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HOT|COOL

INTERNATIONAL MAGAZINE ON DISTRICT HEATING AND COOLING

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GREEN VERSUS BLACK HEAT:

ARE WE AT RISK OF COLOR BLINDNESS?

Climate and reduction of CO2 emissions have reached the very top of the agenda in most countries. People have taken on the responsibility, and therefore, the topic has received the highest political interest - and priority. If we are not careful, investments, political focus and peoples understanding will work against our climate goals.

By Lars Gullev, CEO at VEKS

In April 2021, the EU member states, and the European Parliament agreed to reduce CO_2 emissions by 55% by 2030 compared to 1990 levels. Although it was a long, complicated process to agree on a common goal - a green EU - it was probably the most straightforward part.

Now it's getting tricky, and the subsequent discussions have already begun - can green be graded?

At first glance, one would not think it possible - but on 2 February 2022, the EU has created serious, legitimate doubts about what is green and what is black.

As part of the EU Action Plan for a Greener and Cleaner Economy, in line with the Paris Agreement and the UN's Global Goals, the EU has phased in a new classification system (taxonomy) to ensure uniform identification of green and environmentally sustainable investments in the European market...

The taxonomy classifies an economic activity as environmentally sustainable based on several criteria. The problem with the taxonomy is that most people now will feel great uncertainty and ambiguity about defining black or green fuels - and green technologies.

The European Commission has now recognized both natural gas and nuclear power as greenish - and we have initiated a process in which the colors "green" and "black" are no longer unambiguous.

Burning coal emits less CO_2 than burning lignite - but does it make coal a green fuel? Most people will probably think that coal is a "black fuel."

Burning oil emits less CO_2 than burning coal - but does it turn oil into a green fuel? Most people will probably think that oil is a "black fuel."

Burning natural gas emits less CO_2 than burning oil - but does it make natural gas a green fuel? Although the word "natural gas" signals a product from nature, natural gas never becomes a green fuel.

Once the European Commission has classified nuclear power and natural gas as green technologies/fuels, the rationale is that it is necessary to accept imperfect solutions for a transitional period to achieve the goal of climate neutrality in the EU by 2050.

Others express that this is a case of greenwashing.

But how did we end up here, where the traditional colors "black" and "green" now take on a different meaning?

One could imagine that several countries slowly realize that the transition from a fossil-based society to a green, sustainable society is more complicated in the real world than in the political world.

Therefore, there is likely to be a compromise between the EU's two heaviest players, France, and Germany.

With the dramatically rising prices of, i.e., natural gas, France has been quick to catch the ball - about 75% of France's electricity production comes from nuclear power.

With the decision in Germany to phase out nuclear power - and thereby increase the dependence on natural gas - the Germans have been dependent on natural gas also "joining the pool."

It is thus a traditional barter.

With the introduction of taxonomy, one has - overstating it a bit - gone from a science-based standard to a political norm.

A significant challenge will be that if you choose to invest your pension in green investments in the future, you risk that part of the money going to natural gas or nuclear power. Unless, of course, the pension fund states explicitly that the investment only makes for renewable energy sources.

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This taxonomy opens the door for money that would have gone to renewable energy, such as wind turbines and solar cells, to go to natural gas and nuclear power, making it very difficult for European consumers to invest sustainably.

Let's hope that the European Parliament will end this redefinition of green and black colors.

There has been massive criticism from several countries that the Commission has not listened, as neither nuclear power nor natural gas should be called green in line with renewable energy.

The Commission sends an entirely wrong signal to investors, and the taxonomy will promote investment in technologies that are problematic for both the climate and the environment.

So, where is district heating on the green/black scale?

The district heating of the future will primarily be based on utilization of surplus heat from data centers, CO_2 capture, from Power-to-X (PtX) factories and waste energy plants, heat from sea- and sewage water heat pumps, from geothermal plants, from electric boilers, and combined heat and power plants based on sustainable biomass. So, district heating will be the greenest you can imagine.

All in all, green, sustainable technologies that either utilize the energy resources in society without a well-functioning district heating system would be lost to society - or technologies based on sustainable fuels.

In our district heating world, there is no doubt about what is green and what is black.

New study shows significant economic, environmental and social benefits from co-development of hydrogen and district heating (DH) in the UK

The UK governments' ambitions for new hydrogen infrastructure n could create new sources of waste heat sufficient to supply the entire UK demand for domestic space heating. But this heat does not have to go to waste. If hydrogen production can be located close to towns and cities, where there is high heat demand, district heating networks could provide significant economic, environmental, and social benefits to everyone - the hydrogen producer, the district heating network, and consumers. This was the conclusion of a study conducted by Ramboll UK on behalf of the Danish Government's Energy Governance Partnership at the Danish Embassy in the UK. Here, we explore whether district heating is in tension with the electrification versus hydrogen debate, the opportunities for district heating from waste heat from hydrogen production, and how to actually make this work through policy and planning.

Hydrogen has been identified by all UK governments as having an important role in the decarbonisation of heating.

Hydrogen is on everyone's mind these days – at least in

DISTRICT HEATING CAN HELP UNLOCK THE HYDROGEN ECONOMY IN THE UK – FOR THE BENEFIT OF EVERYONE INVOLVED

By Jacob Byskov Kristensen, Energy Counsellor, Embassy of Denmark, UK

the energy sector. That is also the case in the UK, were the UK government's Hydrogen Strategy suggests that 250 – 460 TWh of hydrogen could be needed by 2050, making up 20 – 35% of the UK's final energy demand. A key reason for these high estimates is that the UK, unlike many other countries, considers hydrogen as a possible pathway to decarbonisation of the heating sector, including domestic buildings. In the UK, domestic heating is often considered a "hard-to-decarbonise" sector alongside heavy transport and industry. Whether heating of households with hydrogen – blended or not – is a good idea, is still a highly contentious policy topic. In any case, current government policy is such that hydrogen looks set to occupy a cornerstone position in the Net Zero pathway for UK industrial and transport decarbonisation. This in turn means it's likely that huge volumes of hydrogen will be produced on land, and potentially near areas of high heat demand.

What seems to be less well-known, is that like other energy conversion processes the production of hydrogen itself generates heat - potentially a lot of it in the case of the UK. By default, this heat is considered a by-product with no immediate use, which will therefore be vented off into the surrounding environment, leaking substantial cost and potential carbon savings from the hydrogen production process. For some of the most well-known and established green hydrogen production technologies, using electrolysers, as much as 30% of the input energy can end up as waste heat. Even blue hydrogen production technologies (often significant net consumers of heat) yield significant waste heat through their its auxiliary processes. This is especially the case where blue hydrogen production – e.g., steam methane reformation – is combined with carbon capture technologies.

All these observations beg the fundamental question; why not use this (wasted) heat for heating purposes – increasing the efficiency of hydrogen production, creating new revenue for hydrogen producers, and freeing up valuable hydrogen for other hard to decarbonise sectors?

Decarbonisation of space heating in the UK - has the electrification vs. hydrogen debate slowed down the development of district heating networks?

Decarbonisation of heating systems is, by most, considered to be the biggest immediate policy challenge that the UK faces to achieve its Net Zero targets. In 2019, heating of buildings accounted for 23% of the UK's total carbon emissions. Same year, the UK Climate Change Commission estimated that less than 5% of the UK's homes are heated from low-carbon sources – with more than 85% of households heated with natural gas. Awareness of this challenge is nothing new. In 2008, the UK became the first major economy to legislate on climate change – legislation that today includes a binding national Net Zero target by 2050. But while these ambitions have helped yield a transition to low carbon energy sources, such as wind, in the

power sector, relatively little progress has so far been made to decarbonise heat.

Part of the explanation for this is that there has so far been little strategic consensus on the most appropriate transition pathway for the sector. There is, for example, still active and heated debate around the relative merits of electrification vs. hydrogen as the best solution to decarbonise heat. In the UK Government's Heat and Buildings Strategy from 2021, a strategic decision on the "role of hydrogen" in heating was effectively postponed until 2026. For better or worse, this uncertainty is making it difficult for stakeholders and investors to make long-term decisions for their business and industry.

The impact of continued strategic uncertainty around decarbonisation of heat is perhaps illustrated by the DH sector. The technology has been around for more than a Century and is widely recognised as a low-regret policy option to decarbonise heating in densely populated areas. A central reason for it being "low-regret" is that not only is it well-established technology, providing the lowest cost Net Zero option to many households, but it also yields opportunities to exploit synergies with both electrification and the hydrogen pathways for space heating.

Unfortunately, this fact seems to have been drowned out amidst the noise of the discussion on electrification vs. hydrogen. This could at least in part explain why DH in the UK today still serves less than 3% of households - compared to for example over 65% in Denmark. So although great policy strides in the UK are being made, it remains to be seen if the DH sector will end up with the favourable, stable and long-term framework conditions that it has been craving for so many years.

The study to investigate possible synergies between hydrogen and district heating in the UK context

In an attempt to highlight the "low-regret" nature of DH, the Danish Energy Governance Partnership at the Danish Embassy in the UK, together with Ramboll UK, decided to launch a study in early 2021. The study was set to investigate possible synergies between evolution of "the hydrogen pathway" and the DH sector and draw inspiration from some promising case studies in Denmark and the Netherlands.

To capture the particular circumstances of the UK, the study focused its inquiry on case studies and stakeholder engagement with several geographical "clusters" in the UK where hydrogen production and DH are understood to be rapidly evolving in tandem*. Across each cluster, existing, planned, and potential hydrogen production and DH networks were identified and mapped, and a technical assessment was undertaken to shortlist opportunities to capture and utilise hydrogen waste heat.

The South Humber area was eventually selected from a shortlist for further economic modelling and assessment. This case was particularly interesting as it included three ambitious new hydrogen production projects; two very substantial (2 x 100MW) green hydrogen projects, and another large (700 MW) blue hydrogen project. In addition, the area has several DH networks currently under consideration.

Significant economic, environmental and social benefits

The study concluded that it is technically feasible to recover heat from new green and blue hydrogen infrastructure without negatively impacting production. It also concluded that heat recovery would actually provide great potential gains in system efficiency, especially for some green hydrogen technologies (14-32% efficiency improvements for the various electrolysers considered). The temperature of the captured heat also proved to be generally compatible with supplying heat networks, particularly newer schemes operating at lower temperatures.

The results of the financial assessment were even more encouraging. Even without an existing DH network in place (as with the South Humber area), the case still proved financially attractive for the hydrogen producer, the heat network operator, and the heat consumers. The heat network option was compared to the best available low carbon heating counterfactual of individual building air source heat pumps.

Table 1 - Key results from financial assessment (*compared to counterfactual of air source heat pumps)

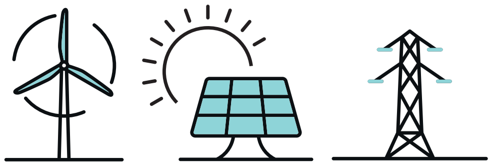
Hydrogen producer	14% IRR, positive NPV
District neat network operator	>4% IRR, positive NPV
Heat consumers	20% reduction in heating cost*

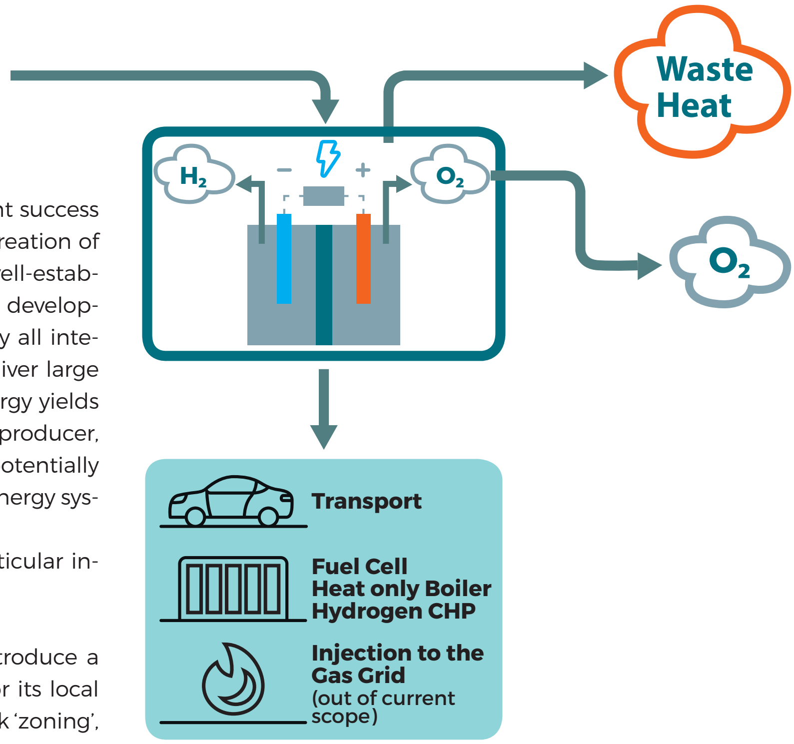
Based on these results, the study firmly concluded that significant economic, environmental, and social benefits are associated with heat recovery from hydrogen production, and its auxiliary processes.

How to reap the benefits?

To seize the opportunities that this analysis points to, hydrogen production and centres of high heat demand need to be in proximity to one another. As heat demand is already fixed, the key will thus be to influence the location of new hydrogen production facilities. This is not a novel undertaking. Most stakeholders across the world are currently contemplating how to best achieve the same end, trying to ensure that this emerging technology, and the ensuing investments, falls in their geography – be that region, nation, or local authority.

* Cases included: Aberdeen City; Leeds City; the Humber Region (split into Beverley, Hull and South Humber)





In Denmark, one of the contributing factors for recent success in attracting hydrogen investments** has been the creation of opportunities to sell waste heat into the country's well-established heat networks. Major new hydrogen projects developing in Esbjerg, Fredericia and Copenhagen are today all integrated parts of local heat planning - planned to deliver large quantities of waste heat into DH networks. This synergy yields additional revenue and branding for the hydrogen producer, low-cost green heat for the DH network as well as potentially important gains in efficiency and integration of the energy system as a whole.
These synergies and cross-sector benefits are of particular interest to national governments.

In the UK, national governments are working to introduce a new tool that could provide similar opportunities for its local authorities and other stakeholders. Local heat network 'zoning', as it is called, is a planning tool meant to allow local authorities to identify and designate areas where DH is recognised as the lowest cost, lowest carbon solution for decarbonising heat. The tool is still under development and its methodology and regulatory reach is therefore still somewhat uncertain. That said, it is standard that any heat planning process includes assessment of existing waste heat sources. As suggested by this study, it might add great value if future heat policy and zoning methodologies also looks at assessment or designation of suitable hydrogen production sites.

If consideration of waste heat from hydrogen sources can be integrated into the future UK heat policy and zoning framework, it could attract renewed interest from hydrogen producers, most of whom at present are unlikely to concern themselves with opportunities for heat recovery. And through their local knowledge and position, local authorities could be the ideal stakeholder to promote this sector integration and ensure that great synergies are realised between two key energy infrastructures of the future.

** The Danish projects are not only producers of hydrogen, but also other e-fuels or power-to-x products

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NEIGHBORHOOD ENERGY APPROACH AS A SCALABLE ALTERNATIVE FOR GAS HEATING

Kick the habit: In the past 50 years, the Netherlands has allowed itself to become addicted to its own supply of natural gas. It will need to kick this habit and find alternatives to heat homes in the future.

The **'neighborhood energy approach'** aims to address three major issues:

- Upgrade local environmental thermal energy
- Connect existing housing at a reasonable cost
- Offer freedom of choice of primary energy supplier


By Roelof Potters – Innovation Manager Alliander, Arnhem, The Netherlands
Hans Korsman – Principal Consultant, Qirion (an Alliander subsidiary), Duiven, The Netherlands

Current situation

The Groningen Gas Field was discovered in 1959 in the north of the Netherlands. It has since been a dominant factor in Dutch energy policy. In less than a decade, an extensive network was built to make natural gas available almost everywhere, at affordable prices, facilitating a swift transition from coal and oil. Now, the field is becoming depleted, diminishing pressures is causing local earthquakes, and the supply of natural gas is switched to mostly foreign sources.

Around 2000, the Dutch electricity and natural gas markets were liberalized, introducing competition between energy suppliers, and giving consumers freedom of choice. However, this freedom of choice was not extended to district heating (DH).

A transition towards renewable sources

The Netherlands has been lagging somewhat in adopting renewable energy sources. Offshore wind may stage a comeback since 57,000 km2 of the European Continental Shelf in the

North Sea is Dutch. The development of large wind farms at sea is ongoing. It is expected to significantly increase the share of renewables in the coming years.

Extensive infrastructure will have to be built to connect production to consumers all over the country. While homes can be heated with electricity, current electrical networks lack capacity. Measured in power for heating, natural gas networks, and connections capacity is at least ten times larger. The transition

from natural gas to electricity cannot be met without significant restructuring and massive expansion of the grids on all voltage levels. The use of heat pumps will considerably reduce the 'power gap' between electrical and natural gas infrastructure, but likely not enough. Even without capacity for electrical heating, network operators experience an unprecedented rise in requests for additional capacity and are struggling to meet demand.

DH is considered a viable alternative in densely populated areas. Even during the Groningen natural gas epoch, it has seen some success in large-scale urban expansion, that is, for newly built housing. Connecting existing housing is much more complex and costly. However, it also has much more potential in volume.

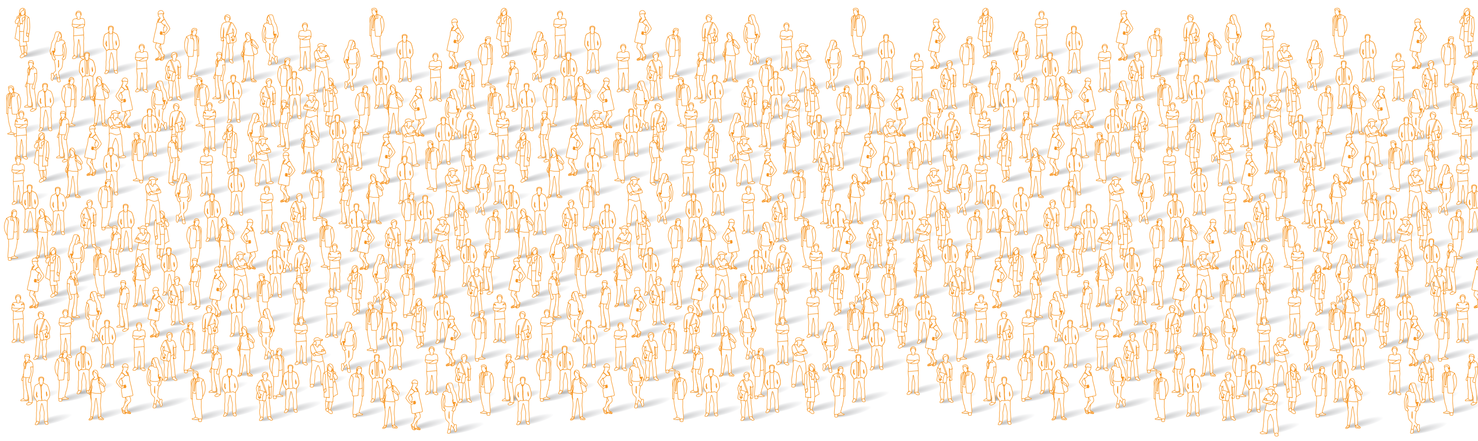
The DH networks use traditional, fairly high temperature, large-scale thermal energy sources such as waste incineration and (natural gas-fired) combined cycle cogeneration plants. There are not enough heat sources to replace natural gas, and the renewable content is debatable. Burning biomass (wood) was heavily subsidized initially but now faces increasing opposition and decreasing subsidies. Clearly, alternative renewable thermal sources need to be developed.

Current market model for district heating

There is another reason why new development in DH is proving particularly difficult: DH is operated as a local monopoly by commercial enterprises, in stark contrast with the liberalized markets for electricity and natural gas. There, consumers have learned to use competition and the free choice of a supplier as a weapon against otherwise assured commercial exploitation.

It is a common opinion amongst DH customers that they are paying too much. Recent price hikes due to much higher prices for natural gas (which serves as price reference) have made things worse and refueled the debate on heating prices. With the current market model, local councils are hesitant to force a monopoly on unwilling citizens.

At the same time, it is not attractive for commercial enterprises to make large upfront investments in infrastructure with low and uncertain returns. Circumstances being what they are, the development of DH as an alternative for natural gas is not going well. Until today, DH has rarely been used to help existing natural gas-connected private homes transition to renewable heating sources.



Community approach

In some neighborhoods, a community approach was taken. Local inhabitants joined together and established a cooperative DH venture, often with help from the municipality. This process typically takes a lot of effort and results in one small neighborhood switching from natural gas to DH with their own source, often heat pumps.

Whereas the cooperative itself is a member's democracy, community cooperation leaves the freedom of choice of the heat source, the service providers, and the energy supply companies to the neighborhood, thus approaching the individual freedom of choice.

We designed a step-by-step process that standardizes the whole process of preparation, communication, finding enough participants, building, and exploiting the DH system. In two pilot projects in Nijmegen and Arnhem, we are improving and testing this approach.

In the meantime, we are working together in a coalition with EnergieSamen, the Dutch union of energy cooperatives, Klimaatverbond Nederland, a union of public organizations that aims for climate solutions and sustainability, and Rabobank, one of the large Dutch banks which is a cooperative itself. The coalition works on institutionalizing the community approach and seeks support from the national government.

The designed process, the lessons learned from the pilot projects, and the coalition's work led to the desired standardization. It makes the cooperative solution scalable and bankable, thus making it efficient to establish.

This leads to the opportunity for over a thousand neighborhoods in the Netherlands (varying from 200 to about 1,000 houses) to make the transition from natural gas to a sustainable heating source.

Technical approach

The community approach needs to be supported with standardized solutions that are technically robust and economically viable. We devised our approach based on earlier experience with traditional DH and some experience using heat pumps. We want our solution to be:

1. Modular

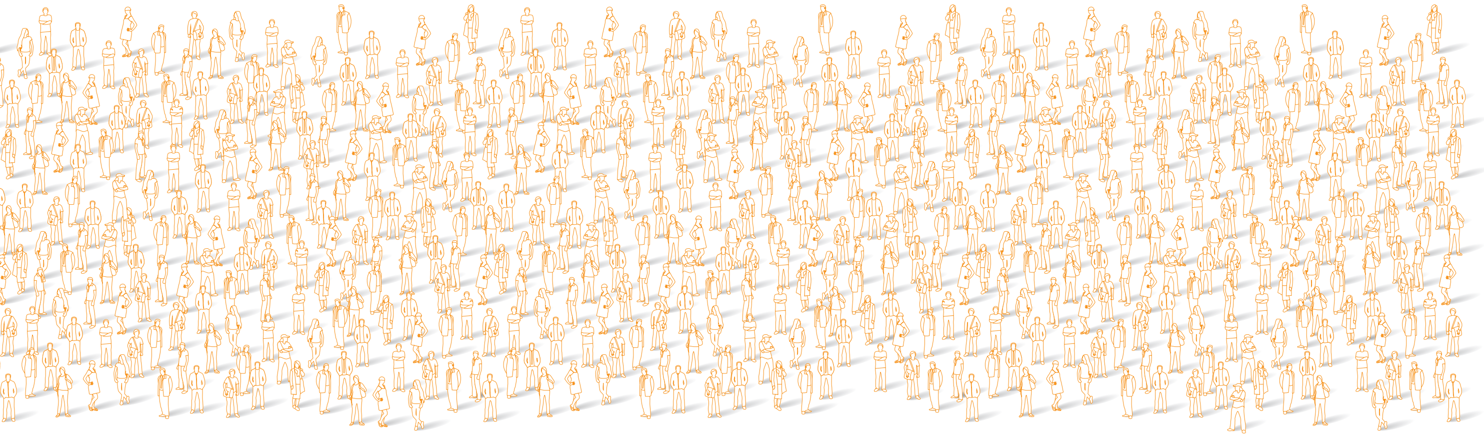
We aim to exploit readily available local sources of environmental thermal energy by upgrading temperature to usable levels with heat pumps, to avoid large upfront investments in long-distance transmission pipelines. However, the availability and cost of local sources may vary considerably. In some places, ground or surface water is easily accessible; in other areas, you need to drill hundreds of meters to gain access. In general, we want the best quality thermal source available at the lowest cost. Modularity must give us the flexibility to adapt while allowing us to employ most of our solutions unchanged. We decided to start with perhaps not the best, but indeed the most ubiquitous heat source available: outside air.

2. Scalable

It is a lot easier to get small projects going, whereas sharing common costs and scaling advantages work in favor of bigger projects once you have them. We want to be able to serve small projects as well as larger ones, and we want to be able to connect nearby small projects to create bigger ones. Modularity must serve this exact purpose. The intent is to reuse a component that has become too small due to local growth in some projects that are just starting elsewhere.

3. Sufficiently low temperature yet practical

Heat pumps work most efficiently at low-temperature lift, that is, the little temperature difference between source



and delivery. Very large heating surfaces such as underfloor heating are preferable, which can be done with a reasonable cost in newly built houses. Not so in existing housing, where the cost of underfloor heating would often be prohibitive. We aim to use existing radiators and employ control technology to operate at the most efficient temperatures for cost reasons continually.
Furthermore, too low-temperature difference distribution systems are impractical and costly, and we need to supply domestic hot water, which requires somewhat higher temperatures of around 60°C. The lowest return temperature possible optimizes transportation. As it happens, this fits well with an array of heat pumps once you connect those in series. We run the array as close to 60°C as weather permits, while every degree of lowered return temperature improves array efficiency. In our first implementation, the array consists of 10 heat pumps supplemented with natural gas-fired boilers with 1.5x heat pump capacity, in series with the heat pump array. This allows us to reduce the heat pump supply temperature further once boilers are needed.

4. Modern

Control of DH equipment in homes is usually done with passive regulators, which cannot connect to apps on mobile phones. We need active (electronic) components to optimize function anyway, which opens a pathway to modern user interfacing.

5. Connected

Heat meters are required to be connected by law, necessitating some channel of communication. This channel allows for firmware upgrades, which we made a requirement for control equipment.

6. Affordable

We need to be cost-competitive compared to alternative solutions. Therefore, we prefer the use of standard (mass-produced) components. To reduce installation costs, field modules are preassembled by design and transported to the site.

Conclusion

DH is an essential tool in transitioning from natural gas to sustainable heat sources in existing houses. This transition can only be made with a cooperation-based, community approach and a modular technical system approach.

7. Upgradable

Having too much ambition for the time available, we were forced to run design teams concurrently on assumed operating conditions, having to settle for less than perfect in the process. We chose to promote this drawback to the guiding principle: the first edition will work, the next one will be better. Wherever possible, we design for upgradable solutions, which are the easiest in software. With production fully operational and about half of the houses connected, we see ample room for improvement.

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DISTRICT HEATING DEVELOPMENT THROUGH FAIR CONDITIONS FOR THE CONSUMERS

Heat demand densities and consumer connection rates determine DH systems' economic viability and sustainability. Hence, encouraging heat consumers to connect —and remain connected— to the local DH system is essential for DH implementation and continuation. However, discussions and the ensuing confusion on the most suitable institutional conditions for encouraging consumers to adopt DH are still ongoing in several EU countries. The study we present here intends to contribute to the ongoing policy discussions.

By Leire Gorroño-Albizu, Mondragon Unibertsitatea (ES), and Jaqueline de Godoy, Aalborg University (DK)

It's (almost) all about consumer connection rates.
District heating can provide environmental and economic advantages in targeted areas compared with other low-carbon heating solutions such as individual heat pumps. Therefore, together with energy efficiency measures, DH systems could play an essential role in decarbonizing the heating sector and the whole energy system in the EU. Yet, the potential for DH deployment is largely untapped in many EU countries, such as Germany, Poland, and Spain, for example.

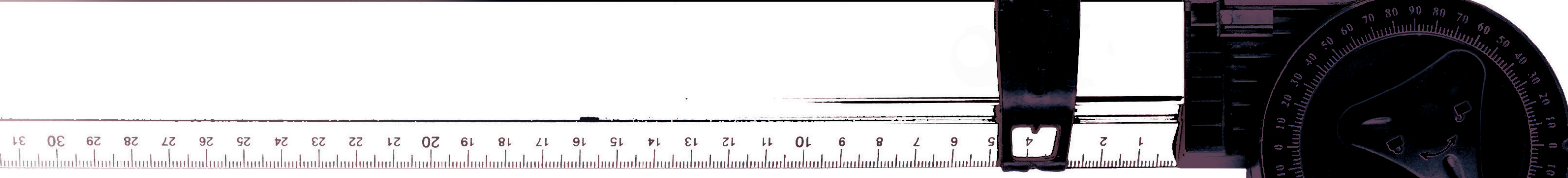
Protecting consumers to promote DH
DH companies' malpractices (see box 1) may counteract DH's comfort and economic advantages to consumers. It may distrust DH systems and encourage consumers to adopt alternative heating solutions. Thus, the design and implementation of fair institutional conditions, based on an appropriate balance between consumer power mechanisms (see box 2), could be essential for DH deployment and continuation in EU countries. We understand that conditions for consumers are fair when DH companies comply with their duty of heat supply and customer relations at satisfactory quality levels while charging a reasonable heat price.

We investigated why the different institutional frameworks managed or failed to promote fair conditions for DH consumers in the context of Denmark and Sweden. Below we present the primary outcomes and lessons from our study on the topic.

BOX 1

Residential heat from a consumer's perspective
Empirical examples from various European countries (including Denmark, Germany, Romania, Sweden, the UK) show that DH companies can misuse their monopoly position and the consumer lock-in effect. Misuse can lead to disproportionate heat prices, price discrimination to attract new customers, complex bills, and tariff structures that discourage DH demand reductions. It can also result in a lack of security of supply, few hours of availability, lack of flexibility at a household level resulting in too low/high indoor temperatures, poor customer service, etc. Such malpractices may put residential DH consumers vulnerable and hinder DH adoption.

DH systems are natural monopolies of local nature, and thus, the control over the decision-making of district heating may be in the hands of just a few people. Furthermore, unlike in electricity and gas systems, there is little space for competition between producers and retailers. Therefore, DH production, distribution, and retail are often integrated under the same company. This structure has several implications, including that dissatisfied DH consumers cannot choose another DH supplier, with their only option being to invest in another heat supply system. Therefore, the consumer lock-in effect is more robust with DH than with other heat supply technologies. Individual heat pumps or natural gas boilers depend on natural monopolies but (have been regulated to) offer consumers the possibility of changing their retailer. The particularities of DH demand the institutional conditions that safeguard consumers' interests and rights for the DH systems to be trustworthy.



BOX 2

Understanding consumer power on the monopolistic DH companies

The analytical framework for 'consumer power in natural monopolies' distinguishes four dimensions of consumer power (or categories of institutional conditions) concerning natural monopolies: 'state regulative power,' 'ownership power,' 'buying power,' and 'communicative power.' The combination may result in various configurations and levels of consumer power.

The hypothesis (supported by this study's results) is that there are links between the configurations and levels of consumer power and DH companies' behavior regarding respecting consumers' interests.

Why compare Denmark and Sweden?

Denmark and Sweden have succeeded in reaching and maintaining high shares of residential buildings supplied by DH: Denmark (64 %) and Sweden (51 %). Despite similarities, the countries have implemented somewhat different regulations and governance models regarding DH systems' price and quality control during the last few decades. When comparing DH in Nordic countries, Sweden has the largest share of commercial ownership and the softest public regulation for DH, with no price regulation and a free consumers' choice of heat supply technology. In contrast, Denmark has the largest share of consumer ownership and the strictest public regulation for DH, with a non-profit (or cost-based) price regulation and, until recently, the possibility to oblige consumers to connect and remain connected to the local DH system. Furthermore, some examples of DH companies misusing their monopoly position have been seen in Denmark and Sweden.

Lessons from Denmark and Sweden

Below, we outline our study's insights; in box 3, we introduce policy recommendations.

1. Free choice of heat supply technology alone does not put sufficient pressure on DH companies to set reasonable DH prices. It must be supplemented with regulation, high transparency, communicative power, and possibly high or very high ownership power (e.g., as in local consumer cooperatives or local municipal companies).

1.1. To ensure a free choice of heat supply technology, individual heating solutions must be available at a competitive price with DH. However, DH can be cheaper than individual heating from a socio-economic perspective, especially in areas densely populated or with excess heat. Therefore, creating effective market competition can result in additional costs for society due to the economic incentives that would be necessary and the reduction in the connected heat demand density.

2. Strong price regulation (such as the cost-based regulation in Denmark) does not ensure reasonable heat prices unless high or very high ownership power is in place (e.g., through local consumer cooperatives or local municipal companies). It should also be coupled with high levels of transparency and communicative ability. Additionally, it could also be essential to address information asymmetry, agency problems, and lack of expertise.

3. Ownership of DH companies influences DH prices and transparency. Under the same regulation, consumer cooperatives and municipal companies result in lower DH prices and higher transparency than commercial or state-owned companies. In Sweden, companies with cost-based pricing are more open about their costs than those with market-based pricing.

4. With the right combination of policies and regulations, local consumer cooperatives and municipal companies can develop and run DH systems and contribute significantly to DH implementation. In Denmark, 94% of the DH demand is supplied by local consumer cooperatives and municipal companies; in Sweden, about 63% is provided through local municipal companies. Cultural aspects may influence the choice of ownership.

5. Regulatory Authorities might not identify all law infringements or questionable practices by the DH companies. Transparency, access to information, and media coverage are essential to monitor and control DH companies. However, for this to work, Regulatory Authorities and poli-

cymakers must address the issues, protecting consumers' interests and rights.

6. Management of DH companies requires knowledge and expertise to avoid poor managerial decisions. Standard guidelines on investment decision-making, merging small companies, and customized expert support could support good management in DH companies.

7. Short-term cost reduction approaches may lead to, e.g., poor system maintenance and higher future costs.

Promoting local and inclusive ownership models (such as local consumer cooperatives or local municipal companies) could be of utmost importance to guarantee that residential DH consumers' rights and interests are safeguarded.

IMPORTANT FINDINGS

Policy insights to support DH systems development

- DH regulation is necessary to protect residential DH consumers, whereas opting for less or more strict regulation may depend on national or regional preferences.
- It is crucial that DH regulation promotes high levels of transparency regarding DH decision-making through regular publication of DH prices by the regulatory authorities, access to financial and technical reports, etc.
- Promoting local and inclusive ownership models (such as local consumer cooperatives or local municipal companies) could be of utmost importance to guarantee that residential DH consumers' rights and interests are safeguarded.

This article is based on the research outcomes presented in the scientific paper 'Getting fair institutional conditions for district heating consumers: Insights from Denmark and Sweden', published under the Creative Commons Attribution 4.0 International License (CC BY 4.0). The above article contains some extracts (sometimes with minor modifications) from the original scientific article.

Jaqueline de Godoy

What makes this subject exciting to you?

In my Ph.D. research, I dive into the society-technologies-energy matters to understand the consequences and the role of energy experts in designing energy systems for the communities they serve. The socio-technical nature of district heating systems needs the continuous alignment of large-scale technical changes with social elements. It implies that those systems must be understood by the interplay between their social and technical characteristics. Therefore, I was motivated to work on this project to understand what cultural aspects can favor or impede the development of such socio-technical systems.

What will your findings do for DH?

Our study can motivate district heating experts to implement (or keep implementing) institutional practices that prioritize the citizens' needs (such as heating at a reasonable price). Fair conditions are an ally to enhance the development of district heating projects.

- It is crucial that DH regulation promotes high levels of transparency regarding DH decision-making through regular publication of DH prices by the regulatory authorities, access to financial and technical reports, etc.

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Leire Gorroño Albizu

What makes this subject exciting to you?

When I moved to Denmark to study the Master Programme in Sustainable Energy Planning and Management at Aalborg University in 2012, there were two things (completely new to me) I got fascinated about: (1) local and inclusive citizen ownership of energy projects and infrastructure and (2) district heating. There were (and still are) so many potential benefits to gain from implementing these solutions! That is why I have dedicated most of my career to learning more about these two topics and disseminating the acquired knowledge - mainly in Europe and abroad. This article is a beautiful piece of that larger work.

What will your findings do for DH?

The intention is to move the discussion from "what works and what doesn't" to "why it works, or it doesn't" – in each context. The analytical framework applied in this study allows us to better understand the reasons behind the (in) effectiveness of local institutional conditions to encourage residential heat consumers to adopt district heating. The framework also facilitates cross-country comparisons and knowledge transfer. Isn't that great?! And to show it, we bring a (tasty) appetizer: lessons from Denmark and Sweden. Enjoy!

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HELLO, HOW CAN WE SUPPORT YOUR CITY?

DBDH is the Go-To-Platform for district energy.
We cooperate with all DH stake holders and support cities in their quest for a sustainable city transformation.

Use our strengths to help your city. We are the link to:

- ✓ Achieving climate goals through fossil-free district energy
- ✓ Strategic energy planning
- ✓ Knowledge on district heating and cooling
- ✓ A wide network of experts
- ✓ Visiting green solutions in Denmark

We do not know everything about district heating, but we know who does ☺
Contact one of our team members. Our advice is free of charge.

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Sector integration and new heat sources

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HEAT 4.0

takes the district heating sector into the next digital level

Useful results for further digital developments

In the later years, dynamic changes in society and the demand for energy-efficient solutions pushes the energy sector towards digitalization. The HEAT 4.0 provides access to new digital inventions on a cooperative basis and has taken a huge leap to secure data exchange in a common system-independent infrastructure.

By Alfred Heller, Managing Director, DTU Compute,
Technical University of Denmark and
Eva Lange Rasmussen, Communication expert,
NIRAS, Denmark

The overall objective within the project HEAT 4.0 is to integrate intelligent IT solutions in a new digital framework to reach a holistic district heating (DH) approach, previously presented in Hot Cool. The HEAT 4.0 addresses the digital needs of the whole sector, from the production site over distribution to the end-users, and creates synergy between design, operation, maintenance, and delivery of DH. Such solutions we call Cross System Services (CSS) and are based on co-operation between components suppliers, scientists at universities, DH companies, consultants, and essential for this article, a common platform provider.

Data-based optimization and common sharing platform for concrete services

The work of this project is mainly based on combining already existing IT tools from the DH sector. The purpose is to build a new bridge between today's different software operating systems to connect systems, exchange and use data securely and more intelligently to obtain innovative and holistic solutions.
The methods developed in HEAT 4.0 have typically been based on digital models derived from DH systems in operation today. Therefore, the used methods are relatively simple but still reproduce reality as well as possible and create a satisfactory concept for further evolution. The solution can be divided into two steps of methods:

1. The first and most straightforward method lets the individual IT models/software share their data insights, called peer-to-peer (p2p). For example, consumers (buildings) share their heating demand forecast with the network component (distribution). The network software can include this information to improve the correctness of its own model. It can hereafter share its predicted operation (flow and temperature) with the production component that optimizes the heat production accordingly.
   In a more advanced solution, the involved software tools give feedback information to each other. For example, the production component could ask to shift demand in time to avoid bottlenecks in production or critical load in the network. The network and building optimization tools would analyze whether this is possible and return updated predictions. Other scenarios could be envisaged.

2. A system-independent data-sharing platform is established for communication between tools and the DH infrastructure. This common platform enables any digital system to share data (inclusive prediction and setpoints for controlling district heating). In future versions, the platform will also be able to host common algorithms and software components.

Data management is the central starting point

DH companies are used to handling all their data within their individual IT infrastructure and SCADA systems. Communication with the surroundings was not applied. Aiming at a much more complex control of the next generation DH demand change in minds, data must be communicated in secure manners to enable a more efficient operation of the entire district system and other services.

The HEAT 4.0 solution has succeeded in developing a 'common data platform' which will guarantee the quality of data by, e.g., validating data, entering missing data, and resampling data

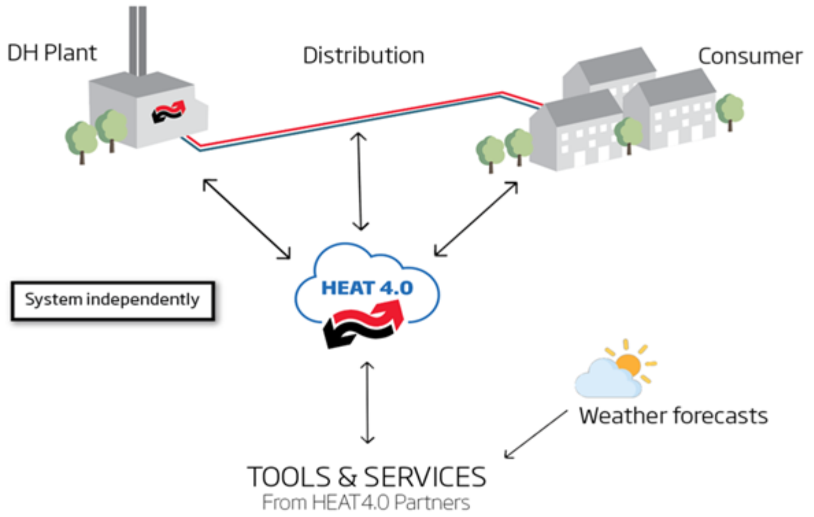

Figure 1: The ICT infrastructure of HEAT 4.0 (very simplified drawing). In the center, you have the consortium-common infrastructure part (cloud). The partner companies' digital tools and services can be provided through the 'common cloud,' enabling the DH operators to choose any combination of services.

to the necessary sampling rates. It also enables DH operators to choose and replace digital services and connect them with plug-and-play technologies through standard data interfaces.

The project partner Center Denmark, a non-profit organization, is in charge of developing this new, commercial cloud platform within the HEAT 4.0 project, enabling business-based value chains. The versions of CSS p2p mentioned above are implemented on this platform for the involved three DH companies. Standardized data exchanging interfaces are tested and ready. Generalized versions are under development, enabling other software firms to involve. The objective is a secure, efficient, and adaptable platform that will save integration hours for the DH companies, making data much more intelligent and giving freedom of choice to the operators. At the same time, the platform supports the operators to meet the privacy regulations, known as GDPR.

Demand for an agile system architecture

Within the HEAT 4.0 project, three DH plants are involved in testing the innovations' ideas, but no DH system in Denmark looks the same. Two of the three DH companies, Bronderslev DH Ltd. and Hillerod Forsyning, have their own and various production sites. In contrast, the energy company TREFOR Varme buys heat from a heat distributor. Since 2014, Bronderslev Forsyning had already e-meters installed whereas Hillerod Forsyning has not. It means that the components involved are all different at the three sites. From a HEAT 4.0 perspective, this variation is a technological advantage as it ensures robustness for the project results and solutions developed.

The DH companies are using first-generation tools that are working independently. The IT tools usually are directly communicating with the SCADA systems - a cumbersome task that often leads to high costs and high time expenditure. In the HEAT 4.0 project, the data integration solutions were developed and standardized, inspired by Industry 4.0, general ICT- and security guidelines. This relatively simple adoption enables the companies to integrate easily and operationally with any IT service provided from outside.

DH from TREFOR Varme, 60,000 DH customers, is environmentally friendly and economically advantageous. TREFOR Varme uses surplus heat from the local Shell Refinery, waste incineration, and wood chips as green energy sources.

Case studies - lessons learned – and valuable results

TREFOR Varme was the first DH company within the project to raise the demand for a 'common infrastructure component.' Thanks to their steadfastness and their enormous organizational effort to 'digitize' their internal system, the HEAT 4.0 partners can refer to precious insights and experiences from this case study. TREFOR Varme introduced a cross-utility ICT strategy that highlights security and robustness. Based on these strict regulations, the current HEAT 4.0 Cross System Optimization (CSO - an optimization service demonstrating the concept of CSS) solution is set in place because it empowers the company to control external services similar to internal hardware and control systems. This was impossible a few years ago, where all controls had to be placed physically within the company property. The head of the DH department, Helge S. Hansen, put it this way.

> Our motivation for joining the HEATman project was partly to contribute experiences and knowledge about the digitization of the heating sector and not least to do so in a cyber-secure way. Next, to try to pull the industry in the direction of an integration function, as our own vision was to integrate up to a single "common integrator" [technology]. The new IT solution was integrated by 'HEAT 4.0 Ready' software suppliers and the benefits of this co-operation we are to achieve these days.
>
> **Helge S. Hansen, CEO,**
> **Trefor District Heating, Kolding, Denmark**

From own experiences, TREFOR Varme concludes that it is a good idea for DH plants, in general, to let other competent specialists handle IT integration in a time where systems and threats from cybercrime have become significantly more complex. In a few bullets, they sum up the specific results they have achieved through their project involvement so far:

- As the cyber-secure connection, high data security is to be predetermined by one integrator, which continuously optimizes and improves the concept. In other words, secure data exchange, which can be used for the entire district heating sector.
- There are economic and timewise savings, fewer problems with incorrect data through standardized technical integration and "one integrator contact."
- The secured data exchange between several software systems enables especially smaller DH companies to digitize.

Another DH plant involved in the project, Bronderslev Forsyning, has announced their satisfaction being a test partner of the project and put it in this way:

> At Bronderslev DH Ltd., we have for some years successfully been working with data from Smart Meters to create added value for the company and the customers. The HEAT 4.0 project has given us new unique possibilities to step up in digitization and explore the

Bronderslev Forsyning, Varme, with 5000 DH customers, has one of the most energy-efficient CHP plants globally. It combines concentrated solar heating (CSP) with wood chips and converts the energy into electricity and DH via a so-called ORC system (Organic Ranking Cycle).

use of more advanced technologies. Especially, the idea about the cloud-based Cross System Optimization has given us new valuable insights and provided us with more advanced tools to operate the entire utility more efficiently - from production to distribution and end-consumers.

Thorkil B. Neergaard , CEO, Bronderslev DH, Denmark

The industrial approach – a new beginning?

In the HEAT 4.0 project, 17 innovative partners have worked closely with universities and DH companies to deliver state-of-the-art digital solutions to the DH market. The project has pushed the development of existing digital products and new innovative cross-system products.

The pioneers are a) EMD International provides investment and production optimization software, added bidding software to the electricity markets in an integrated portfolio, b) Enfor provides localized weather and heat load forecasts, plus temperature optimization software for the network operation, and c) Neogrid, Leanheat and NorthQ that provides optimization and control software for all size building operation. Danfoss that has acquired the partner Leanheat within the project's lifetime, has designed a software solution suite – "Danfoss Leanheat Software Suite" - that is an end-to-end solution. This solution is similar to the system described above but since it's an open architecture it can easily integrate with EMD, ENFOR and others. Combinations are possible. As a result, HEAT 4.0 has shown the flexibility of the approach with open interfaces, standards, and shared infrastructure components. (IoT-based) data-services support the shared infrastructure by the pipe producer LOGSTOR (part of Kingspan Group), pump producer DESMI and metering provider Kamstrup, which all together aim at monitoring and predicting maintenance and other services that both support the DH-company and their customers, as well as balancing energy-, economic efficiency with the secured high indoor environment. Examples of value generation from sector integration enabled by the given agile infrastructure proposed by HEAT 4.0 also consist of utilizing large thermal capacities of buildings and the DH network for storage, called flexibility. This service aims at supporting the stabilization of the electrical systems by shifting demands in time and power. Other integrated services optimize temperature, flow control qualified by measurements across system components, models, and automated analytics.

The examples mentioned above show the limitless opportunities for new, more intelligent IT systems. We are proud of the small successful steps HEAT 4.0 has taken towards digitalizing the DH sector. As a result, various combinations of cross-system-optimization (CSO) tools implemented prove the agility of such an ICT architecture. HEAT 4.0 is reaching its final stage, and we are looking forward to presenting the exact values of the partners' efforts during the year 2022. The digital journey has just begun with the innovative project HEAT 4.0, supported by the Innovation Fund Denmark.

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Partners in HEAT 4.0, 2021

Niras
AAU
DTU Compute, DTU Management and DTU Civil Engineering
Danfoss
Leanheat
EMD
Enfor
Neogrid
TREFOR Varme
Kamstrup
Grøn Energi/ Dansk Fjernvarme
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Member company profile: devcco

Making cooling in a hot world

Worldwide district energy venture

Devcco is a private, independent company owned by its founding partners. Highly dedicated and experienced individuals founded it to develop projects and provide global services in the district energy industry.

Devcco is a provider of concept, business strategies, restructuring, feasibility studies, energy master plans, governance, and project management. Thus, supporting companies in developing central cooling business in technical, commercial, financing, and organizational areas. It has shown that Devcco significantly assists companies during the commercial and organizational development stages when introducing central cooling.

Today, Devcco is involved in a wide range of projects at all levels throughout the world, managed from the company's base in both Sweden and Denmark. Devcco applies an engineering approach that considers in-depth project management and a business model strategy to ensure a technology blueprint and a strong business which is also the case for AffaldVarme Aarhus (AVA). AVA is a Danish district heating (DH) company located in the second largest city and is currently working on integrating district cooling (DC) with Devcco assistants.

Achieving higher efficiency

An energy design depends on the environment and its geographic location, as it is affected by weather, building, infrastructure, potential sector coupling, etc. Subsequently, energy solutions can be similar in technology but not in design, making it challenging and fascinating to introduce DC/DH. Devcco has evaluated based on these experiences and found that especially one key parameter significantly influences energy systems, the efficiency.

Higher efficiency is achieved by shifting from conventional cooling in buildings to central cooling, incorporating components like chillers/heat pumps and cooling sources. Such a DC system, considering heat pump/chillers and seawater-free cooling, would increase the efficiency by 5-6 times compared to a conventional chiller and split system. Similarly, shifting refrigerants to one with a lower global warming potential will decrease the environmental impact and leakage while increasing efficiency and positively influencing the climate. All of these contribute to a decrease in power demand, thereby reducing operational costs and fossil-based emissions. These are important reasons why Devcco finds efficiency so crucial in any energy system and a "simple" approach to support our customers.

Building for a climate-friendly sector coupling

It is common to apply seawater as a cooling source to ensure cooling year-round. In addition, excess heat from cooling can be utilized, e.g., by heat pumps. Heat pumps are excellent for integrating DC and DH, as less work is required to supply the DH system while working in synergy with the DC side and with a side-benefit of coupling the electricity sector associated with the power consumption for the heat pump. Furthermore, sector coupling has several benefits such as flexibility and a potential extra trading opportunity:

Firstly, DC does not impose similar regulations as DH and is therefore allowed to have an economic surplus in Denmark. Secondly, DC is achieving a new role as an electricity consumer benefits trading with ancillary services where the heat pump responds to electricity price signals.

Sector coupling provides a more climate-friendly and cheaper supply of cooling and heat while meeting the Danish government's goals. Frequently, a company introduced to DC will see this as side-effects. However, the Devcco team specializes in every area of DC and constantly seeks to follow future development by being adaptive.

Taking the next step

Future DC/DH systems can also benefit from the ongoing digitalization of the energy system. This digitalization leads to a smart and energy flexible of supply and demand, demand-side management (DSM). Thinking of DSM, one always assumes power and energy systems like intelligent grids or microgrids. While this is true, the heating system can also benefit from a DSM line of thinking. A DC/DH organization can play two roles in a DSM system, a supplier of heat and a consumer of power. The DC/DH can, in one scenario, be a flexible load to the power system, and in another have their consumers as the flexible loads of heat, giving them two positions in a sector integrated system. However, there is a need for changes in Danish regulations for this to become a reality. Nevertheless, will smart energy utilization in an integrated sector system assumably be the future energy system. Thus, Devcco's motivation to follow this trend and be a helping guide in a digital intelligent energy world.

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NEXT ISSUE

HEAT PLANNING IN GERMANY

The new German goverment has set out ambitous plans for energy planning for the whole of country. Read more from our "reporter" at the Danish embassy in Berlin.

HOW TO PRICE-ESTIMATE A CONVERSION TO DISTRICT HEATING?

The pipe network cost is a big chunck of the overall investments in a DH network. Learn how Gentofte north of Copenhagen optimize their configuration.

ARE WE DIVERSE ENOUGH IN THE DH SECTOR? THE ANSWER IS CLEARLY "NO!".

Read about how a network in the UK work hard to make the sector there more diverse and inclusive.

NEW TECHNOLOGY: Digital thermostatic valves

DBDH HAS JUST LAUNCHED ITS PODCAST SERIES ON DH DEVELOPMENTS WORLDWIDE.

This link leads to our RSS-channel. Stay tuned for the next podcast about how two Danish cities convert from gas to DH.