kamstrup

# Energy efficient heat supply

District heating in the new energy reality

# Smart metering provides the basis for high energy efficiency by adding transparency and data-based knowledge to district heating

The new energy reality requires an integrated and intelligent energy system with district heating as its natural cornerstone. But improving energy efficiency and facilitating the transition to renewable energy sources and waste heat requires a level of transparency in the district energy system that can only be derived from frequent and accurate meter data.

Data-based knowledge from smart metering solutions enables district heating utilities to continuously monitor, evaluate and improve the efficiency of the distribution network, the energy performance of buildings and the involvement of end users.

This makes smart metering critical as a means to meeting the challenges of the integrated energy system and, just as importantly, as a platform for utilising the opportunities it brings.

In this white paper, we outline this new energy reality and the role district heating plays in it. We take a closer look at what characterises the intelligent energy system and explore the importance of efficiency and transparency throughout the energy chain all the way to the end user. Finally, we take a sneak peek at what will influence and drive district heating in the future.

# The new energy reality

Today's energy challenges call for smarter and more energy efficient cities focusing on sustainable resource utilisation. Intelligent district heating plays a key role in this development.

As global energy demand and urbanisation continue to rise, fossil fuels are being exhausted and the financial as well as environmental costs of energy production increase. This necessitates a focus on reducing consumption as well as improving the efficiency of how energy is produced, managed and distributed.

**Cities represent only 2-3%** of the total land surface, but nearly half of the world's population lives in cities – and this number is expected to increase to 80% by 2050. Today, cities are responsible for 75% of energy consumption and between 60-80% of total global emissions.

*Source: lgi-consulting.com/sectors/*

**Earth Overshoot Day –** the date on which humanity's resource consumption for the year exceeds Earth's capacity to regenerate those resources that year – comes earlier every year.

*Learn more at overshootday.org*

Date of EOD on the release year

| Year | Overshoot date |
|---|---|
| 1987 | December 19 |
| 1995 | November 21 |
| 2005 | October 20 |
| 2008 | September 23 |
| 2010 | August 21 |
| 2015 | August 13 |
| 2016 | August 8 |

## The potential of district heating

District heating is fundamentally about moving heat from accessible energy sources to consumers with a heat demand. It involves the production of hot water at a central plant, which is then piped underground to individual buildings for space heating and domestic hot water.

The benefits of district heating include:

- It is **more efficient** than an individual boiler and also, the local environmental impact is reduced
- It is **flexible, environmentally sound and makes perfect "green" sense** because it allows utilities to put waste heat to good use and to integrate renewable energy sources like wind and solar efficiently
- It can use all kinds of fuel, which **provides fuel flexibility and a secure supply of energy**, and unlike local boilers, district heating can quickly be converted
- It is **easy and safe** for the consumers because it requires a minimum of maintenance and limited technical skills.

Today, approximately 50% of the EU's annual energy consumption goes to heating and cooling, while 20% goes to electricity and 30% is used on transport. For years, the smart electricity grid and "the electrification of everything" has been positioned as the answer to the energy challenges of the future.

However, the potential to optimise energy consumption related to heating and cooling is actually far greater. It is just a much more fragmented industry than electricity – and one that was previously lacking an overall focus.

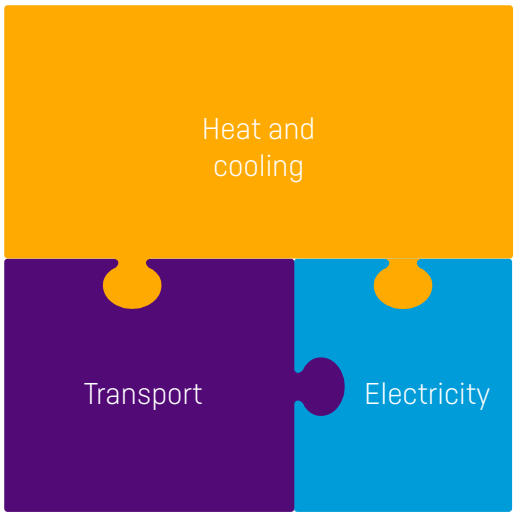
At European level, district heating is now considered an existing and proven technology with great potential to support the EU targets for the energy sector, including decarbonisation. For example, the waste heat from power generation, industry etc. must be transported and distributed wherever the demand is – which is what district heating is all about.

Today, district heating only makes up approximately 10% of Europe's total energy consumption for space heating, but studies have shown that it is realistic to increase this number to 50% by 2050[1].

Fully unlocking the potential of district heating requires one overall system integrating the different energy sources – and thereby adding intelligence to urban energy communities. Enter the era of smart cities.

**It is estimated**, that the waste heat from power plants and industry in Europe would cover the entire European heat demand, if it were collected in district heating systems.

*Source: heatroadmap.eu*



## How do you raise the IQ of a city?

Smart cities represent total efficiency within all areas. Characterised by a holistic approach to their energy management, smart cities create integrated energy systems based on the synergies of electricity production, heating, cooling and transport – and district energy is a crucial element in connecting the dots.

Smart district energy networks combine district heating and district cooling while at the same time integrating and balancing the fluctuating energy from renewables and waste heat as well as serving as thermal storage. This makes them a central smart city component and a prerequisite for optimal utilisation of low-carbon and renewable energy[2].

**"District heating provides an answer to these challenges** *and should, therefore, be considered as the backbone of tomorrow's urban communities and smart cities.[3]"*

– Lars Gullev, Managing Director of VEKS and Chairman of DBDH.

## Political consensus and focus

Through the EU's Energy Union, even more focus has been put on the energy sector and its role in achieving a more efficient use of energy resources as well as reducing pollution and $CO_2$ emissions.

However, with European imports of gas and oil from Russia and the oil states amounting to approximately EUR 400 billion every year, security of supply is also a key driver of this development – in some countries perhaps even more so than sustainability.

Accordingly, the European Commission's Heating and Cooling Strategy[4] published in February 2016, recognises the crucial role of district heating in the decarbonisation of European buildings, shifting to renewable energy as well as in realising a sustainable, independent and secure supply of energy.

The share of renewable energy in heating and cooling was estimated to be 17% in 2014. As part of the EU's energy and climate goals for 2030, EU countries have agreed on a new renewable energy target of at least 27% of final energy consumption by 2030[5].

**Denmark was one of the first** nations to use district heating, which is described as the backbone of Denmark's energy supply. The success of district heating in Denmark is the result of a combination of grass roots, a strong political focus, and long-term planning in the energy sector.

While district heating is undisputedly a well-proven concept by now, it continues to evolve. The experiences and development of state-of-the-art technologies in pioneering countries such as Denmark continue to create new opportunities in a new energy reality.

**Danish district heating in numbers**

- Approx. 430 district heating plants and 60,000 km of pipes
- 63% of all Danish homes – that's 3.2 million Danes – are connected to district heating systems
- 98% of Copenhagen is covered by district heating
- Approx. 10,000 people work in the Danish district heating industry.

*Source:*
*Dansk Fjernvarme, danskfjernvarme.dk*

# Shifting focus and raising the bar

District heating is the cornerstone of a truly integrated energy system, where demand adapts to the fluctuating production based on renewables and waste heat – but it will require a much higher degree of flexibility than today.

The integration of renewables and waste heat requires intelligent cross-sector energy systems. This places new demands on district heating utilities, as they will be dependent on an increasing number of production sources that fluctuate depending on power generation, industrial production, wind conditions, sunshine hours etc.

## Supply and demand reversed

Utilities used to base their production on traditional forecasts. In other words, the better they were at predicting the consumption, the more efficient they were able to be. In an integrated energy system, it will be the other way around. Here, heat production is based on multiple fluctuating energy sources resulting in a variable heat supply that must be matched with the demand from buildings and end users in the other end of the district heating system.

Getting the whole system to balance and interplay efficiently increases the need for flexibility throughout the entire value chain. This necessitates adding to the mix the energy performance of buildings as well as involving end users much more than they are today.

Boosting the energy efficiency of buildings is critical because the gains from optimisations in the distribution system will often depend on how the buildings perform under different conditions.

This may be in relation to both the building envelope and the technical heat installation. Additionally, buildings can potentially act as thermal storage capacity in the network.

Also, energy consumption and peak demands are still closely connected to the behavior of end users. Easing their access to knowledge about their consumption and behaviour will enable them to better understand their energy use and take an active part in saving energy and utilising it optimally.

## What characterises the intelligent energy system?

The intelligent and integrated energy system focuses on high energy efficiency in order to reduce energy waste. This involves utilising the available energy sources as efficiently and sustainably as possible while creating the ideal circumstances for integrating renewables. The district heating networks are used to link the available heat sources with the heat demand from buildings and end users.

**By lowering return temperatures in the network,** district heating utilities not only reduce energy waste but also boost the efficiency of their production based on renewables.

The challenge for district heating utilities will be to balance the electricity systems while at the same time utilising waste heat from industries and integrating as much renewable energy as possible. This requires running production close to the limit and lowering distribution temperatures, making it even more crucial to continuously manage and optimise their production and distribution network decisions.

Utilities must constantly be able to assess the current conditions to decide if, for example, they should start the heat pump, or if it would make more sense to get their heat from Combined Heat and Power production (CHP) or e.g. solar.

## Knowledge-based optimisation

Imagine if you knew the weather forecast, the exact behaviour of your end users, and how individual buildings would perform under various weather conditions. Then imagine that you were also able to see the dynamics and the retention time in the distribution network.

This knowledge would enable you to make exactly the right decisions about your energy production and distribution for the upcoming operating hours. Unlike assumptions and theoretical models about e.g. the distribution system, this knowledge would be based on facts and what is actually going on in the network.

This is one of the focus areas of the 4DH Research Centre developing 4th generation district heating (4GDH) technologies and systems. 4GDH focuses on energy efficiency, flexibility, and integration of all renewable energy sources and waste heat. Therefore, in 4GDH systems, synergies are created between grids and components, production and system integration, and planning and implementation[6].

Higher energy efficiency goes hand in hand with lower and more flexible distribution temperatures because they allow 4GDH to efficiently utilise renewable energy sources, while still fulfilling both the requirements of low-energy buildings and energy conservation measures in the existing building stock.

**The 4DH Research Centre** is a collaboration between industry, universities and the public sector investigating the potential and development of 4th Generation District Heating (4GDH).

*Read more at: 4dh.dk*

# The need for efficiency

Efficiency is not only key to achieving the transition to sustainable heating and cooling but also critical for district heating to remain competitive and attractive to end users.

In traditional district heating countries, revenue from energy sales per end user will decrease by 1 to 1.5% per year due to energy renovations and an overall reduction of energy consumption. Also, the energy transition involves substantial costs as does running an energy efficient heat supply based primarily on renewable energy sources and waste heat. Finally, district heating faces a huge challenge in remaining competitive compared to other heat sources, e.g. individual heat pumps and geothermal heat, which may seem like the obvious choice to end users when it comes to low energy houses.

These developments all call for district heating utilities to focus continuously on improving the efficiency of the entire value chain from production to end users. Improved efficiency will enable them to reduce operational costs while at the same time unlocking opportunities for additional growth by being able to offer a larger variety of services.

## Improving efficiency

There is a need for a new and improved production mix so that heat can be produced more efficiently and at a lower cost. For example, implementing heat storage – on a day-to-day basis as well as seasonal storage – would allow utilities to avoid expensive peak load production. Bringing the system more into balance and having fewer fluctuations will lead to a more optimal production.

Another area that holds significant potential is better utilisation of the capacity of the existing system. As district heating's share of the heat supply must grow, there will be a need to connect new urban areas and more buildings to the existing district heating networks. These are either buildings that are not yet connected to the network or new buildings arising in existing district heating areas as the result of urban densification.

Greater efficiency and better utilisation of the capacity in the existing network rather than expanding and upgrading pipelines represents considerable savings for district heating utilities because it allows them to defer or completely avoid investments in assets that tie up capital for many years to come.

## Keeping district heating hot

In order for district heating to remain attractive to end users, utilities will need to offer a lower connection price as well as other products and services than raw KWh alone.

This could, for example, be the introduction of new billing schemes based on other parameters than the overall energy consumption. It could also be consulting services or maybe we will even reach a point where district heating utilities take responsibility for the substations, sell comfort and provide the specific service of maintaining 21 degrees in end users' living rooms.

## Efficiency benchmarks

The overall efficiency in district heating utilities varies a great deal from country to country, typically as a result of the framework conditions to which district heating has been subjected.

In countries like Denmark, there has been a continuous focus on efficiency and energy savings throughout the years. This has been expressed through specific commitments to continuously making improvements to a degree where utility companies have been obligated to get their customers to reduce their energy consumption, subsequently buying less energy.

In other countries, improving efficiency has not been a focal point, which leaves vast untapped potential. A number of indications suggest that in the future, we will see national benchmarking models whereby utility companies are benchmarked specifically on their operational efficiency.

**In Denmark,** the Ib Larsen Committee proposed in late 2015 that the district heating sector must make optimisations worth DKK 500 million by 2020 through a so-called regulatory benchmark. This benchmark will include the approx. 200 largest companies, which represent 95% of heat sales. Further benchmarks worth several billion DKK are already being discussed for the years after 2020.

*Source: efkm.dk/nyheder/fjernvarmeselskaber-spare-halv-milliard-aaret*

# Transparency is key

The prerequisite for high energy efficiency and the very foundation of the green transition is transparency. Without frequent meter data, district heating utilities lack knowledge of where and how improvements can be made – and they are unable to evaluate the effect of their actions.

Meeting efficiency targets and running production closer to the limit requires district heating utilities to continuously work on optimising their system all the way to the individual buildings and end users.

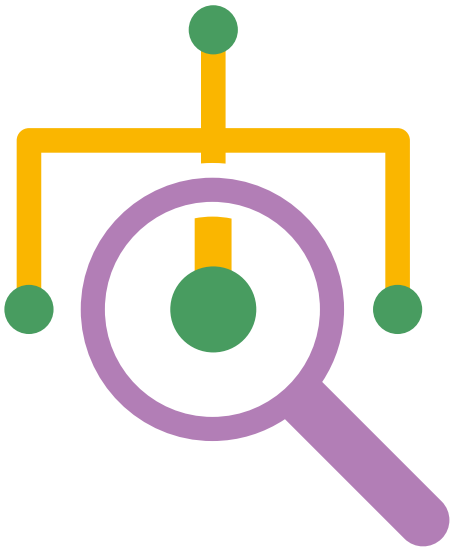
To do so, they must know exactly what is happening in the network – especially at critical points – at all times. Only the frequent data provided by smart metering enables this degree of transparency.

## Billing and beyond

Until now, the primary driver for energy metering has been the need for utilities to bill end users for their energy consumption. This need is often met using basic walk-by or drive-by remote reading solutions that allow utilities to go out and collect data without having to disturb the end users. However, meter data can be used much more proactively. With the strong focus on the added value frequent data can provide, fully automatic network solutions are becoming more common and are now available at a reasonable cost.

Smart energy meters give district heating utilities a detailed overview of the actual state of the distribution network by providing precise information about flow and temperatures, which can be combined with additional measurements, such as pressure, in strategically important parts of the network.

This allows utilities to start working specifically on addressing the installations that place the most strain on the network – due to, for example, high return temperatures or high average volume – thereby generating significant energy savings for them and their customers.



## The value of data

Fundamentally, you cannot optimise what you do not measure. Therefore, smart metering is essential to achieving the goals of the intelligent energy system: low temperatures, high energy efficiency, limited energy waste and a high degree of end-user involvement. In short, the more frequent data a utility has, the more precise its basis for optimisation, and thus, the more value it can create.

For example, metering is necessary to continuously monitor the temperature levels in the network, so that district heating utilities can identify the possibilities and challenges involved in lowering the network temperatures in order to improve the energy efficiency.

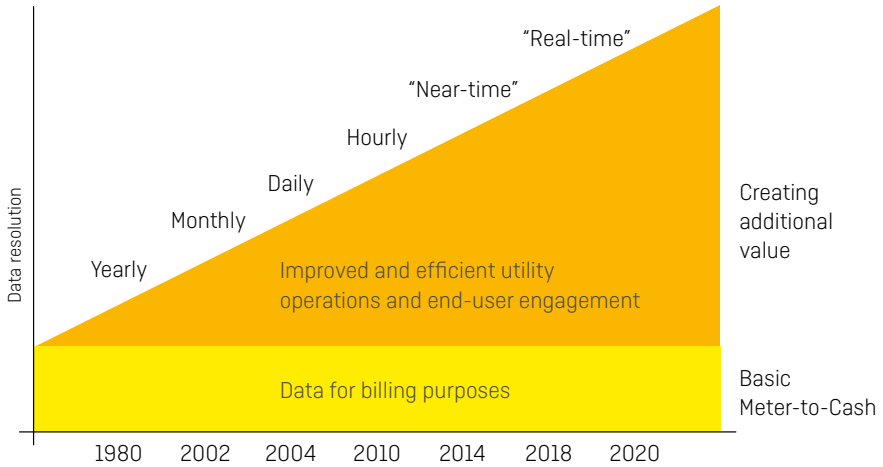
Frequent meter data also delivers a range of other benefits including continuous meter surveillance, which enable fast error detection and the introduction of new services to engage end users – the latter of which will be explored in the next section.

**Some of the most relevant application areas** in terms of improving energy efficiency are

- Identification of faulty or misadjusted substations
- Monitoring temperature levels in the distribution network
- Identification of heat and water loss in the distribution network
- Modelling buildings based on actual heat response and basic weather information
- Leakage detection
- Shaping peak demand to better utilise the existing infrastructure
- Introduction of billing schemes that support a more energy efficient heat supply

*Learn more at kamstrup.com/value*

*Data-based value creation*



# Engaging the end user

Including end users in the equation is crucial to balancing supply and demand in an energy efficient way. Smart metering technology allows district heating utilities to target poor user behavior and lets consumers take an active part in achieving a sustainable energy future.

Poor user behavior by individual end users can put stress on the distribution network and have a negative impact on the entire system. Truly engaging end users to take energy efficient action is, however, not an easy task and it will require district heating utilities increasingly taking on the role of advisors.

## Consumers at the core

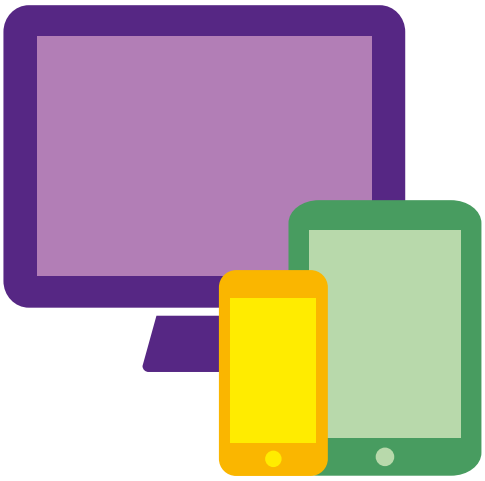
When comparing the same type of buildings, the energy consumption will often differ by a factor 2 or 3 – or more if you compare the energy consumption per $m^2$. If you focus on the volume rather than the energy, there can easily be a factor 10 difference in the amount of hot water that must be pumped out to two identical buildings. As the building stock is the same, these differences are directly related to behavior, which is why it is important to get the end users involved, when energy efficiency is concerned.

**The European Energy Union** places consumers at its very core. They must be both allowed and enabled to participate actively and take responsibility for their part of the energy transition. This involves providing them with solutions and tools to reduce their energy consumption and make sustainable energy choices.

## End-user engagement within reach

In general, engaging end users in their energy consumption has proven difficult, but new opportunities are on the way. Smart metering coupled with advanced data analytics enables a new level of end-user engagement. Also, utilities that are able to reposition themselves as energy advisers helping end users save energy and money, will be rewarded with a higher level of trust and commitment from their customers.

Metering and frequent data are needed to educate end users on the consequences of their energy behavior. A number of solutions are already available that allow end users to follow their consumption by the hour and to benchmark how they compare to other end users with similar profiles.



Alternative billing schemes could also be a way of motivating customers. Maybe in the future, end users will be billed based on their degree of flexibility rather than their consumption of energy – perhaps combined with peak rates, power limitation and penalties for excessive use.

Individual end users can get advice and guidance based on their personal user behaviour and specific property type. For example, knowing that a building consistently performs poorly when cold winds blow from the west, or that it would be profitable to replace certain windows so they can absorb more solar energy, would allow district heating utilities to act more proactively and provide customer-specific guidance.

Utilities could also offer online energy management services or even consider taking responsibility for operating the end user's heat installation in the most energy efficient way.

Creating exactly the right incentives is a prerequisite for engaging end users and making them more flexible and energy efficient. This calls for a wider variety of products and services on the shelves of utility companies – and just as importantly, it calls for frequent meter data in order for utility companies to be able to evaluate their effect.

# District heating in the future

The time for realising the potential of the district heating system of the future is now! Cutting-edge technology and increased digitalisation combined with the know-how and ambitions of experienced industry players will drive district heating to the next level.

At the very core of district heating has always been a collective effort for the common good. In the process of bringing district heating to the next level and fully unlocking its potential, this fundamental idea remains pivotal.

## Taking technology further – together

The individual technologies required in the energy systems of the future already exist, but the challenge lies in combining the right technologies in the right partnerships and eco systems.

While many of the tools needed to create value from data are both available and – compared to basic metering for billing requirements – affordable today, they have the potential to be developed much further together with utilities and research institutes.

This will call for metering manufacturers to go beyond simply providing raw data to district heating utilities. The next natural step is active participation in turning all the information into knowledge and providing analytics that support actual decision making within the utilities.

**The READY project and the 4DH Research Centre**, mentioned previously, are both examples of collaborations among industry players for the purpose of exploring the value of data in the integrated energy system.

*Read more on smartcity-ready.eu and on 4dh.dk*

## The future starts today

Heating and cooling have finally found their way on to the European political agenda as research institutes – Heat Roadmap Europe in particular – along with manufacturers and consultants, have succeeded in explaining and proving the potential of the heating and cooling sector. As a result, they are set to play a key role in the European energy policy.

This is an important step – not least on the way to gathering the fragmented heating and cooling sector in Europe – but it is important to remember that this development is only just picking up speed.

The rapid digitalisation seen in a number of industries over the last few years will also take place in the utility industry and – once again – change the rules of the game. Increased digitalisation of heating systems, from technologies to workflows and analytics, will further improve not just the efficiency of this industry but also society in general, leading towards a sustainable energy infrastructure.

While utilities will be able to control some parts of this development, others will be out of their control. The key to successfully navigate under these new conditions will be to accept that flexibility and a willingness to adapt is the best approach to a future-proof heat supply.

## References


1. *http://www.heatroadmap.eu/*
2. *https://www.euroheat.org/policy/smart-cities/*
3. *https://stateofgreen.com/en/news/new-white-paper-on-district-energy*
4. *https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_ACT_part1_v14.pdf*
5. *https://ec.europa.eu/energy/node/163*
6. *http://www.4dh.dk/about-4dh/4gdh-definition*


Think forward


**Kamstrup A/S**
Industrivej 28, Stilling
DK-8660 Skanderborg
T: +45 89 93 10 00
F: +45 89 93 10 01
info@kamstrup.com
kamstrup.com