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Waste into wealth: how heat pumps can recycle heat to save energy - and the EU policy that matters

Waste Heat Recovery (WHR) with heat pumps is the process of capturing and reusing waste heat that would otherwise be wasted. Waste heat can unlock major benefits as a renewable energy source, capable to satisfy a potential part of the EU's building, industrial process and hot water needs. This paper explores the potential of WHR with heat pumps, the environmental and financial benefits of WHR, the current EU policy landscape, and provides policy recommendations to unlock the potential of WHR.

1. WHR with heat pumps

Heat pumps can capture and reuse waste heat, lifting it to a significantly higher temperature. Waste heat recovery with heat pumps needs three components:

- A waste heat source
- A thermal energy network to store and distribute heat
- A heat sink, in other words a user in need of energy.

Heat sources can be industrial processes, data centres, office and commercial buildings. Often waste heat is the result of cooling processes. Heat networks, also known as district heating and cooling[1] can operate at ambient or – if insulated – at higher temperatures. Heat sinks can be commercial or public service buildings (hospital, offices), industrial processes or high temperature district energy network. Deploying heat pumps helps improve energy efficiency in various applications and reduces the need to generate "new" energy.

Heat pumps are devices that provide heating, cooling, and hot water for homes, businesses, and industries by transferring energy from water or air sources. They "pump" the energy from a lower to a higher level using the refrigerant cycle (evaporation, compression, condensation, and expansion). At the same time, the heat source is cooled down. This process can happen onsite, in an industrial process or a building or between sites, in which case an energy network is needed to transport the recovered energy.

Widely used in offices, hospitals, and commercial centres, heat pumps can also play a key role in decarbonising the EU's industrial sector.

Energy-intensive industries, such as dairy, paper, beverages, and food, as well as nearly any drying process, can retrofit large heat pumps to increase energy efficiency and reduce primary energy consumption. Capable of reaching temperatures up to 200ºC, heat pumps are suitable for process heat supply, often replacing natural gas, and can be two to four times more efficient than traditional heating methods by utilising low-grade waste heat. If both heating and cooling are required, the efficiency is even greater, with one unit of electricity providing five to nine units of useful heating and cooling.

In this case, one part of the heat pump cools a system (a data centre, a building, food processing etc) and recycles the energy extracted by raising its temperature, providing it on the hot side of the heat pump to a user of heat, e.g. a district energy network or a hospital. Higher temperatures can

[1] Reference to Article 2, EPBD that defines district heating and cooling networks as a multi input, multi source energy network.

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be achieved by having several heat pumps, each feeding into the next ('multi-stage installations') and the efficiency can be increased by connecting buildings with complementary heating and cooling needs through thermal energy networks, allowing heat from one building's cooling system to be reused for heating in another. In addition, data centres consume high amounts of electricity to process information and thereby produce large quantities of waste heat. According to the IEA[2], global data centre electricity consumption in 2022 was 240-340 TWh, or roughly 1-1.3% of global electricity demand.

With 17,000 district heating and networks serving 67 million Europeans across the continent, waste heat recovery is an established solution in urban areas. This interactive map displays all low-grade heat sources available in all European Union countries (UK included) and includes also industrial waste heat and heat from waste incineration plants. Today's challenge of greening district heating lies in the conversion of fossil-based heat generation to emission free heating and cooling, as can be provided by heat pumps.

2. The environmental and financial benefits of WHR

Reusing waste heat will lower costs for consumers by decreasing the demand for primary energy sources and reducing the need for additional heating systems, as it is cheaper to just reuse energy than it is to buy it or to produce it.

Waste heat can replace fossil energy otherwise used to produce heat, without putting further pressure on the electricity grid. Fully enabling waste heat through an integrated approach has the potential to save € 67.4 bn a year (in 2050) once fully implemented in the EU[3] – around the current GDP of Slovenia. Savings become particularly relevant when it comes to space heating in existing buildings, where the deployment of heat pumps can replace energy demand and reduce the need for deep renovation. Recent studies have shown that heat pumps can be deployed in partially renovated buildings, making a larger number suitable for decarbonisation. This efficiency grows as more applications including data centres, electric cars and hydrogen electrolysis compete with heat pumps for an increasingly strained electricity grid.

The industrial sector needs to re-utilise waste heat to meet energy efficiency targets as its own waste heat sources are currently only rarely exploited and major potential is being wasted. This energy potential matches the **total energy demand** for heating and hot water in residential and service sector buildings across the EU27 + UK, which stands at approximately **3,180 TWh per year**[4].

3. EU policy landscape

The EUs "Fit-for-55" package includes the use of waste heat in many provisions, as it recognises the need to stop wasting thermal energy. The different pieces of European legislation addressing waste heat recovery are listed below.

Renewable Energy Directive (RED III)

The renewable energy directive sets an overall target for the share of energy from renewable and waste heat sources of 43.5% to be reached by 2030.

- **Definition of Waste Heat and Cold (Article 2)**

"Waste heat and cold means unavoidable heat or cold generated as by-product in industrial or power generation installations, or in the tertiary sector, which would be dissipated unused in air or

[2] https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks
[3] https://heatroadmap.eu/wp-content/uploads/2019/02/HRE_Final-Brochure_web.pdf
[4] Connolly, D., et al. (2013). Heat Roadmap Europe 2: Second Pre-Study for the EU27. Department of Development and Planning, Aalborg University

water without access to a district heating or cooling system, where a cogeneration process has been used or will be used or where cogeneration is not feasible".

To qualify as waste heat or cold under the RED III, four cumulative criteria must be met:

1. Waste heat and cold should be 'unavoidable'. It cannot reasonably (technically and economically) be avoided or internally consumed or reduced (at all stages) through technical and energy efficiency improvements.
2. The generation of waste heat and cold should be a 'by-product'. The primary aim of the process should not be to generate that specific fraction of heat and cold.
3. The generation of waste heat and cold should take place in '*industrial or power generation installations, or in the tertiary sector'.*
4. The heat or cold *'would be dissipated unused … without access to a district heating or cooling system'.* The heat or cold stream has to be delivered to a district heating or cooling system. Waste heat recovery without access to a district heating or cooling system, for instance on-site or to a single building cannot be accounted for the purposes of RED.

In addition to these four cumulative criteria, for a heat or cold stream to be considered as waste heat or cold and contribute to the fulfilment of the RED targets, the definition states an overall requirement to always consider *'cogeneration'* of both electricity and heat before resorting to heat only production.

- **Mainstreaming renewable energy in buildings (Article 15a)**

Paragraph 2 of Article 15a allows waste heat and cold to account for up to 20% of a Member State's renewable energy share. If this is the case, the target shall be increased by half of the percentage used.

As explained in the European Commission guidance on heating and cooling aspects in Articles 15a, 22a, 23 and 24 of the Renewable Energy Directive, if a Member State were to set an indicative target of 50%, they would be allowed to count 10 percentage points (20% of 50%) of waste heat and cold towards that target. The indicative target would then however increase by 5 percentage points (half of the percentage of waste heat and cold counted towards that target), resulting in an indicative national share of 55%.

- **Mainstreaming renewable energy in industry (Article 22a)**

Article 22a introduces an indicative target for the industry sector and a mandatory renewable liquid and gaseous fuels of non-biological origin (RFNBO) target. In particular, it mandates that *"Member States shall endeavour to increase the share of renewable sources in the amount of energy sources used for final energy and non-energy purposes in the industry sector by an indicative increase of at least 1,6 percentage points as an annual average calculated for the periods 2021 to 2025 and 2026 to 2030."*

Article 22a mandates that only waste and cold supplied from efficient district heating and cooling may be accounted and that there is no upper limit when calculating by how much the target must be increased as a result of accounting waste heat. The target should be increased by half the percentage points of waste heat and cold counted.

Article 22a also specifies that waste heat from networks *"where all the thermal energy is used exclusively on-site and is not sold should be excluded".* This provision targets industrial sites where a single enterprise has multiple buildings connected to the same district heating network and consumes its own waste heat.

- **Target for the share of renewables in heating and cooling (Article 23)**

Member States may count waste heat and cold towards the average annual increase of renewable energy in the heating and cooling sector. This annual increase is set to at least 0,8 percentage points per year for the period 2021 to 2025 and to at least 1,1 percentage points for the period 2026 to 2030. Waste heat can cover a maximum of 0,4 percentage points of this increase.

Article 23 also mandates Member States to assess the potential for utilising renewable energy and waste heat and cold in their heating and cooling sector. *The assessment shall consider available and economically feasible technologies for industrial and domestic uses to increase the use of renewable energy in heating and cooling and, where appropriate, the use of waste heat and cold through district heating and cooling.*

- **Target for the share of renewables in district heating and cooling (Article 24)**

Member States shall endeavour to increase the share of energy from renewable sources and from waste heat and cold in district heating and cooling by an indicative 2,2 percentage points per year.

Member States with a share of energy from renewable sources and from waste heat and cold in district heating and cooling above 60 % may count any such share as fulfilling the average annual increase. Member States with a share of energy from renewable sources and from waste heat and cold in district heating and cooling above 50 % and up to 60 % may count any such share as fulfilling half of the average annual increase.

Energy Efficiency Directive (EED)

- **Energy efficiency first principle (EE1st) (Article 3)**

Article 3 requires Member States to ensure that available energy efficiency solutions that meet the same specific need/policy objective, are assessed in planning, policy and major investment decisions.

The Commission's recommendation 2024/2143 sets guidelines for the interpretation of Article 3 of the EED and provides examples of possible alternatives or complementary solutions to plans for additional infrastructure developments in energy systems and non-energy sectors. Waste heat recovery is listed as an alternative /complementary solution in the heat, industry, and ICT sectors.

In addition, the recommendations suggest measures across policy areas to facilitate the EE1st principle's application. The reuse of waste heat and integration of waste heat in district heating networks is listed as measures in the policy area of energy supply and distribution.

- **Commission Delegated Regulation 2024/1364 on the first phase of the establishment of a common Union rating scheme for data centres** (Implementing Article 12 of the EED)

Reporting on data centres should ensure that the information and key performance indicators – set out in the Annexes to the Delegated Regulation 2024/1364 - are inserted in the European database on data centres. The key performance indicators are to measure the energy consumption, power utilisation, temperature set points, waste heat utilisation, water usage and use of renewable energy of data centres.

- **Heating and cooling assessment and planning (Article 25)**

i. *Member States are encouraged to take adequate measures for the development of efficient district heating and cooling infrastructure and waste heat utilization*.

ii. *Member States shall include in their regional and local heating and cooling plan an estimate and mapping of the potential for increasing energy efficiency, including WHR (municipalities having a total population higher than 45 000).*

- **Heating and cooling supply (Article 26)**

i. *Set the criteria for an efficient district heating and cooling system to ensure more efficient consumption of primary energy and to increase the share of renewable energy in heating and cooling supply going into the network.*

ii. *Member States shall ensure that data centres with a total rated energy input exceeding 1 MW utilize the waste heat or other WHR applications, unless they can show that it is not technically or economically feasible.*

  - This obligation applies to all operating data centres above 1 MW threshold where waste heat or other waste heat recovery applications are not currently used. In data centres where waste heat is not used or there is no other waste heat recovery application, an assessment of potential use of waste heat needs to be done.

iii. Member States shall ensure that operators of thermal electricity generation, industrial installations, service facilities, and data centres conduct a Cost-Benefit Analysis (CBA) when planning new or significantly refurbishing energy production facilities above certain energy input thresholds.
  - For thermal electricity generation installations (energy input above 10 MW), the CBA should assess the costs and benefits of providing for the operation of the installation as a high-efficiency cogeneration installation.
  - For industrial installations (energy input above 8 MW) and service facilities (energy input above 7 MW), the CBA should assess utilisation of waste heat on-site and offsite.
  - For data centres (energy input above 1 MW), the CBA should assess waste heat recovery and potential connections to district heating or cooling systems, considering technical and economic factors.

Taxonomy

WHR is recognised as a climate mitigation and green investment measure in the EU Taxonomy Regulation. The Climate Change Mitigation delegated Act (Section 4.25) of the Taxonomy clearly states that waste heat brings a substantial contribution to climate change mitigation, and it is compliant with the requirements of the Do Not Significant Harm (DNHS) principle.

Waste Framework Directive

Waste heat is not directly mentioned in this Directive. However, it establishes a waste hierarchy that shall apply as a priority order.

Guidelines on State aid for climate, environmental protection and energy

According to the guidelines, waste heat projects can be eligible for funding when they are part of an existing efficient district heating system.

Net-Zero Industry Act

Recital 67 of the Net Zero Industry Act mentions waste heat as follows: *"To support the integration of energy from renewable sources into the Union's energy system and its benefits for cost-effective decarbonisation, the sustainability contribution of bids may take into account the contribution to energy system integration through, for instance, energy storage, waste heat and cold recovery and the production of renewable hydrogen."*

Urban Wastewater Treatment Directive (UWWTD)

Article 11 of the UWWTD mandates Member States to "*ensure that energy audits, as defined in Article 2, point (32), of Directive (EU) 2023/1791, of urban wastewater treatment plants and collecting systems in operation are carried out every four years. Those audits shall include an identification of the potential for cost-effective measures to reduce the use of energy and enhance the use and production of renewable energy, with a particular focus to identify and utilise the potential for biogas production or the recovery and use of waste heat either onsite or via a district energy system, while reducing greenhouse gas emissions.*

The first audits shall be carried out:

(a) by 31 December 2028 for urban wastewater treatment plants treating a load of 100 000 p.e. and above and the collecting systems connected to them

(b) by 31 December 2032 for urban wastewater treatment plants treating a load of between 10 000 p.e. and 100 000 p.e. and the collecting systems connected to them."

4. The missed opportunity of on-site waste heat

Currently, waste heat is primarily defined in the context of industrial processes and power generation, with its application mainly associated with the tertiary sector (meaning services) and district heating and cooling. This narrow definition overlooks significant opportunities for so-called **on-site waste heat recovery** in HVAC applications, including exhaust air within buildings. While on-site waste heat focuses on localised energy reuse within the same facility, **off-site waste heat** involves transferring and utilising energy across different locations, usually requiring more extensive infrastructure and coordination across district cooling and heating facilities.

Reusing **on-site waste heat** is relatively straightforward, as it primarily involves upgrading existing heating and cooling systems and modifying existing pipework. Workers already employed in the heating and cooling sector hold the necessary skills to carry out such upgrade without the need to enroll in further specialisation courses.

Applications like data centres, wastewater treatment plants, hospitals, and other processes must maintain continuous operation. In this context, these facilities present a significant opportunity to speed up the decarbonisation of heating and cooling systems across the EU. **They offer a cost-effective and easily implementable solution.**

Additionally, while some permitting is still required, it is far less extensive compared to the municipal planning and permits needed for waste heat recovery in district heating and cooling (DHC) networks.

When upgrading heating and cooling systems, there is often an opportunity to integrate chiller and boiler plants into a single, highly efficient, electrified thermal management system. This consolidation reduces the amount of mechanical equipment on site, lowering costs and offering a high return on investment for building owners.

Both **heat exchangers** and **heat pumps** play a key role in on-site waste heat applications. Heat exchangers reinject waste heat into the system, while **heat pumps** can convert waste heat into heat with higher temperature.

We need a comprehensive legislative approach to the issue that looks at both off-site and on-site waste heat recovery. Our specific recommendations for what that should include can be found below.

EHPA policy recommendations

Our policy recommendations can be grouped around three areas.

1. Harmonise regulation and standards and fill in the gaps in the EU legislation

- **Create an improved framework for the accelerated deployment of heat pumps: develop the necessary policy and financing frameworks** to help the sector reach the REPowerEU target of 60 million additional heat pumps installed in Europe by 2030. Expressed in energy, this comes to almost 1,500 TWh of Final Energy Consumption (FEC) supplied by heat pumps in 2030. In our document "Heat Pump Accelerator", we offer an overview of the solutions to the challenges identified by industry stakeholders, governments and NGOs to the deployment of heat pumps in Europe. In regard to WHR, we recommend to:
    - Regulate the re-use of waste heat by making it mandatory for entities such as data centres, air-conditioned buildings or industries to draft a plan for exploiting waste heat.
    - Regulate the use of industrial heat pumps by making it mandatory for industries to link the required and waste heating and cooling in their process design planning.

- **European WHR guidelines:** develop comprehensive EU-wide guidelines for the implementation of WHR, ensuring consistency, sharing of best practices across the continent

- **Comprehensive definition of WHR:** the waste heat definition must cover all relevant and feasible waste heat applications, **including on-site waste heat recovery, for example from the cooling of buildings**. EU legislation provides a narrow definition limited to the waste heat which can only be used in district heating and cooling applications in RED III. Further references to "waste heat" in other legislation refer either to the broader use of waste heat (e.g. EED, Article 23, Annex IX) or exclusively to its use in district heating and cooling (e.g. EED, Article 24, EU Taxonomy)[5].

- **Expand the role of waste heat** beyond district heating and cooling by, for example, setting sectorial targets for suitable industrial sectors and large commercial buildings (e.g. hospitals, airports, hotels, data centres, commercial kitchens etc.). Highlight that the maximisation of waste heat collection requires district heating and cooling networks to operate at the lowest possible temperature level, ideally at ambient temperature. Ensure that the distribution of thermal energy across the boundaries of individual lots is legally feasible. Encourage cities to consider (ambient temperature) district heating and cooling networks as part of infrastructure, next to electricity, data, water, and waste water.

- **EU Taxonomy:** while waste heat recovery is already recognised as a climate mitigation and green investment measure under the Taxonomy, "the production of power using waste heat" is currently missing, despite being a carbon-neutral solution. For this reason, we would recommend adding waste heat to power (utilisation of waste heat from industrial and tertiary sources to produce electricity for internal or external usage) to the list of energy measures that should be considered under the EU Taxonomy regulation.

- **EU emissions trading system (ETS):** notwithstanding the considerable benefits for sustainability and climate, WHR from industrial processes should be eligible for free

[5] https://heatleap-project.eu/wp-content/uploads/2023/06/HEATLEAP_Policy_Paper_7-June-2023.pdf

allocation within the ETS. By doing this, it will be more financially attractive for industries to adopt WHR.

2. Recognise WHR in climate plan assessment

- **National energy and climate plans (NECPs):** Member States and relevant local authorities should incorporate strategies related to waste heat in their upcoming National Energy and Climate Plans (NECPs) as well as in their heating and cooling assessments and local plans. With regards to the specific measures for the integration of renewable energy technologies, all countries will support the deployment of heat pumps, mostly in individual households as an instrument for replacing fossil-fuel individual heating appliances. Nevertheless, a plan to utilise waste to energy technology is envisaged only in Poland's NECP, while Denmark is planning to terminate subsidies for incinerations[6].

3. Establish financial mechanisms and boost incentives

- **Carbon Border Adjustment Mechanism (CBAM):** ensure that the CBAM incentivises industries within the EU to invest in WHR technologies as a way to reduce their carbon footprint and increase their competitiveness.

- **Tax rebates at national level:** provide tax rebates or deductions for companies that achieve energy savings via WHR.

- **Low-interest loans:** huge annual savings from WHR can be made – and can even become revenue. Nevertheless, upfront costs for fully electric systems remain high and put off customers. Access to financing should be made easier by establishing low-interest loan programs, so that companies can face high upfront costs for capital-intensive WHR projects.

- **Encourage Power Purchase Agreements (PPAs):** removal of barriers to PPA is essential to ensure market-based deployment of renewable energy, and thus WHR recovery.

[6] DISCUSSION PAPER by the Energy Community Secretariat How would heating and cooling sector contribute to EU 2030 decarbonisation goal – NECPs measures DP 04/2021 / 11 October 2021