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RHC Event

How to fully decarbonise the heating and cooling sector in Europe?

10 April 2024
Graz (Austria)

Marco Calderoni (Chair of RHC-ETIP)

Andrej Misech (Coordinator of RHC-ETIP Secretariat)

Introduction to the RHC-ETIP & Relevant Funding Calls for RHC Solutions

RHC-ETIP overview

- Founded in 2008 and recognised as an ETIP by the European Commission in 2016
- ETIPs have been created by the European Commission in the framework of the new Integrated Roadmap Strategic Energy Technology Plan (SET Plan) by bringing together a multitude of stakeholders and experts from the energy sector

KEY OBJECTIVES

Speeding up the **uptake** of RHC technologies and **stepping up to the challenge** of the entire industry with a special focus on industrial and manufacturing capacity, new manufacturing procedures and addressing supply chains (incl. related risks)

Increasing the profile and the **role** of RHC in the process of decarbonisation of the energy system including support to the **definition** of a **stable** and **favourable research policy framework** for the development of renewable H&C technologies at EU level

Focusing on **accelerating projects** on the ground, **replication**, and developing **bankability** of the projects

RHC-ETIP overview

Representing research and industry of heating & cooling technologies in Europe:

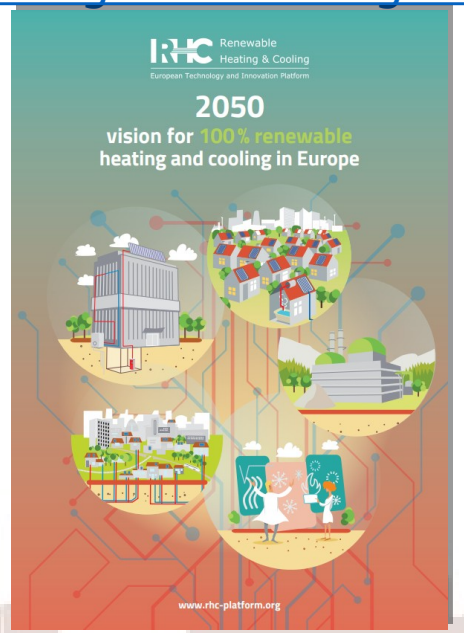
- Solar thermal
- Biomass
- Geothermal
- Heat pumps
- District heating & cooling, and thermal storage

RHC-ETIP's work is structured in solutions-oriented horizontal working groups:

- 100% RE Buildings
- 100% RE Districts
- 100% RE Cities
- 100% RE Industries
- SSH-HWG

Recent achievements

- 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



Recent achievements

- Preparation and publishing of technology-specific SRIAs: Solar Thermal, Biomass, Geothermal, Heat pumps, DHC & Thermal storage

Recent achievements

- 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 for the Horizon Europe‘s Work Programme 2025
- Recommendation paper on «How to Make Renewable Heating and Cooling Transition Socially Just? »

Other activities

- Organisation of **national and regional roundtables** to engage national stakeholders, to inform and update them on the work of the RHC-ETIP, exchange expertise and best practices and receive concrete feedback on strategic documents
- Active participation to the definition of a **stable and favourable research policy framework for the development of renewable heating and cooling technologies at EU level** through monitoring and preparing input to the key EU R&I policy priorities and public consultations
- **Online projects database** to track the ongoing projects in the area of renewable heating and cooling, with a focus on those which are funded at EU level. Ready to consult or submit your project
- Organisation of **annual conference: 100% RHC Event**
- Development of **RHC industrial strategy**
- **Establishing a RHC accelerator and a one-stop shop** for RHC projects, to develop their bankability and stimulate their market uptake
- Strengthening **cooperation initiatives among RHC stakeholders at national level**
- Enlargement of the **RHC-ETIP to complementary sectors and new markets**, with experts involved in promoting the renewable heating and cooling sector

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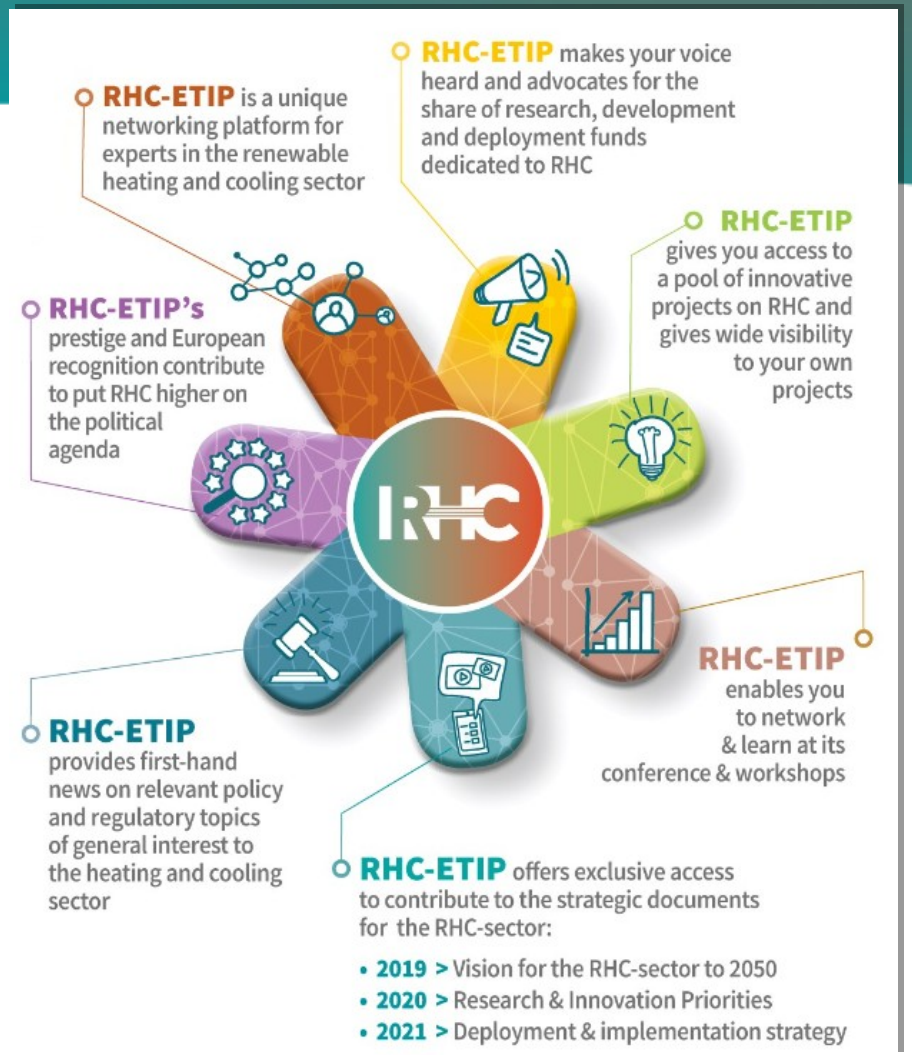
Become a member



*Participation to the activities of the RHC-ETIP is free and on a voluntary basis.

Horizon Europe

- HORIZON-CL5-2024-D4-01-01: Low-disruptive renovation processes using integration of prefabricated solutions for energy-efficient buildings

Key details:

Type: HE Innovation Action

Opening: 07 December 2023

Deadline: 18 April 2024

Deadline very close!

Foreseen budget: EUR 10,000,000 (2 projects of around EUR 5,000,000)

Topic: Low-disruptive renovation processes, using prefabricated modules that are quick and easy to apply to enable increasing the renovation rate of the European building stock

Expected TRL: 6-8

Horizon Europe

- HORIZON-CL5-2024-D4-01-02: Smart grid-ready buildings

Key details:

Type: HE Innovation Action
Opening: 07 December 2023
Deadline: 18 April 2024
Foreseen budget: EUR 10,000,000 (2 projects of around EUR 5,000,000)
Topic: Deliver solutions to improve the interoperability of European buildings with energy carriers (e.g. electricity grid, district heating networks) and with non-energy services (e.g. mobility) to allow buildings to play an active role in the energy system integration
Expected TRL: 6-8

Deadline very close!

Horizon Europe

- HORIZON-CL5-2024-D4-01-03: Alternative heating systems for efficient, flexible and electrified heat generation in industry

Key details:

Type: HE Innovation Action

Opening: 07 December 2023

Deadline: 18 April 2024

Deadline very close!

Foreseen budget: EUR 16,000,000 (3 projects of around EUR 5,300,000)

Topic: Further research and upscaling work to demonstrate the potential of alternative forms of energy, e.g. ultrasound, microwaves, plasma, infrared, visible and ultraviolet radiations... to be deployed on an industrial scale

Expected TRL: 6-7

Horizon Europe

- HORIZON-CL5-2024-D4-02-01: Industrialisation of sustainable and circular deep renovation workflows (Built4People Partnership)

Key details:

Type: HE Innovation Action

Opening: 17 September 2024

Deadline: 21 January 2025

Foreseen budget: EUR 16,000,000 (2 projects of around EUR 8,000,000)

Topic: Develop innovative, seamless workflows from design to off-site prefabrication, to installation, construction on-site, maintenance and future dismantling, reuse and recycling of prefabricated elements, duly considering life cycle performance, sustainability, and the potential to use the buildings as carbon sinks. Ensure the proposed approaches aim to achieve the highest level of energy performance

Expected TRL: 6-8

Forthcoming!

Horizon Europe

- HORIZON-CL5-2024-D4-02-05: Digital solutions to foster participative design, planning and management of buildings, neighbourhoods and urban districts (Built4People Partnership)

Key details:

Forthcoming!

Type: HE Innovation Action

Opening: 17 September 2024

Deadline: 21 January 2025

Foreseen budget: EUR 10,000,000 (2 projects of around EUR 5,000,000)

Topic: Development of digital solutions for a stronger participation of end users, citizens and other relevant stakeholders in the design, planning and management of the renovation of existing buildings, neighbourhoods and / or districts.

Expected TRL: 6-8

Horizon Europe

- HORIZON-CL5-2024-D3-02-10: Market Uptake Measures of renewable energy systems

Key details:

Type: HE Coordination and Support Action

Opening: 17 September 2024

Deadline: 21 January 2025

Foreseen budget: EUR 8,000,000 (4 projects of around EUR 2,000,000)

Topic: Develop solutions facilitating the wider uptake of RES in the energy, industrial and residential sectors either for the entire renewable energy market or focusing on a specific energy sector, such as electricity, heating, cooling or renewable fuels

Forthcoming!

LIFE programme

- LIFE Clean Energy Transition sub-programme
- Budget of nearly €1 billion
- The EC will publish the calls for proposals for the LIFE 2024 programme on **18 April** with anticipated submission deadlines on 19 September 2024
- Dedicated call on heat pumps: LIFE-CET-HEATPUMPS2024
- Several **info days are foreseen** to take place after the publication date (virtual information sessions from 23 to 26 April 2024)

Relevant funding calls for RHC technologies

Innovation Fund

- Financed by EU Emissions Trading System revenues -> **€40 billion between 2020-2030**
- The Fund focuses on **highly innovative clean technologies and big flagship projects** with European added value that can bring significant emission and greenhouse gas reductions
- €6.5 billion in EU funding awarded to **104 projects so far** (large-scale and small-scale)
- The projects need to be sufficiently mature in terms of planning, business model, and financial and legal structure
- Projects are selected based on different criteria: effectiveness of greenhouse gas emissions avoidance, degree of innovation, project maturity, replicability and cost-efficiency
- The Innovation Fund **supports up to 60% of the relevant costs** calculated according to the methodology indicated in each call for proposals
- IF2023 call closed on 9 April 2024. Expected open of the next large-scale call in Q4. Small-scale calls previously opened in Q1 of each year

Clean Energy Transition Partnership

- An initiative co-funded by the EU that brings together public and private stakeholders in the research and innovation ecosystems, from European and non-European countries and regions. CET Partnership aims to foster transnational innovation ecosystems and overcome a fragmented research and innovation landscape.
- CETP Joint calls are usually performed in 2-stages: submission of a pre-proposal followed by an invite to submit a full proposal
- Joint Call 2023 – deadline for full-proposal submission on 27 March 2024
- Joint Call 2024 – opening of the pre-proposal submission expected in September 2024
- CETPartnership Joint Call 2024 Infoday (online) expected shortly before the opening of the joint call

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10 April 2024
Graz (Austria)

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RHC Event

How to fully decarbonise the heating and cooling sector in Europe?

10 April 2024

Graz (Austria)

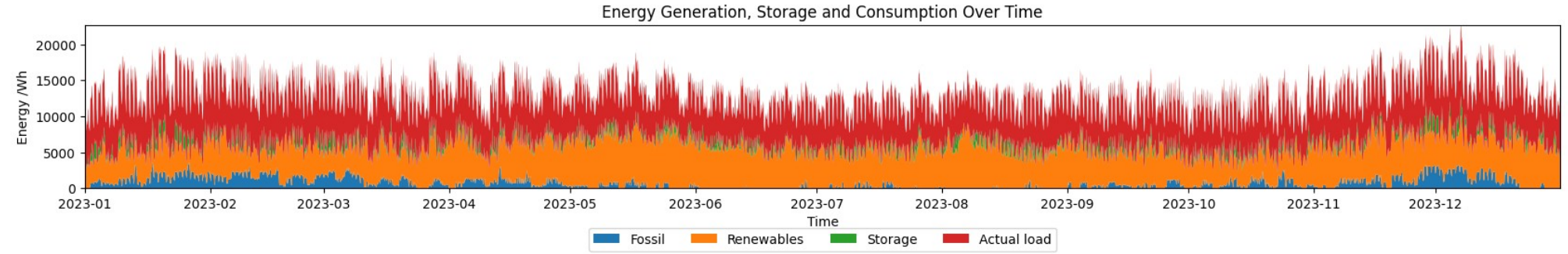
Marco Calderoni

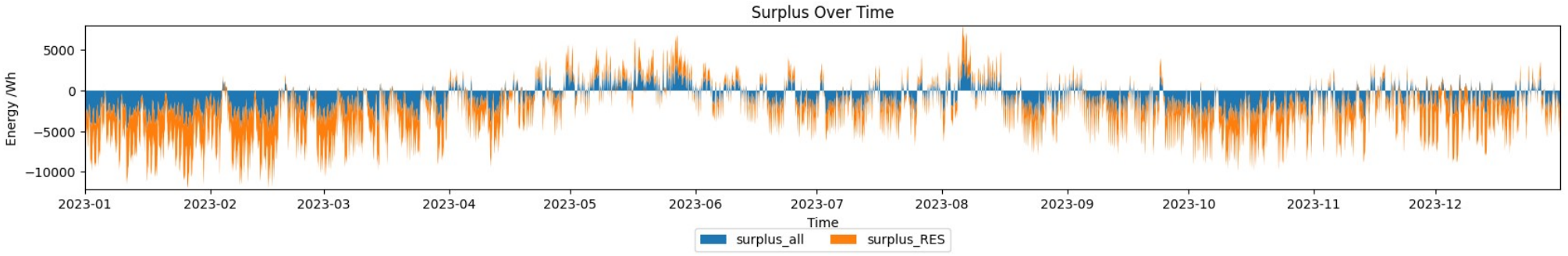
Thinking the Heating and Cooling Sector and the Power Sector Together: Sector Coupling

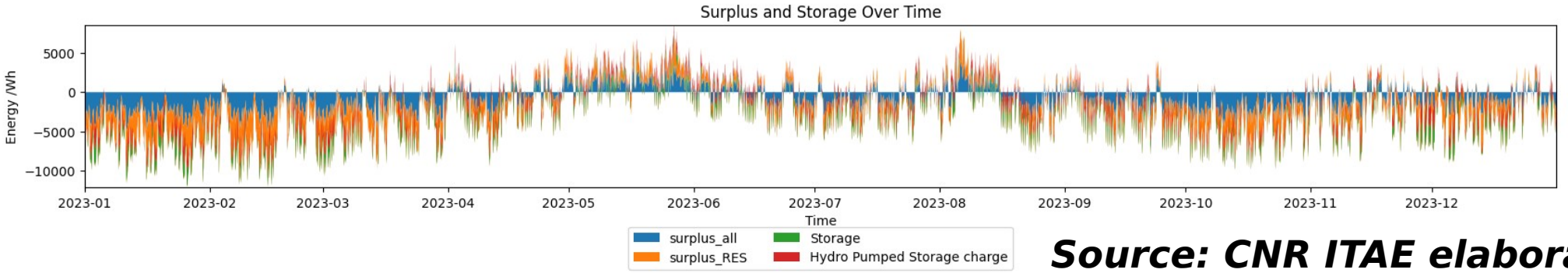
Storage of electricity

- Electricity is hard to be stored directly on a large scale.
- Nowadays, pumped storage covers more than 90% of stored electricity in the EU35 but is limited in expansion due to regional and environmental restrictions.
- It is expected that storage capacity has to increase by 2 to 3 orders of magnitude to avoid curtailing RES electricity.

Why is flexibility needed

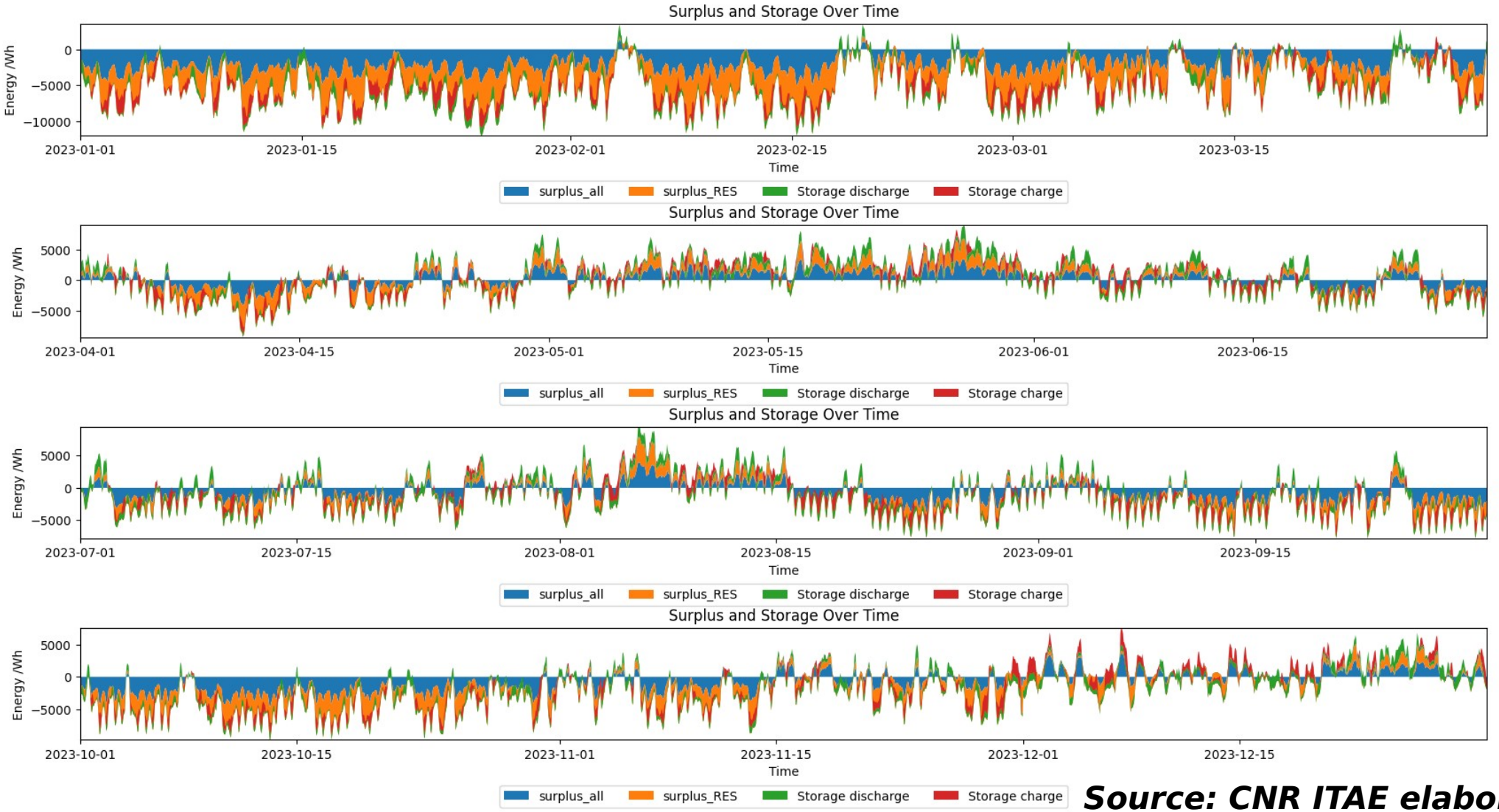






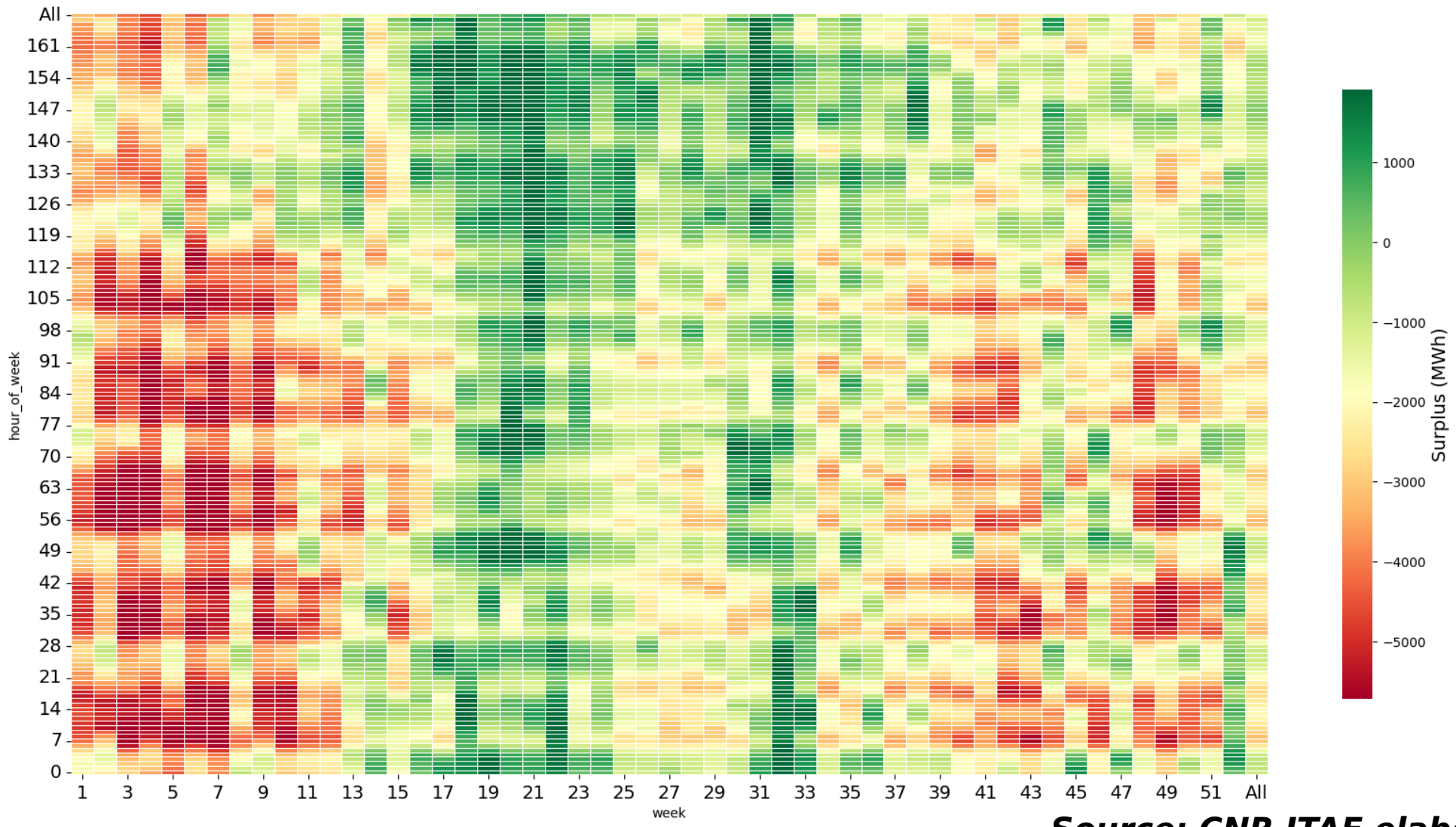
Source: CNR ITAE elaboration of ENTSO-E data

Why is flexibility needed



Source: CNR ITAE elaboration of ENTSO-E data

Why is flexibility needed



Source: CNR ITAE elaboration of ENTSO-E data

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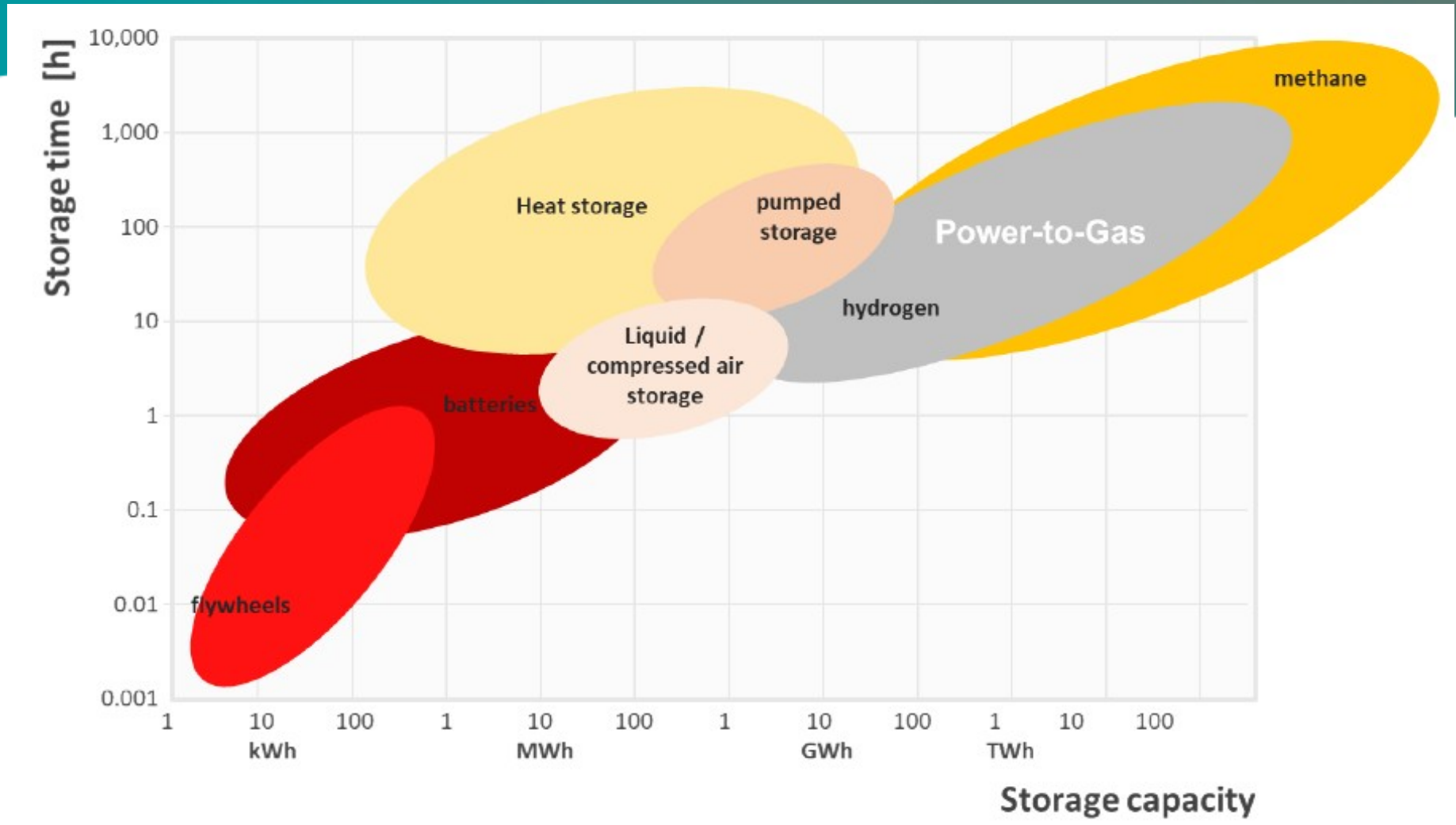
Thermal Energy Storage ranges over a wide range of sizes



Flexibility through sector coupling?

Energy flexibility of a building is defined as *"The ability to manage its demand and generation according to local climate conditions, user needs and grid requirements".*

Can RHC-connected TES actually contribute to making the energy system more flexible?

Simple answer: Yes, if large scale.

Complex answer: Perhaps even domestic-scale storages if well managed/aggregated.

Installed TES capacity

Taking into consideration only the electric DHW tanks in EU28, a total storage capacity of about 125 GWhth is installed.

stalled Capacity of Thermal Energy Storage

;a F Cabeza, Harald Mehling, Joaquim Romaní

Flexibility through sector coupling?

Initial data from the HYSTORE project:

1,879 h per year of RES surplus

4,200 MWh maximum RES surplus in on day (< DHW TES installed in AT)

Under the hypothesis that ½ of the TES is always hot and ½ can be used:

- 482,000 DHW water-based TES of 200 l or PCM-based of 17 kWh
- 56,000 TCM TES of 150 kWh storage capacity (weekly/bi-weekly storage)

Title

- Fetching data from EU TSO from ENTSOE transparency platform (using the API in Python)
- Evaluation of energy surplus and RES surplus over the year
- Evaluation of the heating/cooling demand of the building stock at national level (using demand.ninja project data in Python)
- Evaluation of the theoretical electricity consumption of buildings for heating/cooling
- Superposition of surplus and heating/cooling consumption to define peak shaving and load shifting services

Flexibility through sector coupling?

Discussion points:

- Increasing TES means changing the consumption pattern -> also the production pattern changes
- Will the sizing of TES change in order to provide flexibility?

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10 April 2024

Graz (Austria)

Dr.-Ing. Ralf-Roman Schmidt

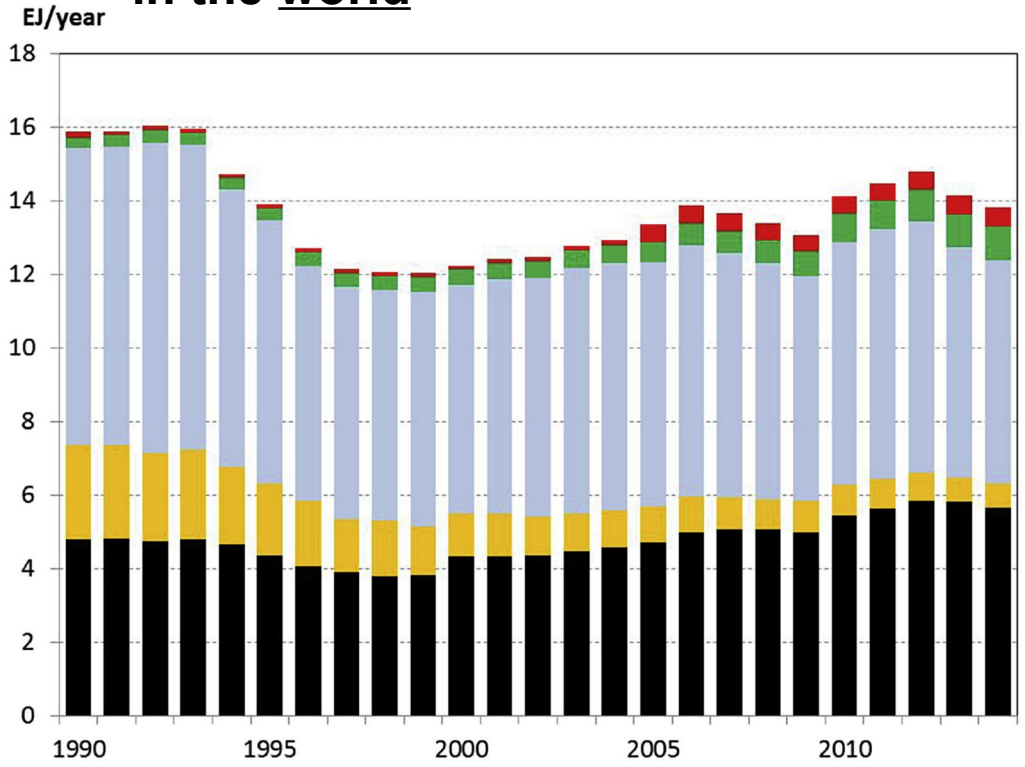
Innovative Concepts for Heating and Cooling in Cities and districts

AUSTRIAN INSTITUTE OF TECHNOLOGY

TOMORROW TODAY

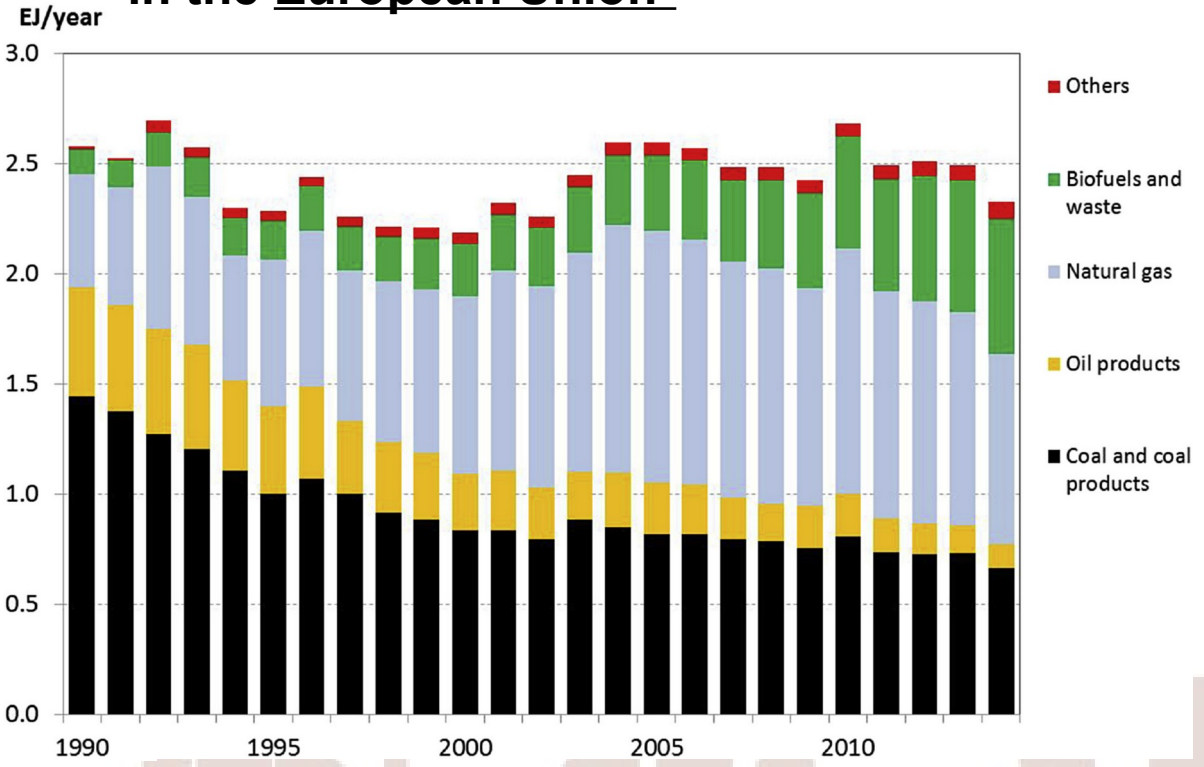
Motivation

Heat supplied into all DH systems in the world*



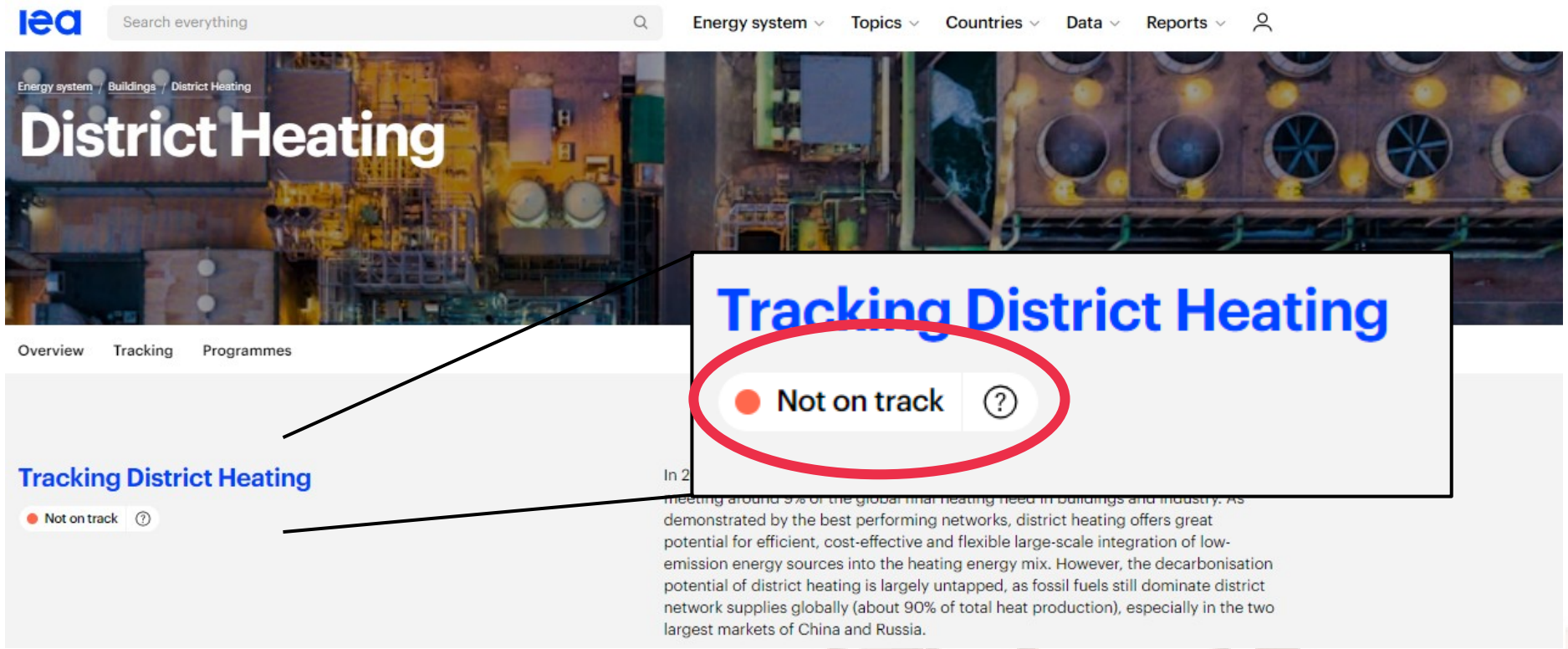
*according to original energy supply sources used

Heat supplied into all DH systems in the European Union*



source: Sven Werner, International review of district heating and cooling, Energy, Volume 137, 2017 https://doi.org/10.1016/j.energy.2017.04.045

Motivation


iea
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District Heating
Overview
Tracking
Programmes
Tracking District Heating
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Tracking District Heating
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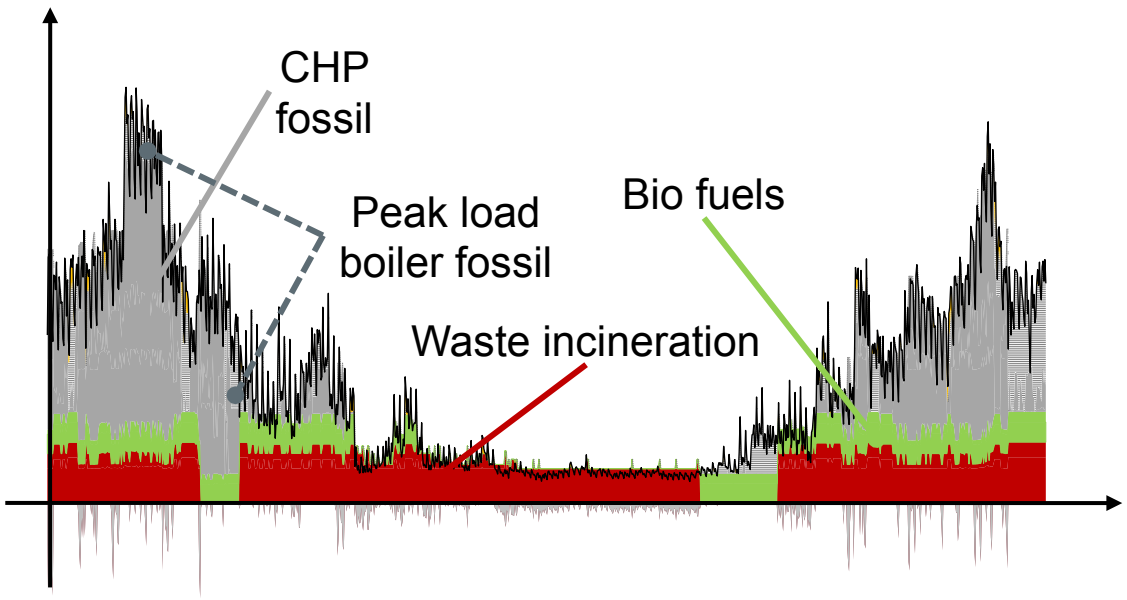
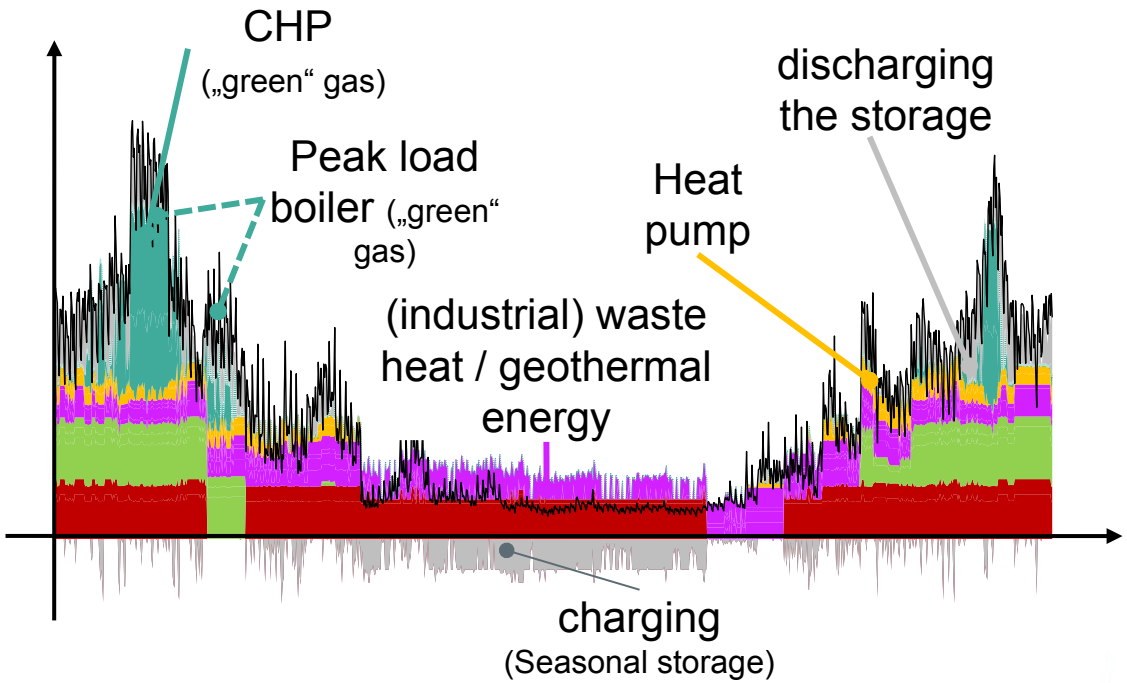
In 2
demonstrated by the best performing networks, district heating offers great potential for efficient, cost-effective and flexible large-scale integration of low-emission energy sources into the heating energy mix. However, the decarbonisation potential of district heating is largely untapped, as fossil fuels still dominate district network supplies globally (about 90% of total heat production), especially in the two largest markets of China and Russia.

District heating supply today and tomorrow?

2024

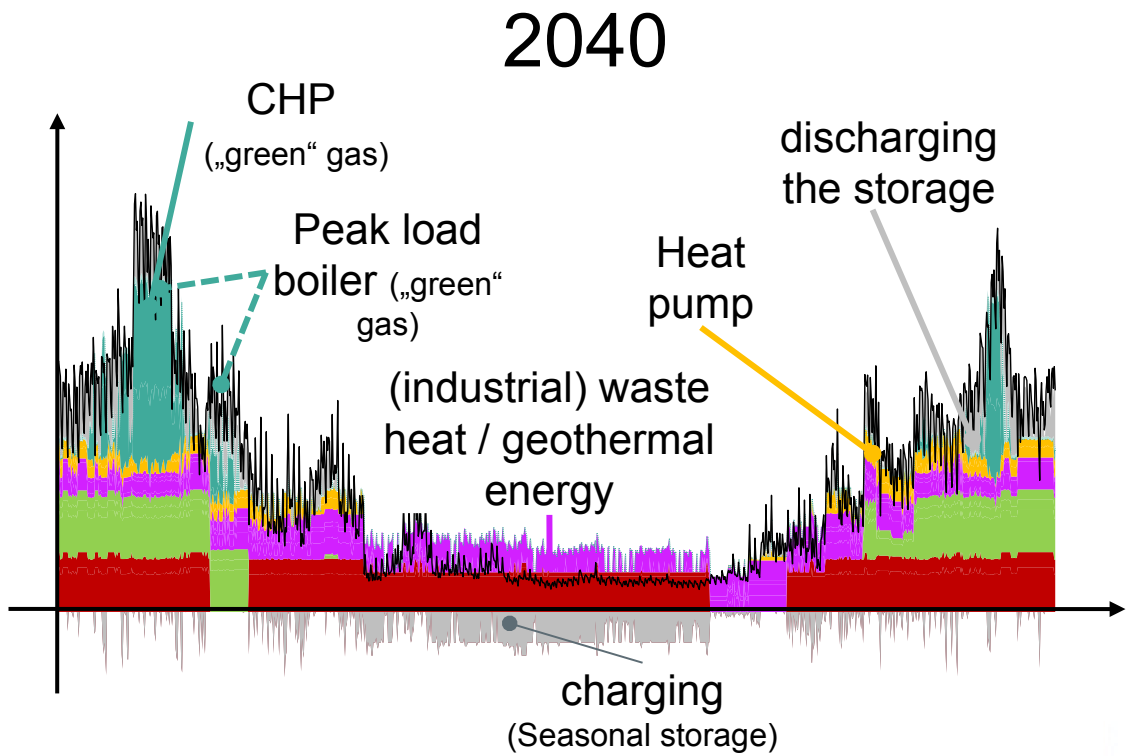


2040



Innovative Concepts

- infrastructure
- Peak load („green“ gas)
- CHP („green“ gas Gas)
- Seasonal heat storages
- (Industrial) waste heat
- Large scale heat pumps
- Geothermal energy
- biomass
- Waste incineration



Large scale heat pumps

trends

- Waste heat from sewage treatment plants
- Surface water and air as a source
- High temperature heat pumps
- Alternative working fluids
- Flexible operation

examples

Esbjerg (DK)

Värtan Stockholm (SE)

challenges

- Availability of heat sources and secured operation (winter)
- High network temperatures
- Future prices of electricity and available grid infrastructure
- Implementation (permissions, realization, operation)

Quellen:
https://www.man-es.com/discover/esbjerg-heat-pump
https://www.friotherm.com/wp-content/uploads/2017/11/vaertan_e008_uk.pdf

(Industrial) waste heat

trends

- Implementation of „new“ heat sources
  - Data centres
  - Electrolysis waste heat
  - Cooling processes
- Combination with large scale heat pumps

examples

AWS Data Center Dublin (IR)

Stockholm Data Park (SE)

challenges

- Surplus heat in summer
- Economic feasibility and business model
- Dependencies of external supplier

Quellen:

Stockholm Data Parks sets new standards for sustainable data centers

Seasonal thermal energy storage

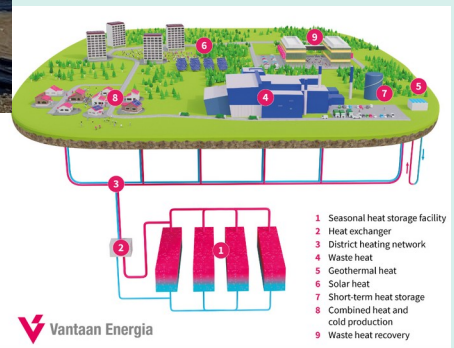
trends

- Geological structures and legacy infrastructures
- New materials
- Model bases operational optimization and design
- Combination of different storage units

examples

Vojens (DK)

Vantaa (FIN)



challenges

- Space demand and construction
- Leakages, insulation, selection of materials, long term stability
- System integration
- Investment costs and long-term economic feasibility

Quellen:
https://www.vantaanenergia.fi/en/the-planning-of-the-worlds-largest-seasonal-heat-storage-is-well-under-way/
Bombert et al - Installation of a thermal energy storage site in an abandoned mine in Picardy (France). Part 1: Selection criteria and equipment of the experimental site

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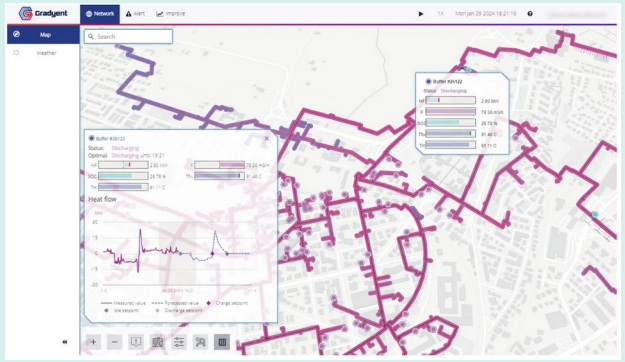
infrastructure

trends

- Decreasing network temperatures,
- Customer involvement, motivational tariffs
- prosumer, bi-directional operat.
- Digitalization, smart controls and demand side management

examples



Digital twins of DH network, e.g. Gradyent in Vienna

challenges

- Different temperature levels from „new“ supply units
- Coordinated network transformation
- Hydraulic limitations for network expansions and new customers
- Complex system with many interdependencies

Quellen:
https://www.gradyent.ai/

And what about the areas outside the DH network?

https://positionen.wienenergie.at/projekte/waerme-kalte/village-im-dritten/?utm_source=mailpoet&utm_medium=email&utm_campaign=energiepolitisches-update_21

https://www.proholz.at/fileadmin/proholz/media/bauholz/2020/003_Modul1_JZeininger.pdf
https://www.tsb-energie.de/fileadmin/Redakteure/Veranstaltungen/Energiewende_und_Klimaschutz/2021/Referentenbeitraege/Johannes_Zeininger_-_Zeininger_Architekten.pdf

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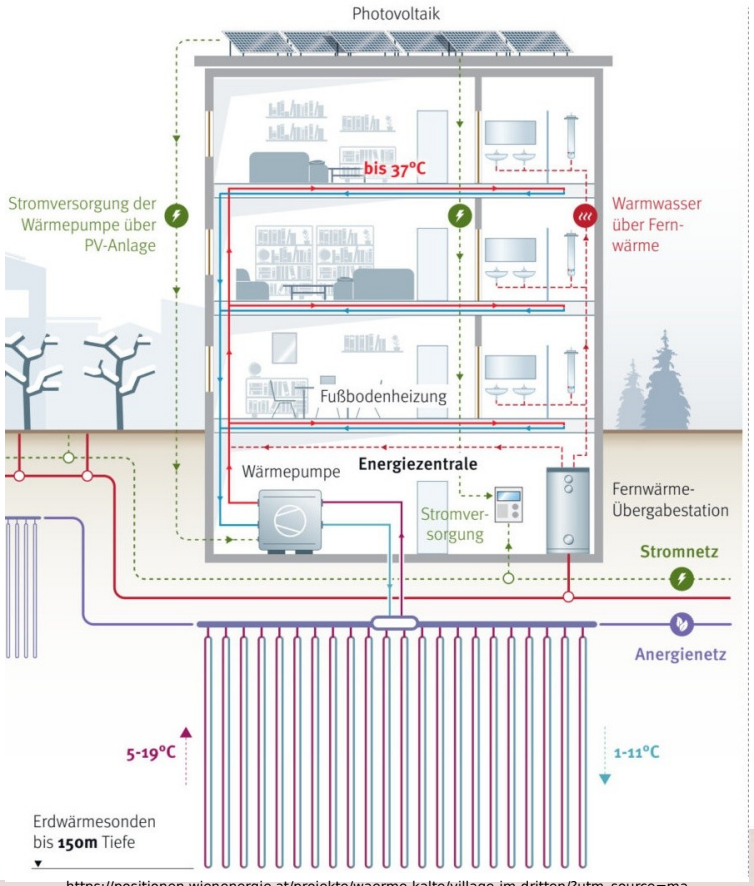
“5th generation” heating and cooling networks

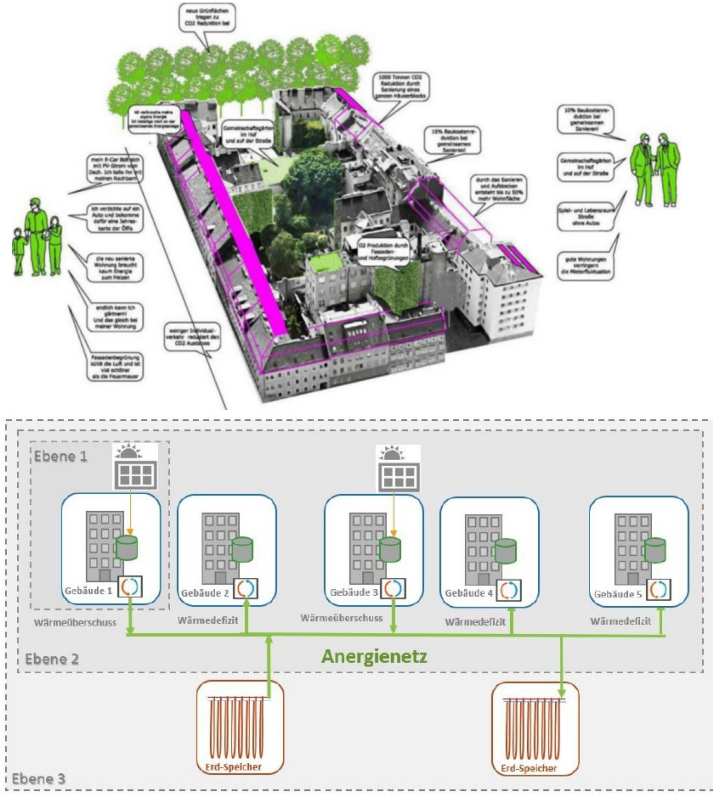
- operate around ambient temperatures,
- together with consumer-side heat pumps.
- waste heat from data centers / cooling processes can be directly utilized.

"Village im Dritten", Vienna



https://positionen.wienenergie.at/projekte/waerme-kalte/village-im-dritten/?utm_source=mailpoet&utm_medium=email&utm_campaign=energiepolitisches-update_21

"Smart Block Geblergasse", Vienna



https://www.proholz.at/fileadmin/proholz/media/bauholz/2020/003_Modul1_JZeininger.pdf
https://www.tsb-energie.de/fileadmin/Redakteure/Veranstaltungen/Energiewende_und_Klimaschutz/2021/Referentenbeitraege/Johannes_Zeininger_-_Zeininger_Architekten.pdf

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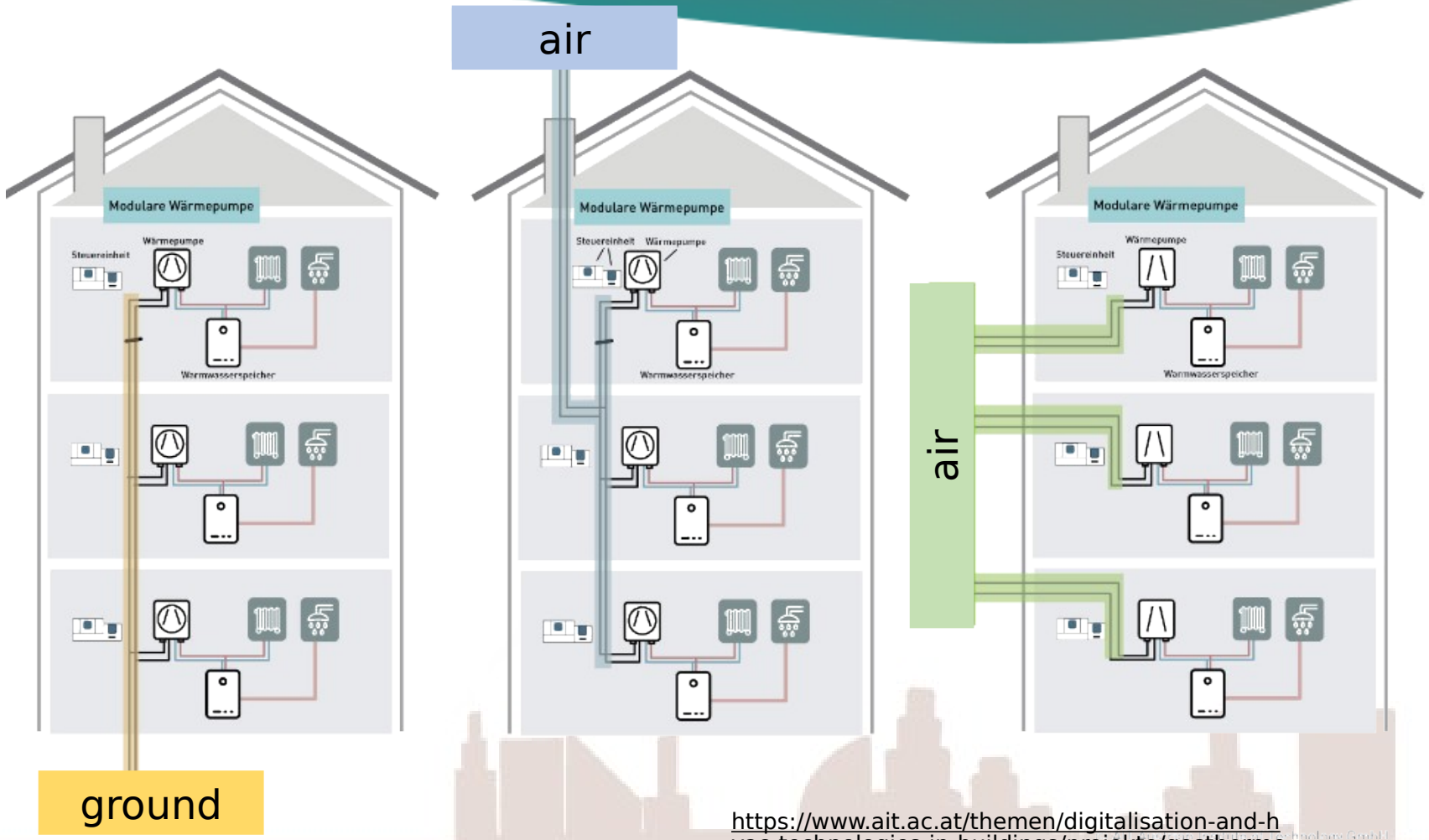
modular heat pumps as gas boiler replacement in large-volume residential buildings.

- The piping can be routed through the now unused chimney.
- waste heat generated during cooling is used to heat water in the summer.



https://www.ait.ac.at/themen/digitalisation-and-hvac-technologies-in-buildings/projekte/gastherme nersatz

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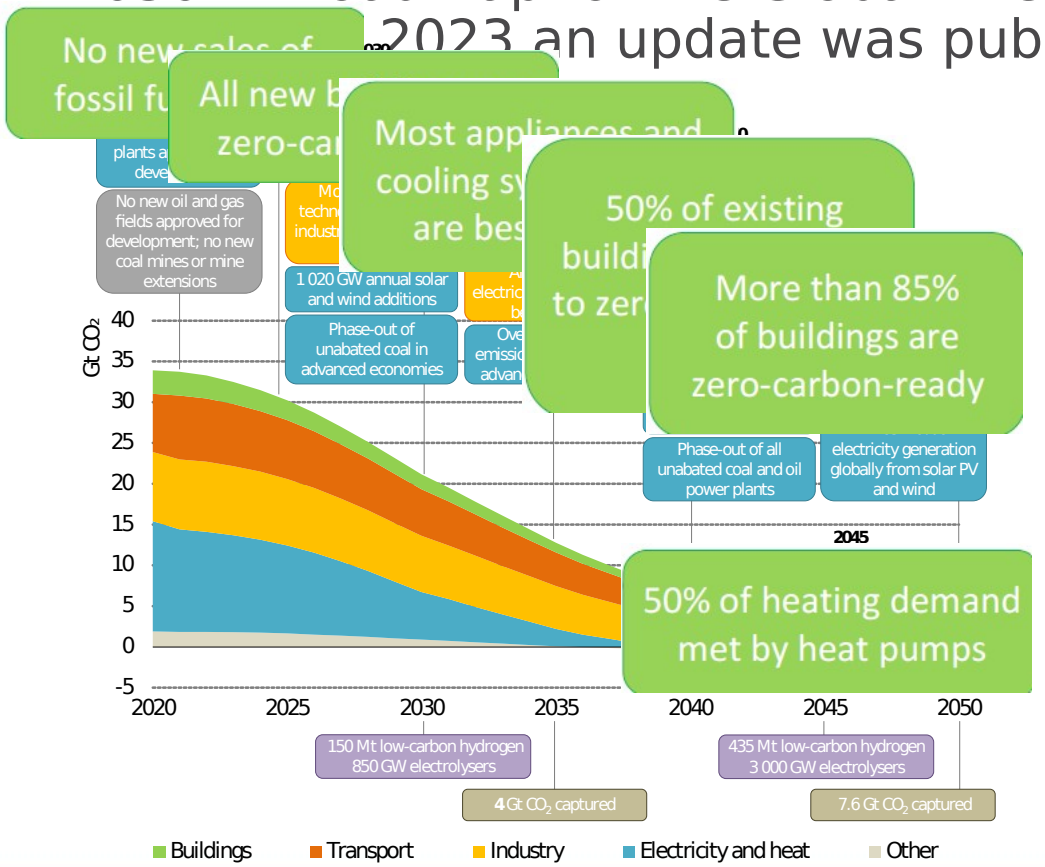
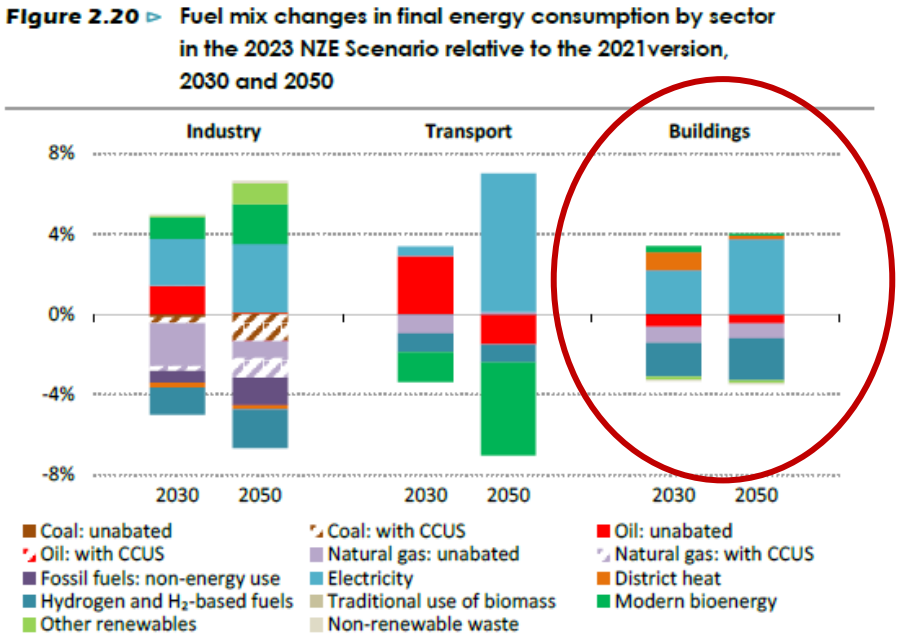
Dr. Caroline Haglund Stignor, RISE, Sweden;
Heat Pump Centre, HPT TCP by IEA

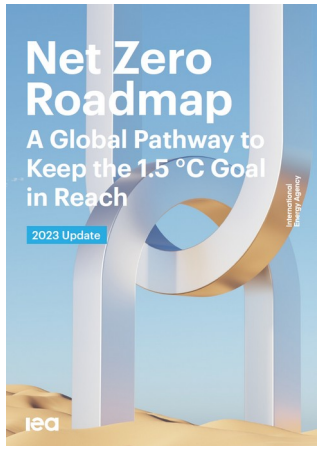
Renewable Heating and Cooling Solutions for Individual Buildings

A Roadmap to Net Zero

- In 2021, the IEA published its landmark report, “Net Zero by 2050: A Roadmap for the Global Energy Sector” – in 2023 an update was published

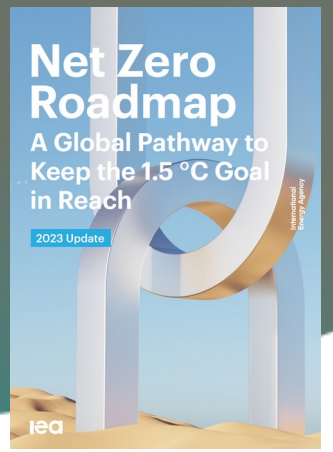




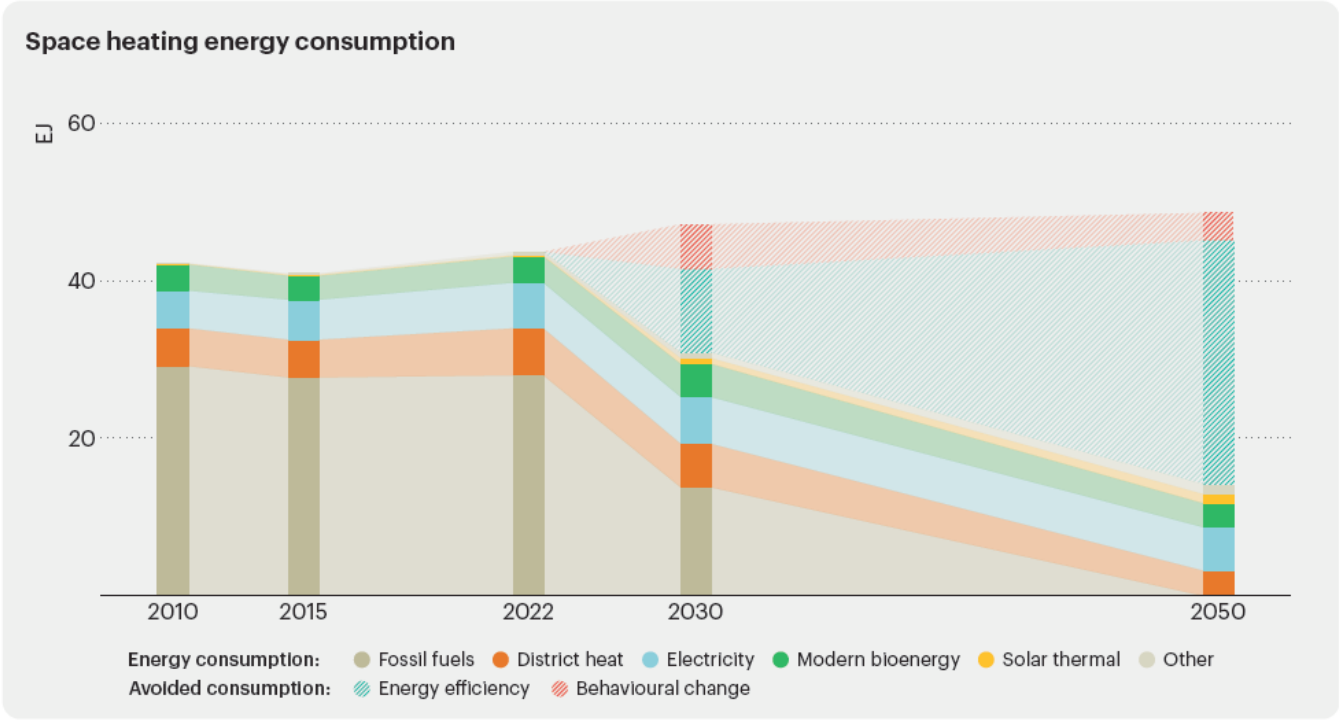


➢ In the buildings sector, the main change is a **faster switch from natural gas to electricity**

Space Heating in NZE Roadmap



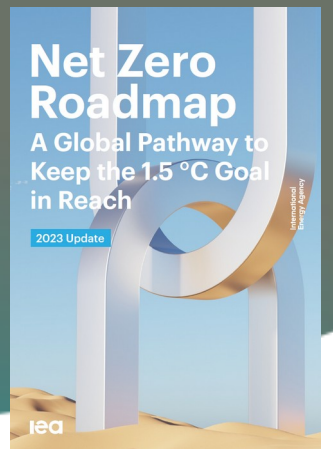
Space heating energy consumption in buildings decreases by almost 70% by 2050 even with a 30% increase in heated floor area in NZE scenario – electrification and increased efficiency from heat pumps



Buildings undergo **deep transformations**. Some **key milestones** of the sector are:

- Beyond 2030 all **new buildings** are **zero-carbon-ready**, and the **retrofit rate** in advanced economies reaches **2.5%**.
- As a result, by 2030, around **20% of the existing building stock** is zero-carbon-ready. By 2050 this share surpasses **80%**.

Space Heating in NZE Roadmap



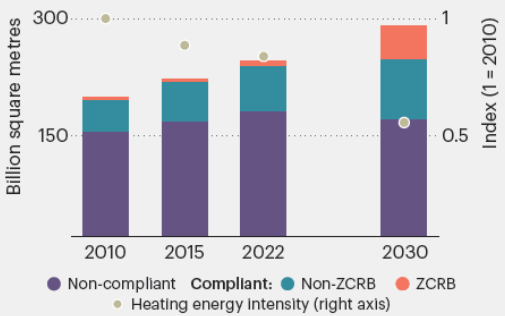
Space heating energy consumption in buildings decreases by almost 70% by 2050 even with a 30% increase in heated floor area in NZE scenario – electrification and increased efficiency from heat pumps

- **Heat pumps** installed in buildings **triple** by 2030 compared to 2022 and increases by a factor 6.5 to reach around 6 500 GW of installed capacity by 2050.

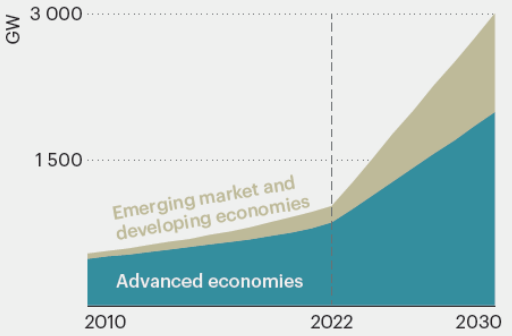
- **Heat pump** average annual **sales growth** of almost **20%** between 2023 and 2030. In the European Union, the annual increase of heat pump sales was over 35% in 2022, implying that the **growth rates** required in the **NZE Scenario** are **feasible**.

Milestones	2022	2030	2035	2050
Heat pumps installed in buildings (GW)	1 000	3 000	4 400	6 500
Share of space heating service demand met by heat pumps	12%	25%	40%	55%
Share of buildings that are zero-carbon-ready				
In new buildings and deep renovations	<1%	100%	100%	100%
In existing building stock	<5%	20%	35%	80%
Retrofit rate in advanced economies	<2%	2.5%	2.5%	2.5%
Heated floor area (billion square metres)	157	170	180	200

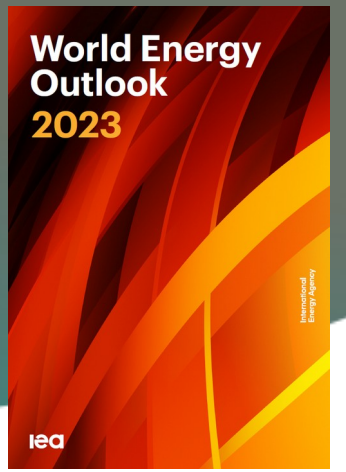
Share of zero-carbon-ready buildings expands rapidly and by 2030 those standards are met in all new buildings



Global heat pump stock nears 3 000 GW in 2030, almost tripling today's capacity

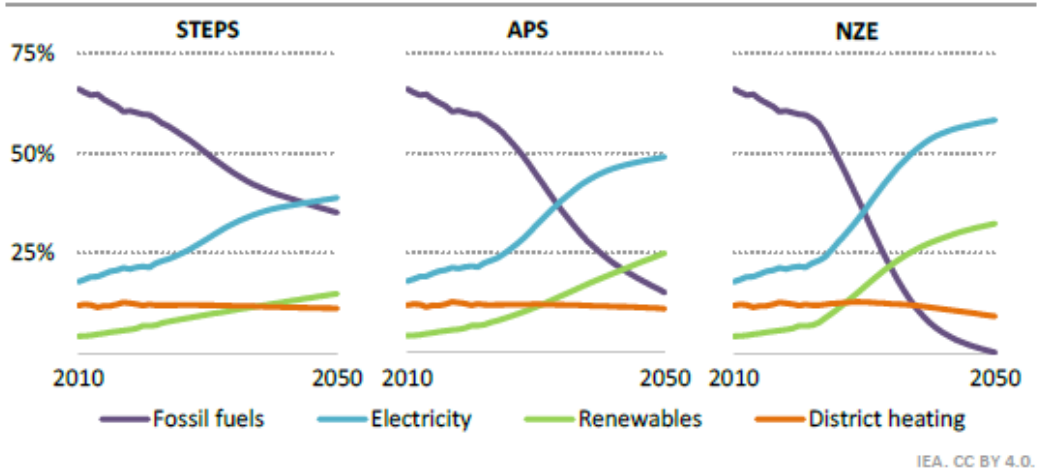


IEA World Energy Outlook



Different scenarios

Figure 3.12 ▷ Share of global energy service demand for heating in buildings by fuel and scenario, 2010-2050



Fuel switching is critical to decarbonise heating, including through the phase-out of fossil fuel boilers and the uptake of heat pumps and other low-emissions options

STEPS Stated Policies Scenario
APS Announced Pledges Scenario
NZE Net Zero Emission Scenario

To reach the **NZE Scenario, policies** that support the decarbonisation of heating include

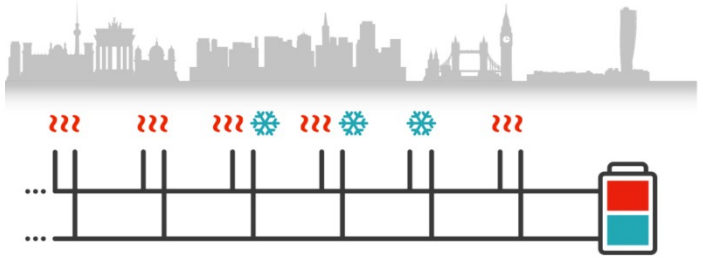
- building energy codes,
- heating intensity standards,
- carbon pricing,
- incentives to adopt **heat pumps** and **clean technologies** and
- **bans** on the **sale** of new **fossil fuel** equipment need to be implemented,

according to IEA. Examples of such policies are already seen in several countries in Europe

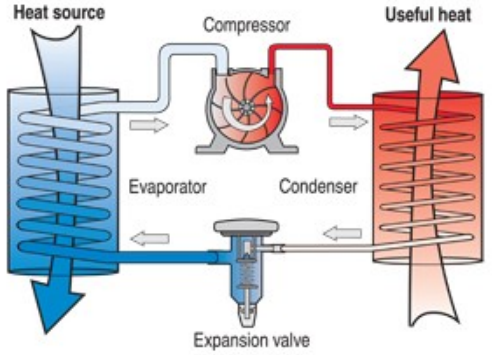
Individual buildings

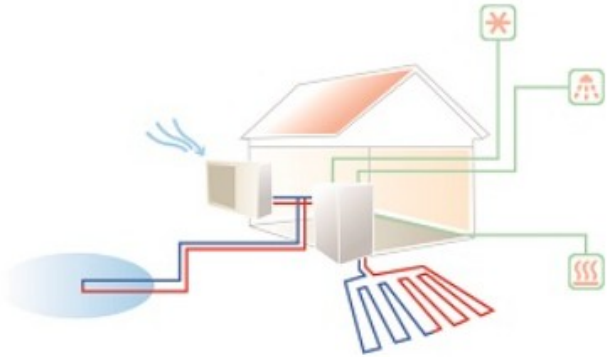
Conclusions – IEA reports

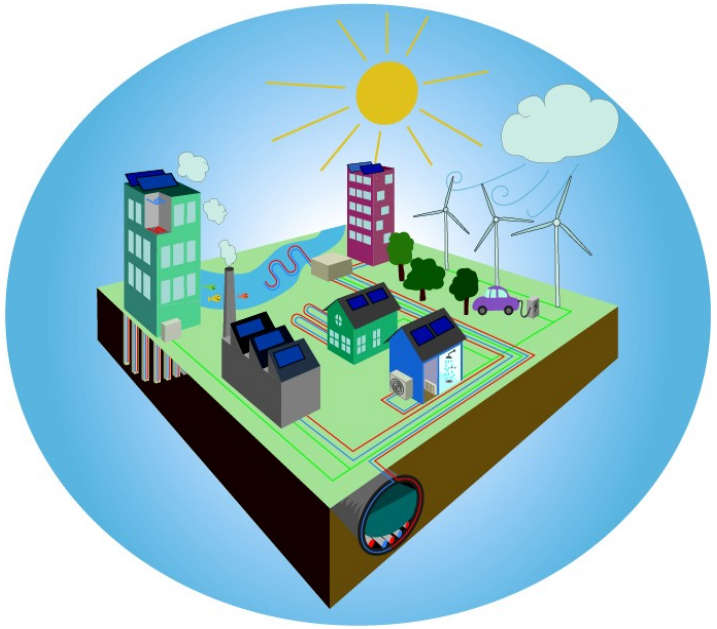
- **Energy efficiency** renovation and **electrification** via **heat pumps are key to decarbonize** heating in individual buildings
- Other **renewable heating techologies** have also **a clear role**
  - District heating (previous presentation)
  - Solar thermal



Source: eon.se







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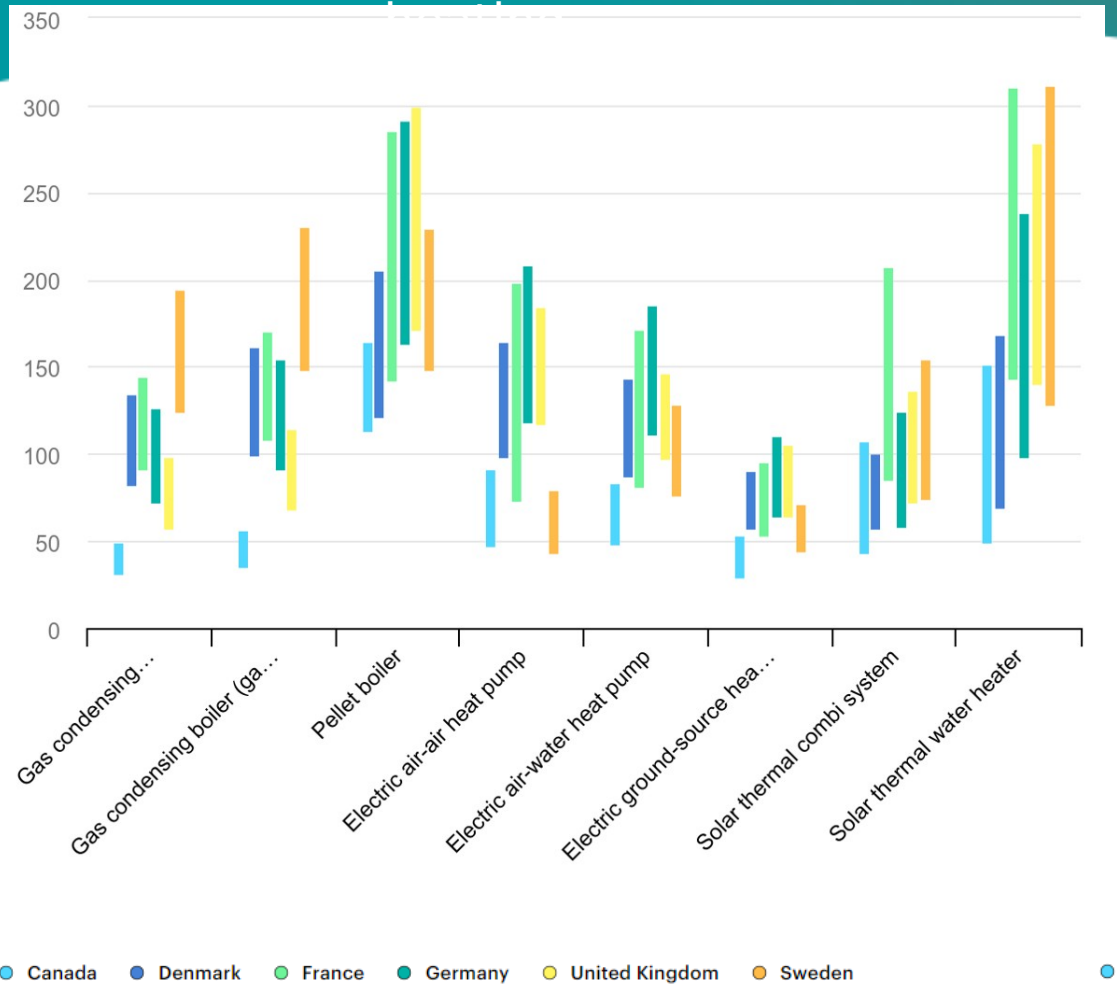
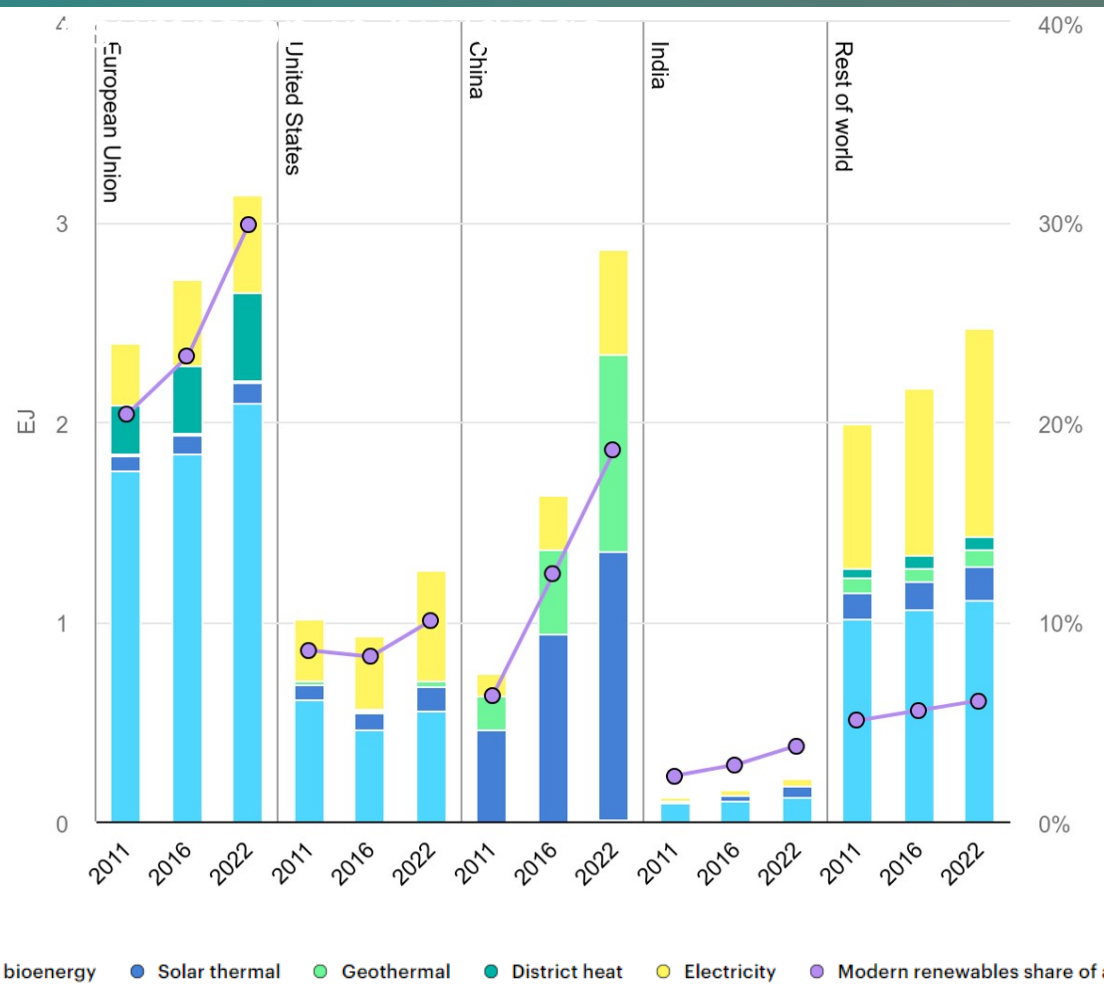
Renewable heating technologies

Levelized cost of



Modern renewable energy use for buildings-related heating and share of total heat



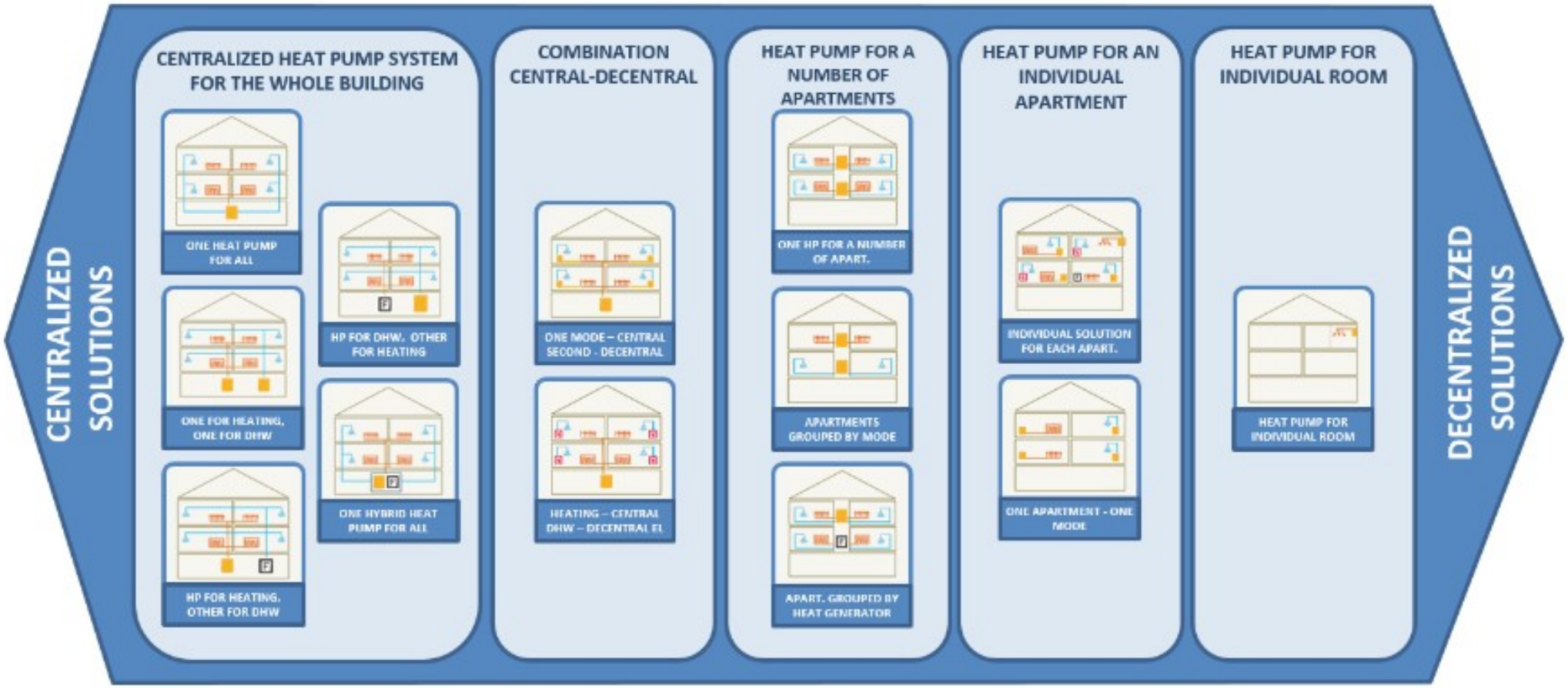
ource: https://www.iea.org/energy-system/buildings/heating#tracking

Switching from fossil fuels to heat pumps

In which type of buildings can heat pumps be applied?

- **New single family buildings?**
  - Yes! If floor heating systems -> very high efficiencies
- **Existing single family buildings?**
  - Yes, in most of them! Works well with radiators. In Sweden over 60% of single family buildings are heated by heat pumps – heat pumps replace many oil boilers!
- **Multi family buildings?**
  - Yes! Some buildings are more challenging than others – many solutions exist!
- **Commercial buildlings?**
  - Yes! Really high seasonal efficiencies can be reached if there is a heating and cooling demand
- **Cold climates?**
  - Yes! Norway, Sweden and Finland are the most « heat pump dense » countries in Europe
- **Climates with cooling and heating demand?**
  - Yes! Many heat pumps can heat AND cool

Heat pumps in multifamily buildings - different many solutions



Progress of deployment

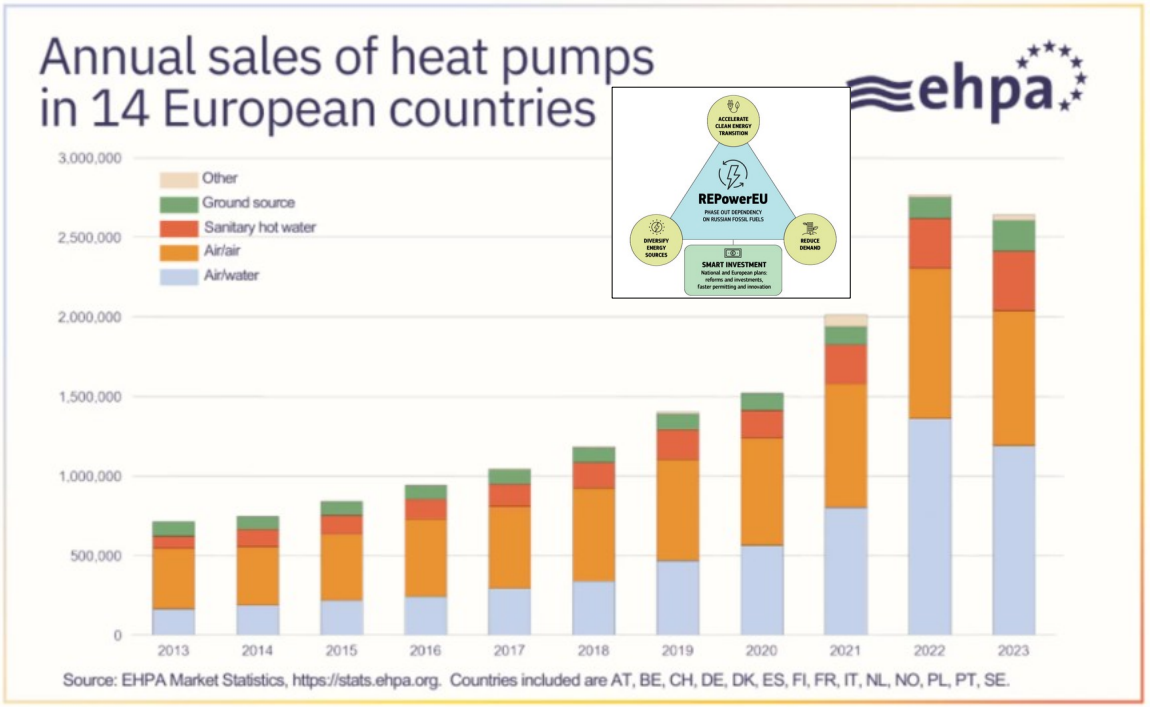
Heat pumps sales declined in most markets in 2023

Reasons behind

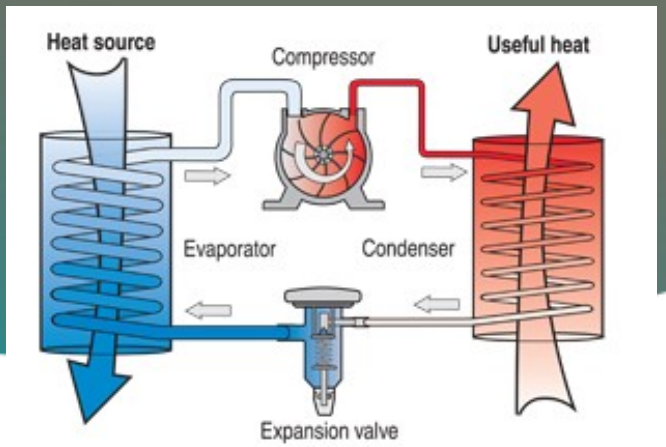
- high interest rates and inflation
  - heat pumps are a major investment for households
  - construction of new buildings slowed down
  - natural gas prices (especially in Europe) have been at much lower levels compared to the peaks in 2022
  - ambiguous policy ambitions – bans are postponed, EC Heat Pump Action Plan on hold

How to reverse the trend?

- stability is of high importance!
  - manufacturing capacity must be increased, investments secured -> stable policy framework to support a market growth
  - clear incentives for electrification and transition away from fossil fuels
- electricity is still significantly more expensive than direct use of fossil fuels on many markets – adjust taxes, levies, invest in clean electricity production



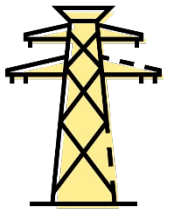
What about cooling?



- All **heat pumps** have a **cold and a warm side** – a **heat source** and a **heat sink**
- If needed a heat pump can **deliver heating and cooling** at the same time
- Many heat pumps can operate in **reverse mode** to **deliver heating** in **winter** and **cooling** in **summer**
- There is **a large, non exploited potential** for improved energy efficency by using both sides of the heat pump
- **Large heat pumps** in **district heating** and **cooling grids** are suitable for providing **simultanous** heating and cooling
- **Demand** for cooling will **increase** – also in Europe

Conclusions

- **More efforts** and an **ambitious, stable policy framework** needed to **decarbonize** heating and cooling of individual buildings
- **Energy efficiency** renovation and **electrification** via **heat pumps are key to decarbonize** heating in individual buildings
  - Other renewable heating technologies have also a clear role
- **Challenges** for **accelerated deployment** of **heat pumps**
  - High upfront cost, electricity-to-gas price ratio -> alternative business modelsadjust taxes and levies
  - Lack of skilled workforce, low awareness and trust in heat pumps -> educate, train, inform
  - Not sufficient power capacity in electric grids -> strengthen, build out, flexibility
  - High temperature of heating system (some buildings) -> renovate buildings, exchange/add radiators
- **Cooling demand** will **increase** – many heat pumps can be used for heating AND cooling – efficiency and flexibility important



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RHC Event

How to fully decarbonise the heating and cooling sector in Europe?

10 April 2024
Graz (Austria)

Thank you!

This session is organised by

RHC Renewable Heating & Cooling
European Technology and Innovation Platform

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RHC Event

How to fully decarbonise the heating and cooling sector in Europe?

10 April 2024

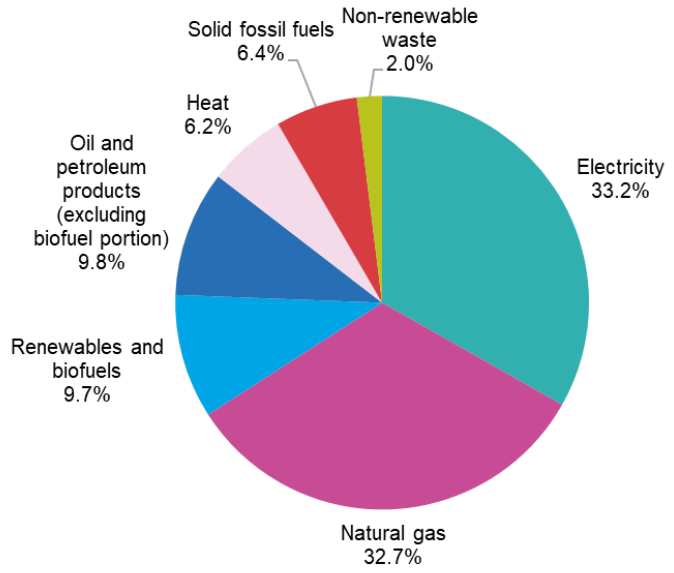
Graz (Austria)

Wolfgang Gruber-Glatzl, AEE INTEC

The Challenge of Decarbonizing Heat Demands of Industries

Industrial Energy and Power Demand in Numbers

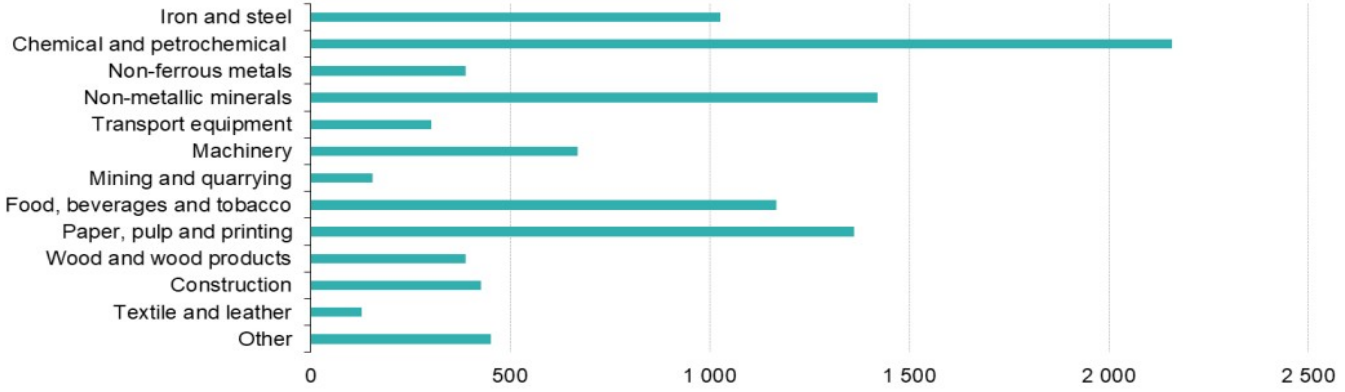
Final energy consumption in the industry sector by energy product, EU, 2021 (PJ)



Source: Eurostat (nrg_bal_s)

eurostat

Total final energy consumption by industrial sector, EU, 2021 (PJ)



Source: Eurostat (nrg_bal_s)

eurostat

- **32% of the European final energy demand is provided by industry**
- **33% is provided by electricity**
- **Process heat accounts for 67% of the final energy demand 30% in the LT sector; 22% in the MT sector; 48% in the HT sector**
- **High share of fossil energy sources**

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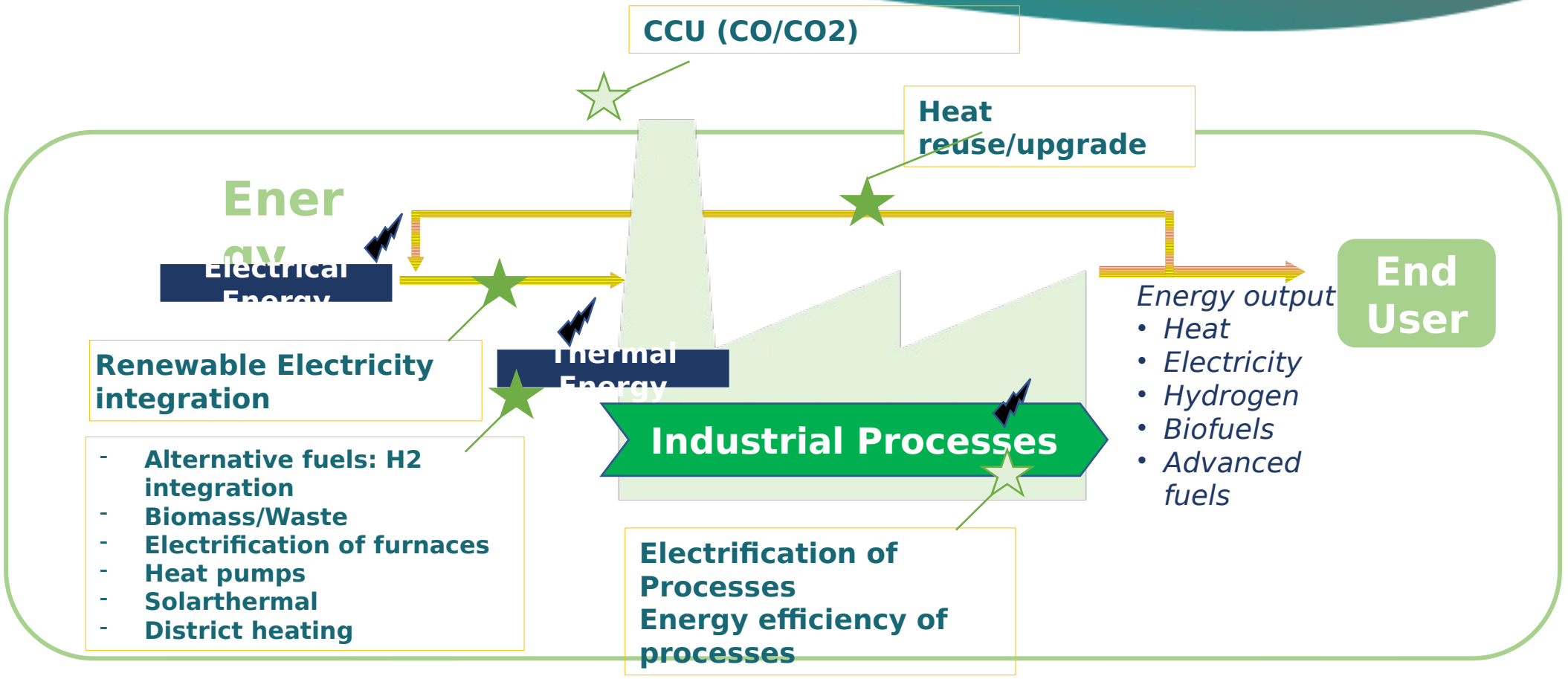
Towards sustainable use of energy



Source: P4PLANET

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Hybridization of the energy mix

Mix of different renewable energy sources is needed to ensure a secure, climate-friendly and cost-efficient energy supply

	Temperature level (commercial)	Technical availability	Availability in time	Economic efficiency (today)	Land requirements (incl. energy generation)	Integration	Potential Germany /EU
Solar thermal	80°C – 420°C	🟢	5000 – 6500 Full load hours	🟢	🟢	🟡	🟡
Thermal storage	60°C - 560°C	🟢	Generates flexibility / replaces electricity storage	🟢	depending on heat source	🟢	🟢
	Options for hybridization						
Electric direct heating	Up to 420 °C	🟢	depending on availability green electricity	🟢	🟡	🟢	🟢
Heat pump Steam compressor	70 °C – 100°C 100-150°C 150-250 °C	🟢 🟡 🟢	depending on availability green electricity	🟡	🟢	🟡	🟢
Storage power plant	100 °C- 550 °C	🟡	4000 h with thermal storage	🟡	🟡	🟡	🟡
Deep geothermal	Up to 200°C in DE	🟡	7000- 8000 h Full load hours	🟡	🟢	🟡	🟡
Biomass (residual, old, damaged wood)	Up to 500°C	🟢	7000 – 8000h Full load hours	🟢	🟢	🟡 Transport	🟡
Biogas (Waste materials)	All temperature ranges	🟢	7000 – 8000h Full load hours	🔴	🟢	🟡	🟡
Green hydrogen	All temperature ranges	🟡	7000-8000 Full load hours	🔴	🔴	🟡 Transport and storage	🟡

- 🟢 Commercially available / competitive / low complexity
- 🟡 Limited availability / competitive in niches / medium complexity
- 🔴 Not available / not competitive / high complexity

AEE INTEC

Source: Deutsche CSP, "Accelerating the Heat transition in the Industry", July 2022, available from https://www.deutsche-csp.com/en-gb/mediathek

Consequent exergetic heat supply on two temperature levels

Above 200°C

- H2
- Green gases (biogas)
- Biomass
- Electricity

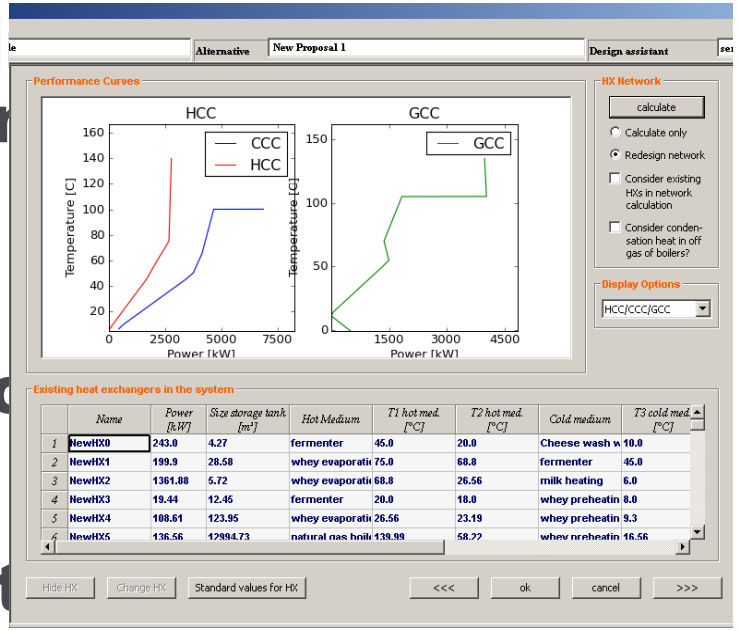
Below 200°C

- District heating coupling
- Heat Pumps
- Solarthermal
- Excess heat
- Geothermal
- Biomass CHP

Efficiency is the first fuel

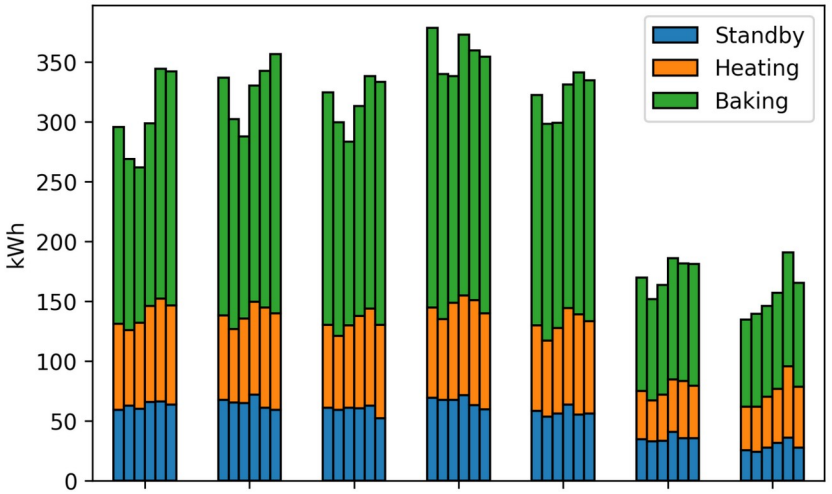
- Reduce consumption and the production of long-lasting products
- Process Intensification:
  - Enhanced process efficiency by reduci
    steps, simplifying equipment design, ar
    energy losses
  - Integration of unit operations into sing
  - Novel reactor designs – batch to conin
  - Advanced process control

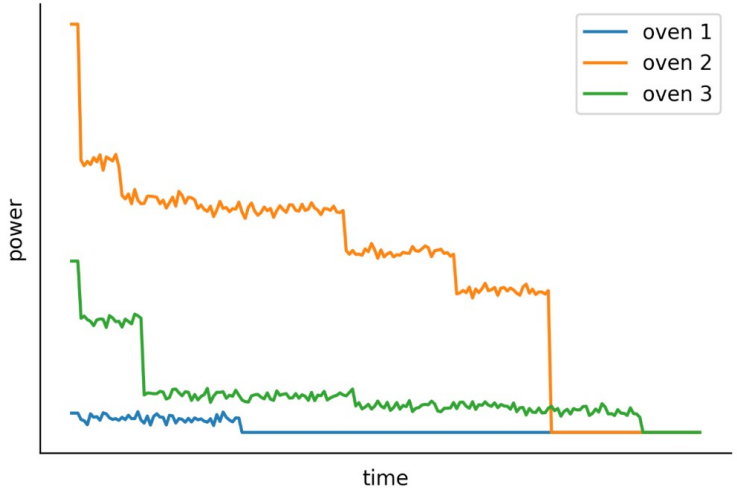
System optimization – optimized Pinch met



Example: Energy Efficiency in Bakeries

- **Avoid deep-freezing of bakery goods**
  - **Develop right grain/doughs**
  - **Inhibit mould growth by UV light and right humidity**
  - **Smart logistics between production and shops**
- **Optimization procedure for timing of baking jobs (ovens and products)**





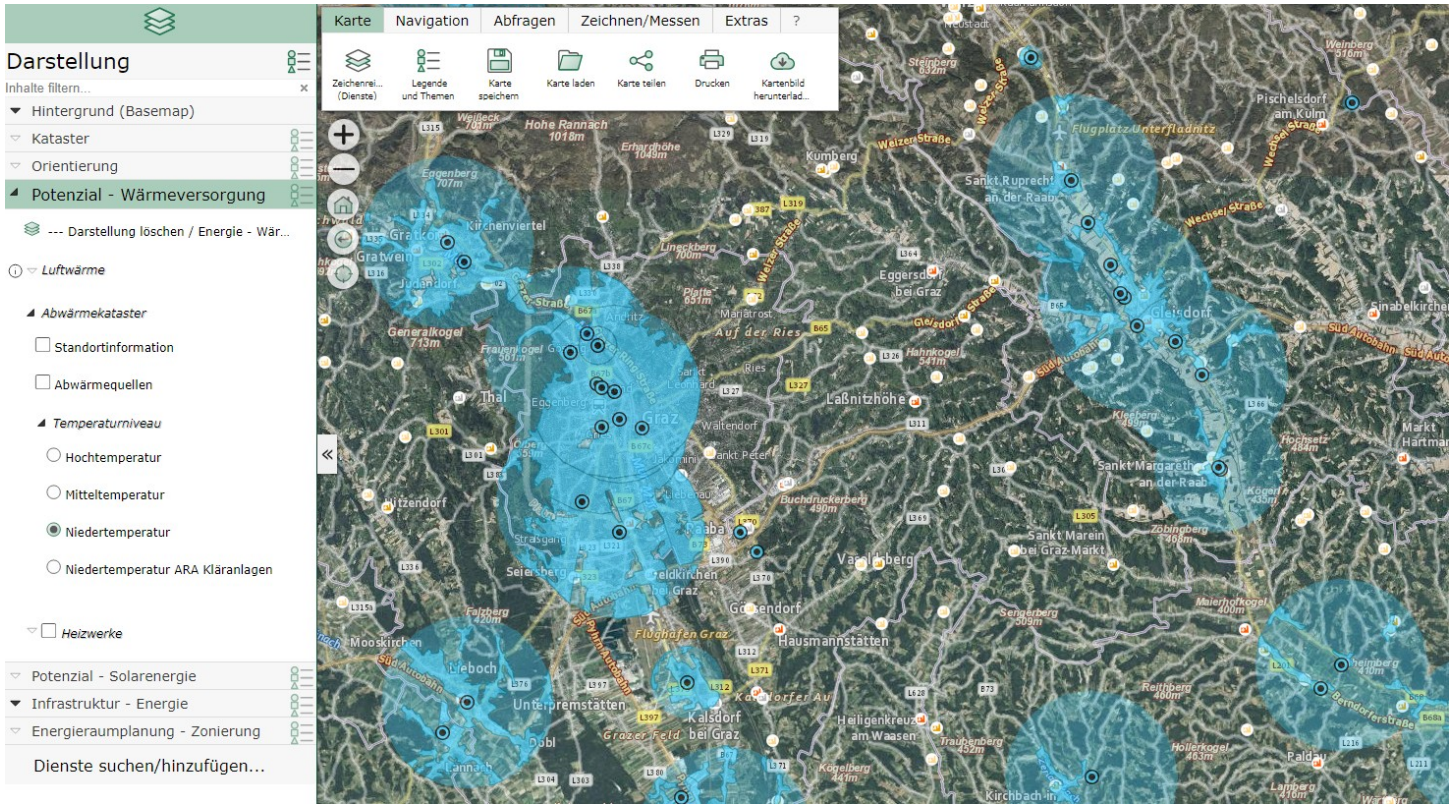
Source: AEE INTEC, Reiter Jana et al (2022) DSMopt, Energy Optimization of a Bakery

Use of the whole excess heat potential! Excess heat map in Styria

- **Technical Excess Heat Potential: 7.58 TWh/a**
  - **9% used (0.70 TWh/a)**
  - **91% not-used (6.88 TWh/a)**

- **Low temperature dominant at not-used potential**
  - **82% <50 °C 5.63 TWh/a**
  - **9% 50-100 °C 0.62 TWh/a**
  - **9% >100 °C 0.63 TWh/a**

- **Put into perspective …**
  - **14% of Styrian final energy demand (52.40 TWh/a)**
  - **29% of Styrian final heating demand (25.78 TWh/a)**



Final Report:
https://www.aee-intec.at/awkst-waste-heat-register-styria-p378

Online Map:
https://gis.stmk.gv.at/wgportal/atlasmobile/map/Versorgung%20-%20Entsorgung/Energiewirtschaft%20und%20-planung

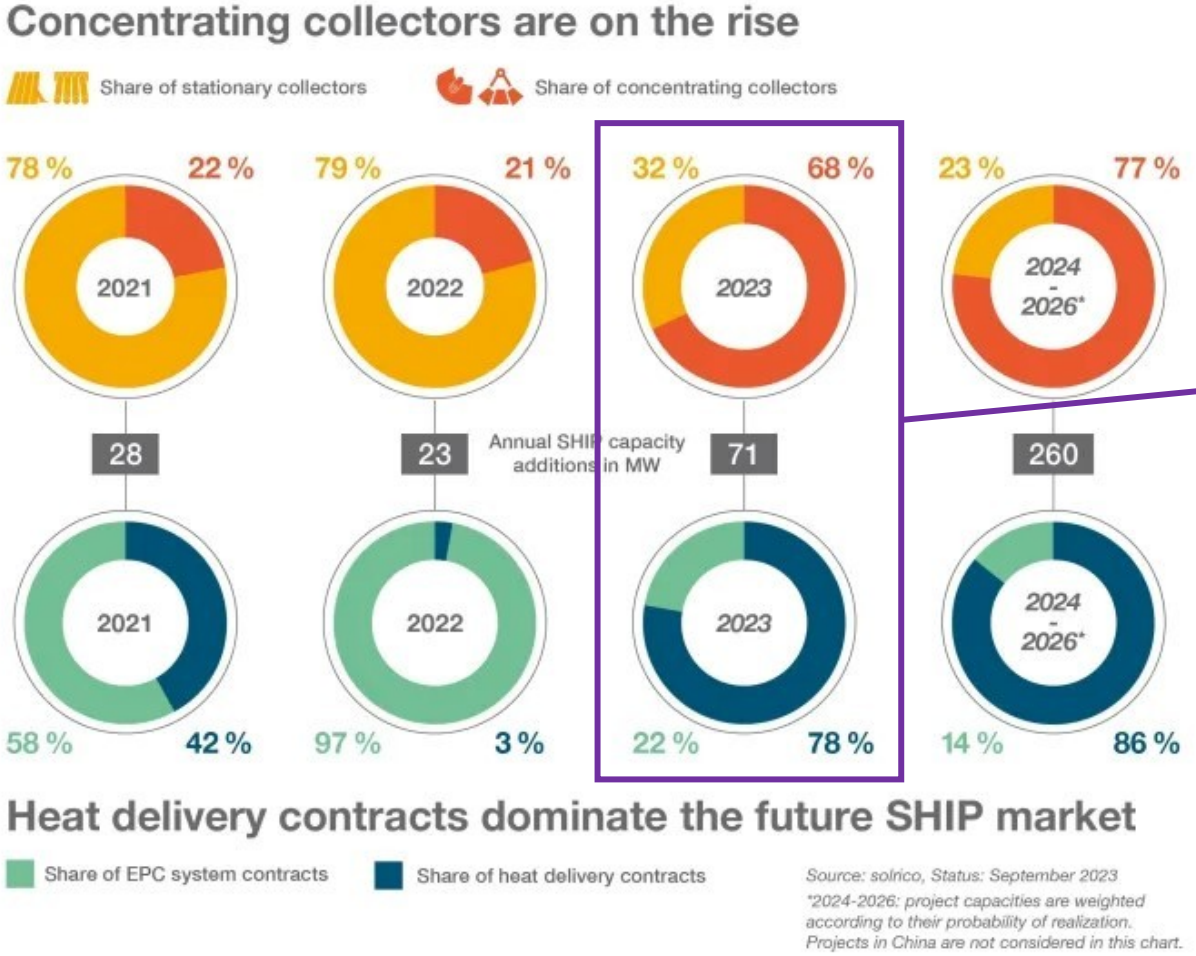
100% renewables at breweries
1st stage implemented 2023/24
2nd stage 100% renewable 2026

- **Heat pump (800 kW)**
- **COP 3.30 @ 88 °C / 23 °C**

Bottling washing machine

Sources of pictures: Puntigamer, Brauunion Österreich. Source of flow sheet

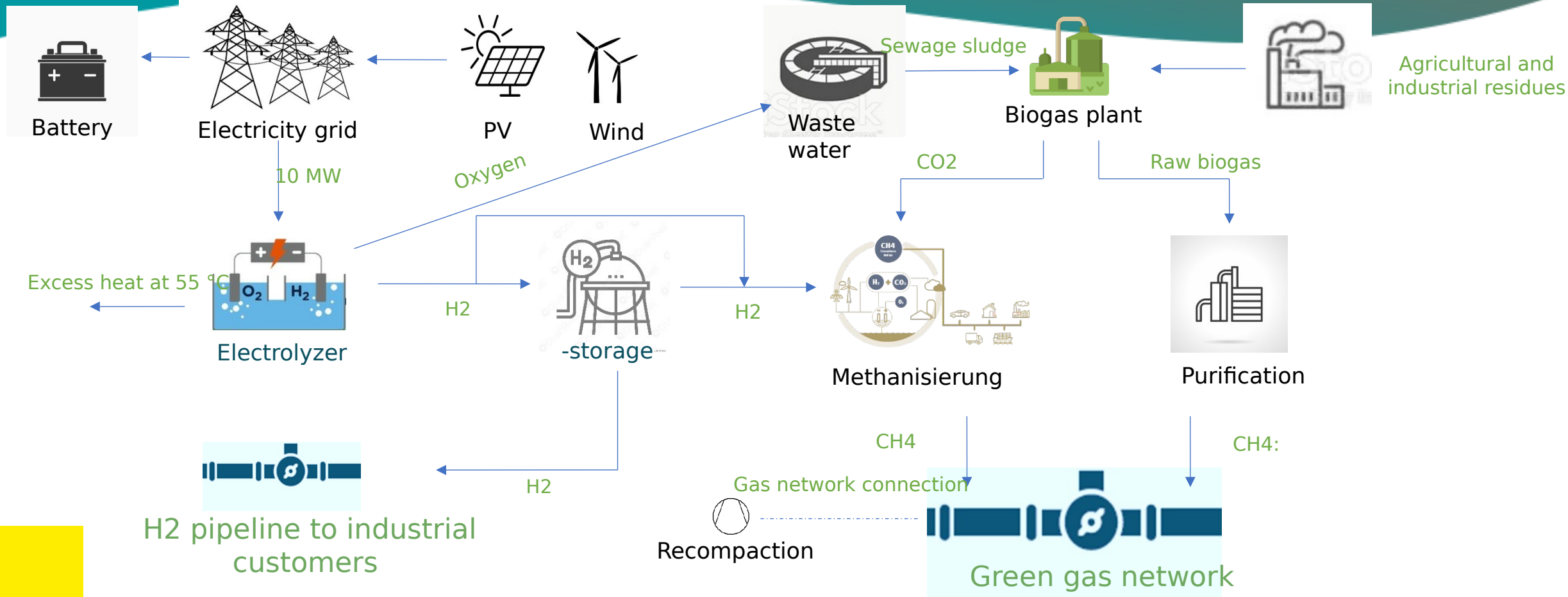
Solar Heat for Industrial Processes (SHIP) Market



- **2023:**
  - **Outlook: 71 MW**
  - **Actual: : 95 MW ***

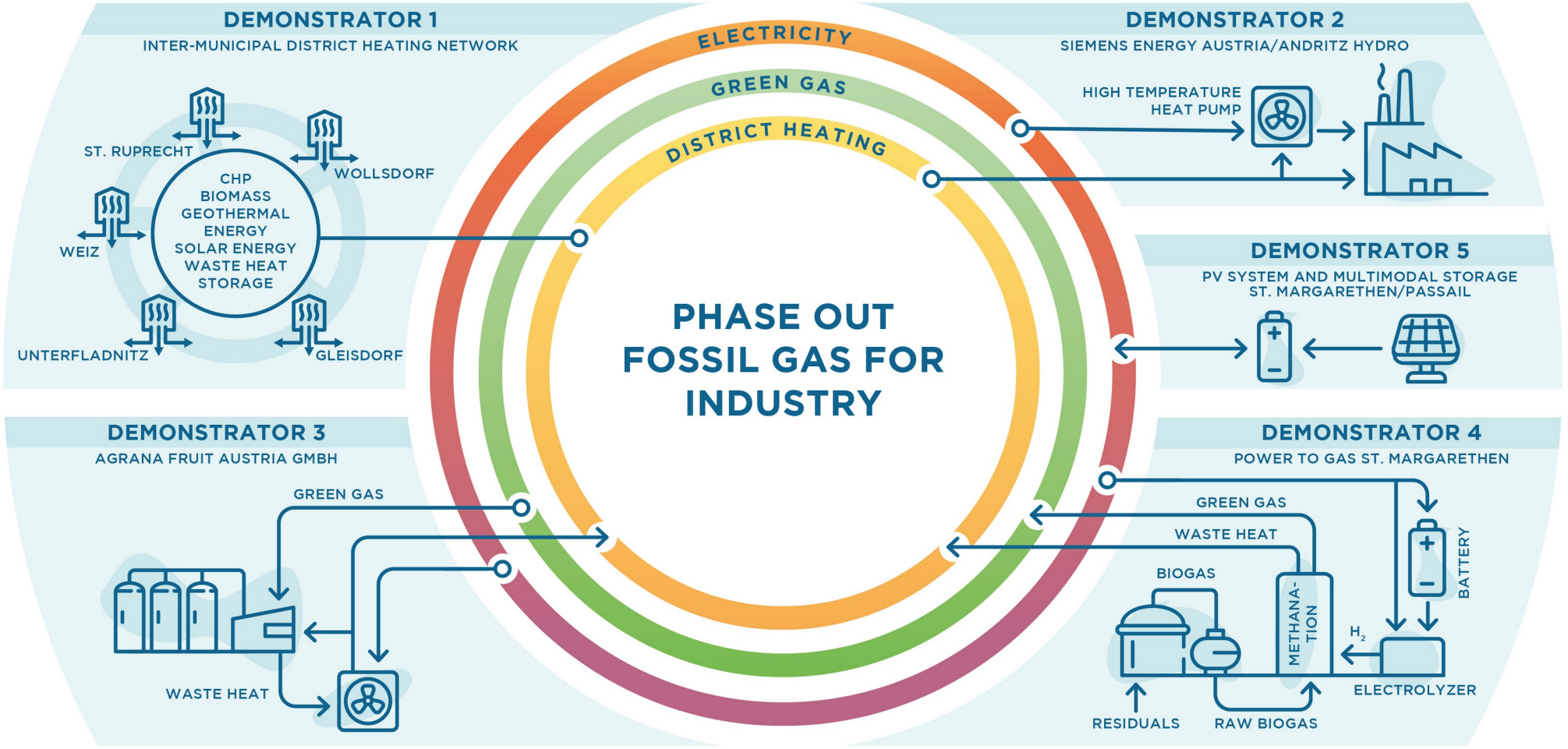
**** Preliminary report of Solar Heat Worldwide 2023***

Increase the green gas production
Renewable gasfield



Source: E-STMK/AEE INTEC

Hubs for Circularity - Concept of Region Weiz



Source: AEE INTEC

Summary

1. Emphasis on **energy reduction and energy efficiency** by excess energy reuse and through disruptive and more efficient (exergetic) processes.
2. I**nnovation in energy technologies**: Focus on developing new technologies for integrating electricity, improving energy efficiency, and developing **hybrid energy supply**.
3. Consequent energy supply under **exergetic considerations** (two temperature levels) in order to guarantee sustainable supply and availability of sources
4. Use of emerging energy carriers like **hydrogen and ammonia**, along with renewable energy sources and alternative conversion technologies for high temperature processes
5. **Hubs for circularity** play a critical role in driving the transition towards a circular economy by facilitating resource exchange

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10 April 2024
Graz (Austria)

Thank you!

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