Danfoss Impact
Issue no. 2

The world's largest untapped energy source
Excess heat

There is a greener and safer route out of the energy crisis

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In 2022, Collins Dictionary chose the word "permacrisis" as the word of the year. Looking back at the past couple of years, it does indeed seem like the world has been living through one crisis after another. A pandemic. Extreme droughts, floods and heatwaves due to global warming. A devastating war in Europe for the first time in decades. An energy crisis threatening to push the global economy into recession. And most recently, a tragic earthquake in Turkey and Syria.

In Europe, decision makers are still struggling to close the gap between energy supply and demand left by the cut off from Russian gas. Countries are taking reactive emergency measures, such as firing up old coal-fired power stations, as well as signing new nuclear and liquefied natural gas (LNG) leases. The tragic reality is that while some of these measures might help mitigate the energy crisis, they will, at the same time, delay and complicate the green transition that the world so desperately needs.

Sadly, decision makers overlook that there is a readily available, greener, cheaper and safer alternative, namely, smarter use of the energy we already have. One way to do that is by using the vast amounts of energy that are currently wasted across sectors. Wasted energy often comes in the form of excess heat and is a byproduct of most industrial and commercial processes; factories, data centers, wastewater facilities and supermarkets all produce vast amounts of excess heat. In the European Union (EU) alone, excess heat amounts to 2,860 TWh/y, almost corresponding to the EU's total energy demand for heat and hot water in residential and service sector buildings[1]. Much of this excess heat could instead be captured and used[2].

The picture is the same in the rest of the world and yet the potential of this excess heat is still not recognized. Excess heat can be reused to supply a factory with heat and warm water or exported to neighboring homes and industries through a district energy system. Excess heat is a hidden resource of energy, and it is all around us.

Using excess heat is energy efficiency in its purest form. In our recent Danfoss Impact, we showed how energy demand is set to grow dramatically in the years to come due to population growth and rising incomes. Without urgent action to tackle the demand side of the green equation, using every single unit of energy more efficiently, we will not get on track to meet global climate goals. According to the International Energy Agency (IEA), a global push for more efficient use of energy can reduce CO_2 emissions by an additional 5 gigatons per year by 2030 compared with current policy settings. This is one-third of the required reduction needed to meet the Net Zero by 2050 Scenario[3]. In terms of energy security, these energy savings can help avoid almost 30 million barrels of oil per day (triple Russia's average production in 2021) *and* 650 billion cubic meters (bcm) of natural gas per year – around four times what the EU imported from Russia in 2021[4]. Thus, energy efficiency is a critical solution to many of the world's most urgent crises: It can simultaneously make energy cheaper, more secure and more sustainable.

But if the potential of energy efficiency is so staggering, why are we not already seeing a massive global push for improving efficiency, including reutilizing wasted energy? While the global energy crisis has triggered unprecedented momentum behind the deployment of renewables, which is indeed necessary and encouraging, political attention towards structural improvements in energy efficiency has been close to absent.

Part of the political neglect is arguably happening because of the inherent character of energy efficiency: Energy waste is invisible, and the solutions to increase efficiency in buildings, industry and transport are technical. However, while the solutions may not be as headline-grabbing as wind turbines, they are nonetheless pivotal if we are to find a safer and greener route out of the multiple crises we are facing.

Using energy that would otherwise go to waste would give a productivity boost to the economy and lower energy prices for consumers. Adding to this, excess heat can replace significant amounts of electricity or gas that are otherwise needed to produce heat, and this way, excess heat can help stabilize the future electricity grid and thereby ease the transition to a green energy system. Recycling heat is not only an overlooked measure in the current energy crisis, but also the next frontier of the green transition.

We already have the solutions available today – what we need now is the political will to make it happen. The greenest, cheapest and safest energy is the energy we don't use. Let's get started.

Danfoss Impact is written to share our view on the potential of energy efficiency and electrification to transform our energy system. In the dialog about the energy crisis and the green transition, energy efficiency is often politically overlooked. One reason is that energy efficiency is not as visible as renewable energy technologies. Another reason is that we have fallen short of adequately explaining the enormous potential of energy efficiency and the critical role it must play if we are to reach full electrification of society.

We are writing these whitepapers to uncover the inherent intangible and invisible nature of energy efficiency and to shine a light on evidence from credible sources on the role of efficiency in transforming our energy system. We do not intend to provide all the answers as to what it takes to limit global warming to 1.5 degrees, but we want to stress the importance of curbing demand for energy as a basis for replacing fossil fuels with green energy. We also want to demonstrate that we already have the necessary technologies at our disposal. This issue looks at all the energy that is currently wasted across sectors in the form of excess heat that could otherwise be reused. While recycling materials such as soft drink cans have become the norm, it wasn't always that way. With the energy squeeze the world is facing, we hope that this will be the moment that recycling waste heat becomes the norm.

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Only got 2 minutes?

These are the key takeaways

Excess heat is the world's largest untapped source of energy

In the EU alone, excess heat amounts to 2,860 TWh/y, almost corresponding to the EU's total energy demand for heat and hot water in residential and service sector buildings[5]. Much of this excess heat could instead be captured and reused.

The solutions already exist

Heat recovery technologies exist that can use excess heat from industries, wastewater facilities, data centers, supermarkets, metro stations and commercial buildings. Excess heat can be reused to supply a factory with heat and warm water or exported to neighboring homes and industries through a district energy system. This paper presents concrete policy measures to accelerate the use of excess heat across sectors, benefitting citizens and businesses with lower energy costs and accelerating the green transition.

Reusing excess heat is energy efficiency in its purest form

A global push for higher efficiency can help avoid almost 30 million barrels of oil per day (that corresponds to triple Russia's average production in 2021) *and* 650 bcm of natural gas per year – around four times what the EU imported from Russia in 2021[6].

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Why excess heat?

The absence of demand side measures in the global energy crisis

Among experts there is increasing consensus that spiking energy prices are likely to linger on for the next few years, at least. While the energy crisis escalated because of the devasting war on European soil, the consequences are felt globally. Across the globe, high inflation has sadly pushed families into economic distress, forced factories to curtail production, and slowed economic growth to the point that several countries are now facing a recession. In Europe, where gas supply is vulnerable because of reliance on Russia, gas rationing and significant risk of blackouts might be the result of power supply shortage and grid instability.

What have been the political responses to the energy crisis? Overall, most attention politically has been devoted to supply side measures. In an unexpected positive development, the global energy crisis has triggered unprecedented momentum behind the build-out of renewables. The world is now set to add as much renewable power in the next 5 years as it did in the past 20[7]. This is indeed encouraging and necessary.

But since the build-out of renewables is not a short-term fix, one of the main components in the political response to the crisis has been for governments to increase imports of LNG. This is not a long-term solution since competition to attract LNG will be stronger as Chinese economic activity is likely to pick up again[8]. In addition, most emergency fiscal measures have focused on subsidies, such as income support to households. In contrast, measures to reduce energy demand structurally, such as investment incentives or regulations to push for higher efficiency, are almost absent in current crisis policies (Germany being one of the few uplifting exceptions to this)[9].

Despite skyrocketing energy prices and unprecedented uncertainty on energy supply, we are far from the average efficiency improvement of 4% per annum that is necessary if we are to reach Net Zero emissions[10]. Structural efficiency measures, including regulation to reuse excess heat, are almost absent in the political responses to the crisis. This is the case despite the fact that efficiency measures constitute the fastest and most cost-effective tool to mitigate the energy crisis.

Most remarkably, only very few initiatives have pushed for more efficient use of the vast amounts of wasted energy in the form of excess heat.

> ***"Using gas or electricity for heating is like using a chainsaw to cut butter, as heating can easily be covered by low-value heating sources such as excess heat."***

As we will see in the next chapters, every time an engine runs, it generates heat. Industries, wastewater facilities, data centers, supermarkets, metro stations and commercial buildings all generate large amounts of heat that is currently let out in the air with no efforts to reuse it.

Excess heat, also called surplus heat or waste heat, can be reused through existing and well-proven technologies, most notably heat pumps. Heat pumps are electrically powered devices able to transport heat from one place to another. They can, for example, harness heat from the exhaust fumes of a factory or the heated water from the cooling systems in data centers and circulate it in the heating system of nearby homes.

Reusing excess heat will lower costs for consumers. It is much cheaper to reuse energy than it is to buy or produce it. On a societal level, excess heat can replace significant amounts of electricity or gas that are otherwise needed to produce heat. This way, excess heat can help stabilize the future electricity grid. Paraphrasing Amory Lovins, using high value energy carriers like gas or electricity for heating is like "using a chainsaw to cut butter", as heating can easily be covered by low-value heating sources such as excess heat. Adding to this, in the future energy system, new excess heat sources such as Power to X facilities will emerge and grow in number – generating large amounts of excess heat that can be utilized on large scale.

Compared to a conventionally decarbonized scenario, a full implementation of technologies that tap into synergies between different sectors and enable a utilization of excess heat has the potential to save EUR 67,4 bn a year once fully implemented (in 2050)[11]. These savings result from large fuel savings leveraged by interconnecting the heating and cooling sector with other parts of the energy system and more flexibility resulting in the better integration of renewable electricity sources in the wider system[12].

In short, ramping up the use of excess heat will lower overall energy demand, give a productivity boost to the economy, and ease the transition to a green energy system.

These hidden resources of backyard energy are uncovered in the next chapter.

What is excess heat?

Imagine you passed through a building and the floor is full of one-dollar notes. Would you keep walking and go about your day? Surely most people would make a small effort to bend down and collect the money. When it comes to excess heat, this is not happening: We are metaphorically letting the money flow as we make no efforts to reuse excess heat in our buildings and industries.

Every time an engine runs, it generates heat. Anyone who has felt the warmth behind their fridge can confirm this. The same is true on a larger scale in supermarkets. Keeping food fresh in cooling displays and freezers generates significant amounts of excess heat. A similar process goes for the cooling of the thousands of data centers that are popping up around the world. This excess heat is currently released into the air without any effort to reuse it. Let us take a closer look at this hidden resource of energy.

Data and methodology

In general, there is a lack of overall information on the excess heat potential of different areas. However, we do know that currently very little of the existing excess heat both from conventional and unconventional sources is recovered and used in large-scale applications[13]. Some of the best data on overall excess heat sources is made by experts at the University of Aalborg and Halmstad University and covers excess heat from a number of sources in the EU. In the following, we use numbers from the reports "Accessible urban waste heat"[14] and "Excess heat potentials of industrial sites in Europe"[15].

The numbers presented should be considered as estimates. If nothing else is mentioned, the estimates are so-called "accessible excess heat", which means that the numbers consider the practical utilization potentials of the available excess heat[16]. In that sense, the numbers are conservative because they only consider sources located within few kilometers of urban district heating areas. As we will see there are ways to exploit excess heat that do not rely on such networks, for instance on-site heat recovery[17]. In addition, it should be noted that excess heat comes in different temperatures. At higher temperatures – typically over 80 degrees – it can often be exploited directly, whereas at lower temperatures, it can be boosted by a heat pump[18]. Therefore, the actual utilization of excess heat potentials also relies to some degree on electricity used by technologies such as heat pumps.

When looking at specific cities and regional areas, the numbers are found by using the planning tool, "The European Waste Heat Map"[19]. This tool displays excess heat in the EU27 + UK from both conventional industrial sources and unconventional sources such as metro stations, food production facilities, food retail stores and wastewater treatment plants. The numbers can be considered conservative since the tool displays neither residential and service sector buildings, nor data centers. Moreover, this tool also focuses on sources within a few kilometers of urban areas, therefore discarding remote locations.

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Accessible excess heat in Europe

Heating is one of the largest energy consumers. In Europe, heating accounts for over 50% of the annual final energy consumption, and most European heat is still generated using fossil fuel based sources, almost half of which is natural gas[20]. At the same time, all urban areas in Europe have access to numerous excess heat resources. There is about 2,860 TWh/y of waste heat accessible in the EU, much of which could be reused[21]. To put this number into perspective it corresponds almost to the EU's total energy demand for heat and hot water in residential and service sector buildings, which is approximately 3,180 TWh per year in the EU27+UK[22].

In some countries, the excess heat potential matches the heat demand[23]. In the Netherlands for instance, excess heat amounts to 156 TWh/y[24] while the water and space heating demand is only 152 TWh/y[25].

The picture is similar across the rest of the world. For instance, looking at the industrial sector in Northern China there is around 813 TWh during heating season alone[26] – imagine what the total amount of excess heat in all sectors in the whole of China then looks like!

Let's take a closer look at the potential of excess heat.

Excess heat can accelerate decarbonization of the industrial sector

The industrial sector accounts for 39% of all global energy-related carbon emissions[27] and is – with it's current rate of energy efficiency improvements of 1 percent per annum – not on track to meet the milestones of the Net Zero scenario that would require improvements of 3 percent[28]. The structural challenge for factories all over the world is to meet growing demands for production while curbing emissions. The current energy crisis has placed the industrial sector under a great amount of pressure, since the share of energy costs for production has increased significantly.

Paradoxically, efficiency progress is slowing in the industrial sector. From 2015 to 2020, the rate of improvement in the energy needed to produce one US dollar of industrial value dropped from the almost 2% per year achieved over 2010-15 to just under 1%.[29] The industrial sector needs to improve its energy efficiency at a rate of 3% annually to meet net zero.[30] The overall progress in energy efficiency will continue to be stymied if strong industrial demand for energy persists without a major improvement in industrial energy efficiency.[31]

The good news is that there is a huge, unharnessed potential for the industrial sector, namely utilizing its excess heat. If we look at the EU, industrial sites constitute the largest source of excess heat. The excess heat from heavy industrial sites in the EU amounts to over 267 TWh a year[32]. To put that into perspective, this is more than the combined heat generation of Germany, Poland and Sweden in 2021[33]. If we look only at waste heat sources over 95°C and within 10 km of existing district heating infrastructure, there is a potential of 64 TWh already. This corresponds to 12% of the energy supplied to EU district heat infrastructure annually[34].

The potential is also striking when looking at specific urban areas. Take Essen in the Ruhr district in Germany. There are approximately 50 industrial sites in the urban areas around Essen, and they produce 11.98 TWh of excess heat per year. This is roughly the amount of heat required to heat 1,200,000 households – or close to half of the households in the area.

Three industries – cement, chemicals and steel – account for almost 60% of industrial energy demand worldwide, with emerging and developing economies, in particular China, accountable for 70-90% of the output of these commodities.[35] These heavy industries offer great potential in terms of efficiency since the excess heat from them is at such high temperatures and therefore easy to reuse.

The industrial sector, which is currently not on track to meet the milestones in the Net Zero Emissions by 2050 Scenario, has the ability to shift the needle on global energy efficiency by reusing excess heat. As we will see in the next chapter, there are multiple ways for the industry to reuse excess heat, for instance, it can be reused to supply a factory with heat and warm water, or it can be exported to neighboring homes and industries through a district energy system.

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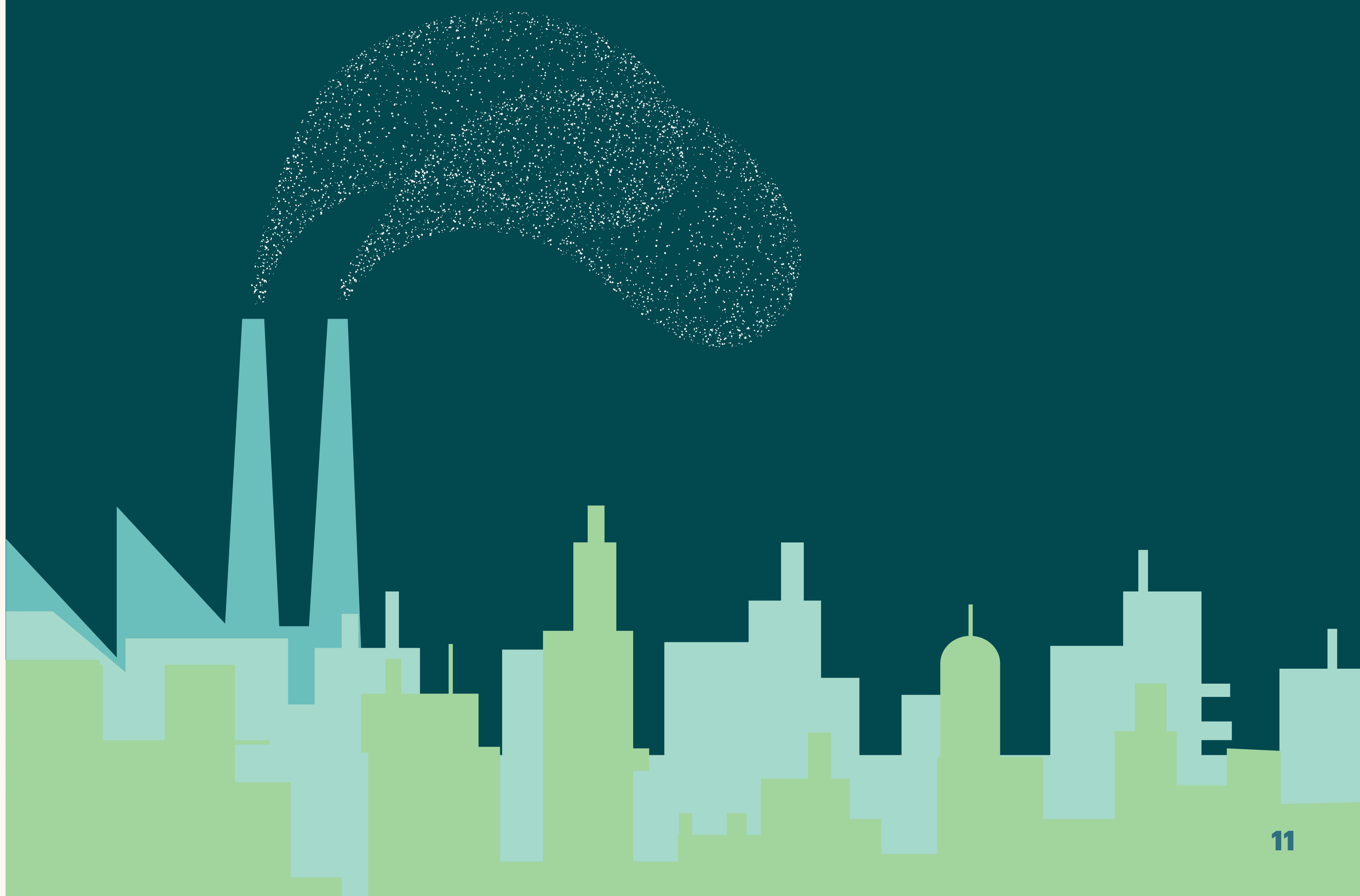
Great results in China from reusing excess heat

Benxi City China

Since 2015, Benxi City has gradually repurposed waste heat resources from the steel industry. Through sector integration, waste heat from steel production processes is reused to heat the city. Those efforts have resulted in a significant reduction in the city's total annual coal consumption, reduced energy bills, and a major improvement in air quality.

Danfoss Chinese factories

Since 2018, Danfoss Haiyan & Wuqing factories have been working to recover excess heat from ventilation and cooling processes. Despite a 22% increase in turnover, heating energy consumption in the factories has decreased by 7%, resulting in an energy productivity improvement of 24% in 3 years. Heat recovery projects have contributed about 15% of these results. The recovered heat saved over EUR 300’000 in energy bills in 2021 alone.



Multiple sources of excess heat in urban areas

Historically, excess heat from the likes of steel and power plants has been reused due to the very high temperatures. But as technology has evolved, many more sources that produce excess heat at lower temperatures have become viable to reuse, as we will see in the next chapter. While industrial sites are the largest source of excess heat, large cities without industry also have numerous sources of excess heat that add up to a considerable amount of energy.

Take data centers. Data has become the lifeblood of today's global digital economy, forming the backbone of the flow of information in cities and powering a range of activities from infrastructure and transport to retail and manufacturing. Data centers are also heavy consumers of electricity. In 2020, data centers in EU27 + UK consumed 100 TWh of electricity or around 3.5% of the region's final electricity demand[36]. According to the IEA, data centers and data transmission networks account for nearly 1% of all energy related greenhouse gas emissions worldwide[37]. Conservative estimates from 2020 counted 1269 data centers across EU27 + UK, for a total of 95 TWh of accessible excess heat yearly[38].

The same goes for supermarkets. Supermarkets are an integral part of communities around the world. They are also big energy consumers. On average, supermarkets consume approximately 3-4% of the annual electricity production in industrialized countries[39].

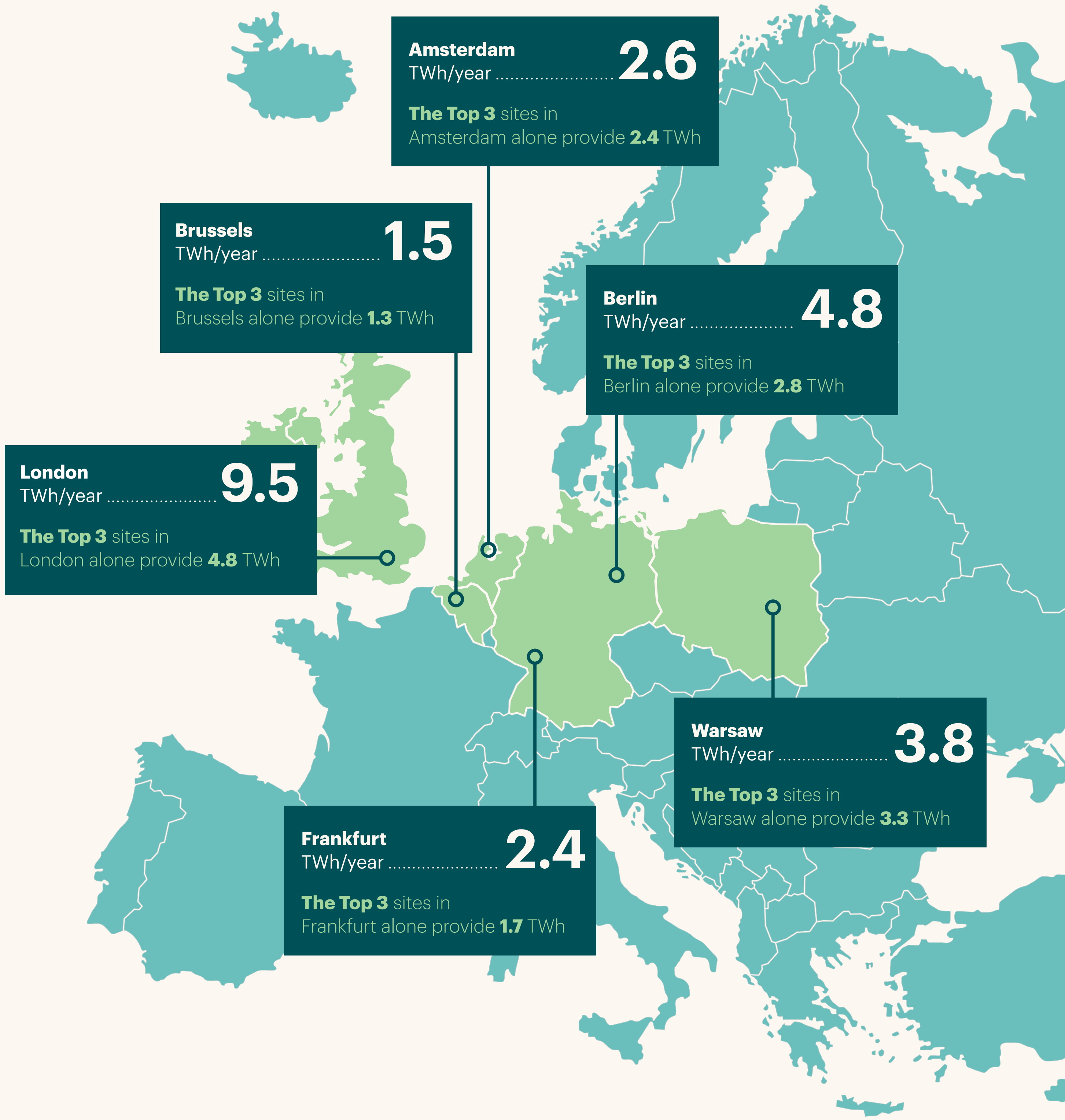
In the EU there is an excess heat potential from food retail of a total of 44 TWh a year[40]. Although this is significantly lower than the excess heat from industrial sites, this equates to the heat generated by Czech Republic and Belgium in 2021[41]. Adding to this, excess heat from supermarkets can be tapped into very easily and reused in the supermarkets themselves in order to heat the space or to provide warm water. All that's required is supermarket owners deploying existing, proven technologies. As the supermarket case shows, this can even contribute to significant energy bill savings – even more crucial in the current energy crisis.

Wastewater treatment plants are yet another considerable source of excess heat, with a potential over the whole EU of 318 TWh of accessible waste heat annually. Even though these sources of excess heat are not as large as the excess heat from industrial sites, together they can cover a considerable amount of energy consumption in urban areas.

For example, let's look at Greater London[42]. The area has 648 eligible excess heat sources including data centers, subway stations, supermarkets, wastewater treatment plants and food production facilities. The excess heat from these sources adds up to 9.5 TWh per year, roughly the amount of heat required to heat 790,000 households. The top 3 sites alone could provide 4.8 TWh of heat yearly.

In the chart below you can see the excess heat potential of selected cities in the EU.

On average, 78.8% of the excess heat depicted below can be sourced from the cities' top 3 sites alone.



How can excess heat be used?

The solutions exist

There are many benefits to excess heat. Ramping up the use of excess heat will lower overall energy demand which, in turn, will lower costs for consumers and businesses alike. It will give the economy a productivity boost since it is much cheaper to reuse energy than it is to buy or produce it. Using excess heat is a greener alternative than most other energy sources and by definition, it is energy efficiency in its purest form. Adding to this, excess heat can help stabilize the electricity grid since it is an alternative to high value energy carriers like electricity.

There are multiple ways to use excess heat. Roughly speaking, the solutions range from very simple solutions that use excess heat for heating purposes in the same unit, to the most advanced solutions in terms of district heating. Let's take a closer look at the options.

1. Reuse excess heat in the same entity

Excess heat occurs in multiple places. Every time energy is used, there is the potential of excess heat. More specifically excess heat can often be found in manufacturing processes or where heating, cooling, freezing and burning processes occur.

The simplest way to use excess heat is to reintegrate the heat into the same processes (see for instance the supermarket case). The temperature of the excess heat will vary depending on the process it results from. For instance, excess heat from heavy industries such as chemicals and cement has a much higher temperature than excess heat from cooling in buildings. Depending on the excess heat's temperature, the heat can be used for different purposes. In general, high temperature excess heat can be used for both industrial processes and domestic usage, while lower temperatures are suitable for domestic usage (for instance space and water heating).

One way to use waste heat internally is by installing a heat recovery unit. A heat recovery unit is worth considering in almost all cases where unused heat energy is produced as a "waste product" in order to increase the efficiency of the overall plant. Heat recovery units make waste heat usable for processes at a similar or lower temperature level. As can be seen in the supermarket case, the excess heat can be used to heat up the store and produce domestic hot water.

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Case: Reuse of excess heat in supermarkets

Keeping food fresh in cooling displays and freezers accounts for most of a supermarket's energy consumption. It might sound counterintuitive, but cooling displays, freezers and fridges produce a significant amount of heat. Anyone who has ever felt the warmth behind their fridge can confirm that. These cooling systems generate significant amounts of excess heat, which is often released directly into the atmosphere and wasted.

In a small town in Southern Denmark, the local supermarket SuperBrugsen has saved a considerable amount of energy by reusing and selling excess heat from the cooling systems.

Since 2019, 78% of SuperBrugsen's heat consumption has been covered by reused heat from cooling processes. And the supermarket has sold 133.7 MWh to other local buildings through the district heating grid.

Three interlinked initiatives have driven the results:

First, the supermarket has converted from chemical refrigerants to a natural refrigerant – namely CO_2 – which has very good heat recovery properties.

Second, a heat recovery unit is installed at SuperBrugsen, and it is designed to recover the waste heat from CO_2 refrigeration systems. The recovered heat is reused to heat up the store and produce domestic hot water.

Third, SuperBrugsen runs energy efficiency programs to ensure long-term efficiency. Cooling systems are monitored, technical parameters are adjusted and regular service has improved energy efficiency and lowered energy consumption even more.

2. Sector integration and smart urban planning

Sector integration or sector coupling refers to the process of optimizing the combination of at least two different sectors of energy demand and production (i.e. electricity, heating, cooling, transport and industrial processes). Sector integration is about maximizing synergies between sectors, converting and storing energy. This can happen on a small scale through urban planning or it can happen on a larger scale through district energy networks (see below). Urban planning can leverage the potential of sector integration and excess heat by connecting energy producers with energy consumers through a smart grid. Large synergies can occur when a producer of excess heat, for instance a data center, is located close to entities that can buy and use large amounts of the excess heat (for example, horticulture). Looking at possibilities for such synergies between energy producers and users in urban planning is called industrial cluster planning and it contributes to decarbonizing our energy system. Furthermore, the collaboration between nearby companies has been shown to provide economic benefits to both the buyer and the seller.

3. District energy

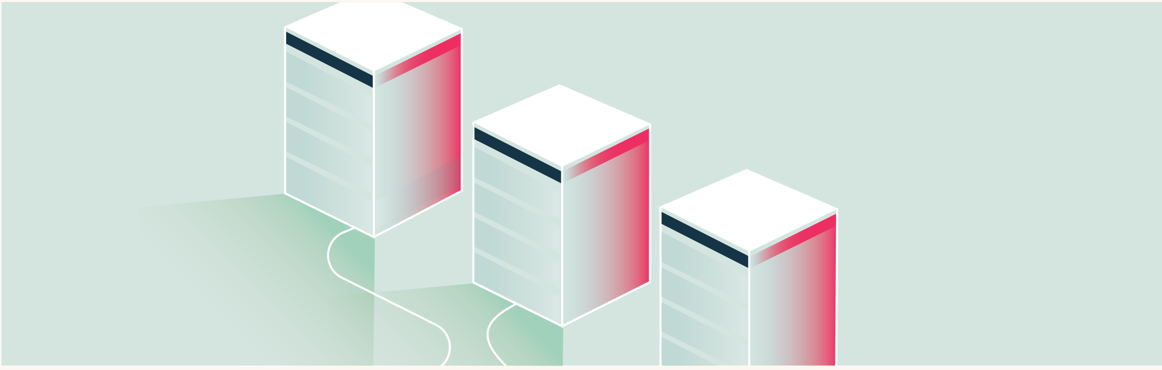
In many parts of the world, district energy systems supply homes and companies with heating as well as cooling. District energy is a collective system that supplies an entire area with heating or cooling. The district heating network taps into heat from a combination of sources, such as renewable sources (solar, geothermal and biomass) and fossil sources, such as at power plants, and distributes it through pipelines to end users in the form of heated water. Today, the majority of global district heat production relies on fossil fuels. According to the IEA, the world needs to double the share of green sources in district heating by 2030 to reach net zero[48]. If we succeed, this will help slash carbon emissions from heat generation by more than one-third.

District energy systems enable a green heat supply today. One of the main strengths of district energy systems is their capacity to integrate different heat sources that can push fossil fuels out of the heating and cooling mix. As district energy technology evolves, more and more green heat sources are able to tap into the system. Today, the so-called 4th generation district energy system allows very low-temperature heat sources to be integrated into the district energy system and provide heating for new buildings that can operate on low-temperatures. The fact that more and more green sources of energy can be used in district heating and cooling puts district energy systems at the center of the green transition.

Another crucial benefit of district energy is that it supports balancing of the grid. One of the key challenges in decarbonizing our grid and increasing electrification is ensuring that supply matches demand. By looking at the energy system holistically and linking different energy sources, district energy allows for the flexible use of power. It enables discrepancies in supply and demand to be evened out so we can exploit the full capacity of the grid. Balancing the peaks will be particularly important as we increase the use of renewables and electrification takes pace.

There are vast district energy systems in China and Europe, and more are expected to come. Denmark is one of the world's most energy efficient countries, due primarily to the widespread use of district heating. In Denmark, 65% of buildings cover their demand for heating with district heating, and more than half of the heat is from green sources such as waste, biomass and excess heat from various commercial processes[49].

Case: The potential of excess heat from data centers



Data has become the lifeblood of today's global digital economy, forming the backbone of the flow of information and powering a range of activities from infrastructure and transport to retail and manufacturing. According to IEA, in 2021 data centers consumed 220-320 TWh of electricity or around 0.9-1.3% of global final electricity demand[43] – this is more than the electricity consumption of some countries [44].

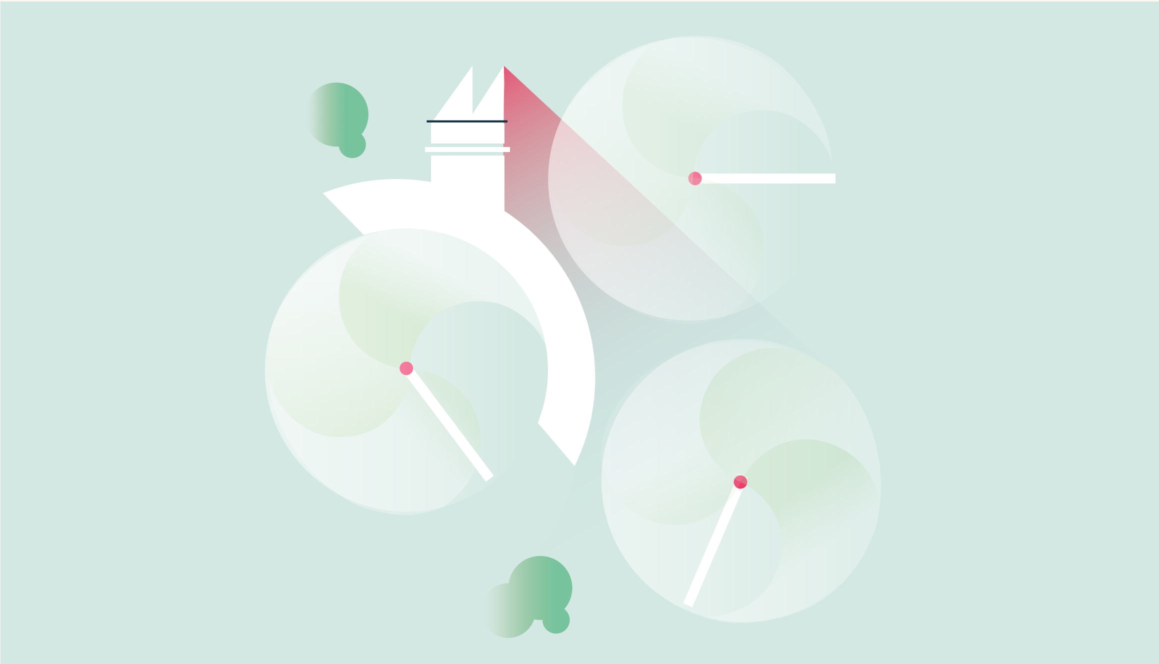
Data centers are also significant producers of excess heat. The servers within a data center generate heat equivalent to their electricity use, and the necessary cooling of these machines also produces a great deal of excess heat. Compared with other sources of excess heat, the flow of excess heat from data centers is uninterruptible and therefore constitutes a very reliant source of clean energy. There are multiple examples that the excess heat from data centers can be reused to heat nearby buildings through a microgrid or it can be exported to the district energy network and used for multiple purposes.

In the city of Frankfurt am Main, there are several projects in the pipeline working towards assisting the city in taking excess heat from data centers and using it towards its entire heat demand of private households and offices. Mathematically, it has been estimated that the waste heat from the data centers in Frankfurt could, by the year 2030, cover the city's entire heat demand stemming from private households and office buildings[45].

In Dublin, Amazon Web Services has built Ireland's first, custom-built sustainable solution to provide low-carbon heat to a growing Dublin suburb. The recently completed data center will provide heat for initially 47,000 m^2 of public sector buildings. It will also provide heat for 3,000 m^2 of commercial space and 135 affordable rental apartments[46].

In Norway, a data center has been co-located with the world's first land-based lobster farm. The co-location company uses a fjord cooling solution to cool its data center, with seawater entering the facility at 8°C and then being released back into the fjord at 20°C. This so happens to be the right temperature for the optimal growth of a lobster. So, moving forward, a new production facility will be built in close proximity to the data center, allowing it to use the heated seawater for the breeding of lobsters[47].

Case: Wastewater facilities as energy producers



According to the IEA, the global water sector uses roughly 120 Mtoe per year, nearly equivalent to Australia's total energy use[50]. Without action, global water-related energy consumption will increase by 50% by 2030[51].

There is significant potential for energy savings in the water sector if all economically available energy efficiency potentials are exploited – not least when it comes to utilizing excess energy.

Wastewater contains significant amounts of embedded energy. Sludge can be extracted from wastewater and pumped into digesters. These produce biogas – mostly methane – that can then be burned to make heat and electricity. Consequently, wastewater treatment plants have the potential to be turned from energy consumers to energy producers.

In Aarhus, Denmark, the Marselisborg Wastewater Treatment Plant (WWTP) produces far more energy than it needs for treating wastewater for the 200,000 people it services.

In fact, Marselisborg WWTP produces so much energy that it can cover the energy needed for the demand for drinking water as well. Marselisborg WWTP offers a pathway to an energy-neutral water sector and shows how to decouple energy from water. The Marselisborg WWTP produces enough energy to cover the entire water cycle of a city area of 200,000 people – all with an estimated return on investment of 4.8 years.

Furthermore, excess heat from wastewater treatment plants can heat buildings and industries through district energy systems.

Recycling heat is not only an overlooked measure in the current energy crisis, but also the next frontier of the green transition

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Policy Recommendations

Many countries and cities are ripe to take advantage of the energy wasted in their backyard. Not least those with an energy demand intensity, a district energy system and large sources of excess heat. In a time of exploding energy prices, gas shortages and climate crisis, it would be a policy failure of immense proportion if decision makers across the continent fail to take advantage of excess heat. Adding to this, the role of excess heat in the future energy system will only grow. The technology for using low temperature excess heat (for instance 4. generation district energy) is maturing and, in the future energy system, excess heat sources such as Power to X facilities will grow significantly. It is crucial that decision makers are aware of this potential when conducting urban planning and designing the financial and regulatory framework for the future energy market.

Regulate. In general, excess heat must be considered as an energy resource instead of waste to be disposed of. Today there are a number of market barriers that prevent market players from leveraging the potential of reusing excess heat. Regulation can remove these barriers, for instance by supporting an equal treatment of waste heat and renewable energy sources used in heat networks. Regulation can also push for greater use of excess energy by making it mandatory for entities such as data centers or industries to make a plan for exploiting the excess heat.

In general, mandatory heat planning will enable cities across Europe to assess the potential and make the best use of locally available resources. For instance, in Denmark, municipalities were asked to map existing heat demand, the existing heat supply method and the amounts of energy used. They also estimated future demand and supply possibilities. Based on this information, overall energy plans were prepared to show the priority of heat supply options in any given area and identify locations for future heat supply units and networks. Depending on the existing energy system, energy planning can both reveal small-scale potential (such as forming the right incentives for heat recovery or the potential of co-generation of heating and electricity) or it can reveal the potential of larger-scale opportunities such as the rollout of district heating.

It is crucial that the scope of the heat planning is wide and detailed, and also includes potential future sources of excess heat, such as Power to X facilities.

Address economic incentives. To further improve energy efficiency by using wasted energy, it is essential to remove both financial and legislative barriers. The current design of the energy market is, in many places, a barrier to sector integration technologies. It either hinders the participation of sector integration technologies in specific markets, or it fails to internalize all positive and negative externalities of respectively low- and carbon-intensive technologies. It is crucial that tax legislation is in favor of using surplus heat and that appropriate network tariff structures should be considered. Additionally, administrative barriers need to be removed to incentivize users to connect to district heating networks, which will also encourage district heating utilities to boost their efficiency.

Establish partnerships. More systematic use of excess heat is, at its core, an exercise that spans sectors and stakeholders. Partnerships between local authorities, energy suppliers and energy sources such as supermarkets, data centers, wastewater facilities and industries can help to maximize excess heat's full potential.

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