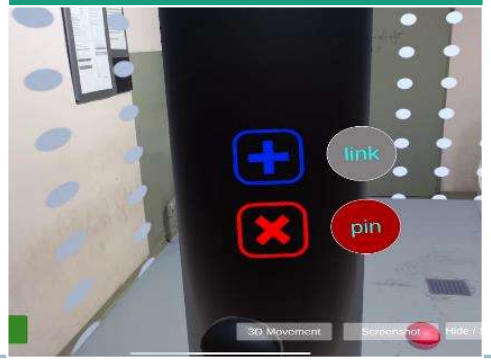
Functionality

Capture

Digital Representation

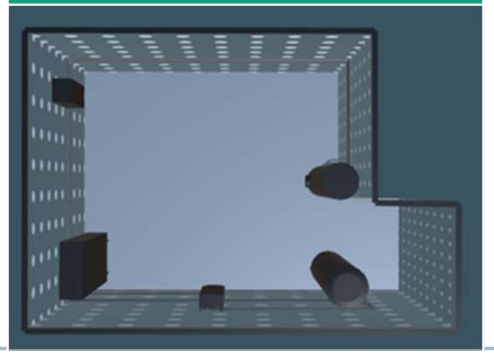
Selection of components from the catalog

Placing in 3D space



Autorouting of pipes etc.

Planning view



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Conclusion

- Climate neutrality cannot achieved by deep retrofit only – defossilisation of heat/cold supply must be a key aspect of any strategy
- Retrofit is still important to foster affordability and ensure healthy indoor conditions
- Transformation takes place at different levels and with different actors – it succeeds when they work together in a coordinated manner and locally adapted solutions are found
- The use of heat pumps in heat supply (residential, real estate, district heating, industrial processes) is picking up speed, and solutions for higher temperatures are also coming onto the market.
- Switching to a high proportion of direct electricity use in conjunction with heat pumps and district heating play a key role in the renewable heat supply of buildings and industrial processes, thus the security of the electrical infrastructure becomes even more important. Flexible operation of Systems can help to ensure this.
- To ensure both installation capacity and affordability – digitalization will be a key competence to be competitive

Thank you for your attention

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