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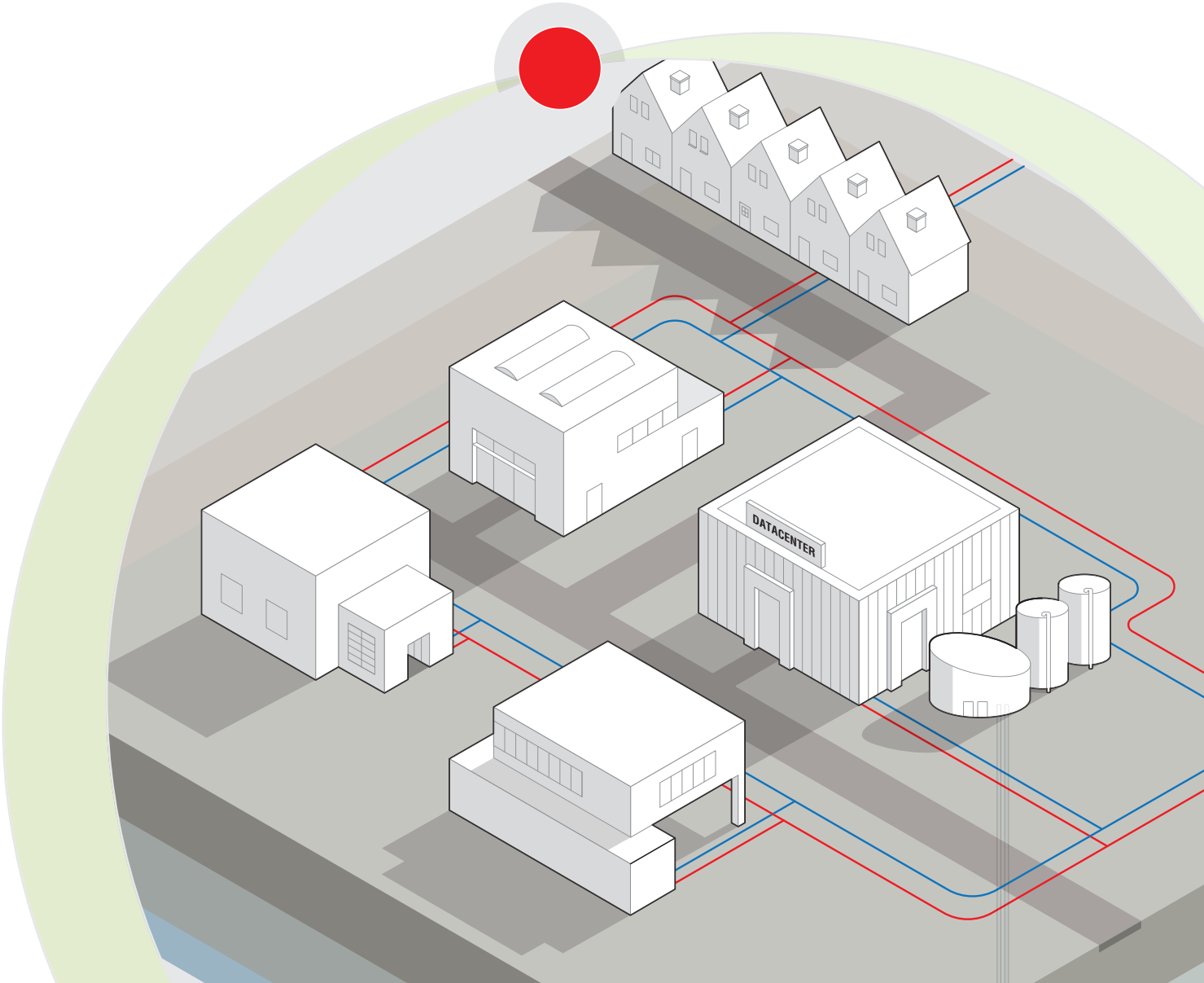
WHITE PAPER

Reusing Residual Heat from Data Centers

HOW DATA CENTERS WILL HELP HEAT 2 MILLION HOUSEHOLDS BY 2030



Contents

1 Residual heat as a primary heat source

Increasing digitisation has meant that data centers occupy an important place in today's society. For data centers, the continuity of providing a service is essential, so that also means being a continuous source of heat. This energy can be used to heat houses and other non-residential buildings and so contribute to creating a carbon-neutral economy in the Netherlands. Currently representing 44% of overall energy demand in the Netherlands, heat plays a key role in the transition to a sustainable energy system that does away with the need for gas-powered plants.

> **"Data centers fulfil an essential role in digitisation and have the potential to do so in energy transition"** – *Dutch Datacenter Association*

Exponential data growth

Amongst other things, developments surrounding the Internet of Things (IoT) and the growing number of internet users worldwide, have been responsible for an exponential increase in the use of data (figure 1).

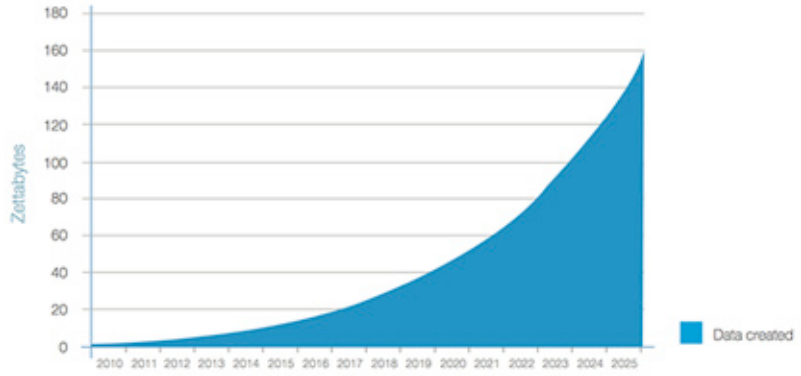


Figure 1: The size of worldwide data traffic annually. Source: IDC's Data Age 2025 Study.

Having an excellent ICT and energy infrastructure at its disposal, the Netherlands has become one of the most important hubs of digital traffic worldwide. The result is that the growth in the Dutch data center market has been explosive: over the last 6 years it has been expanding at an average of 17.5% per year. In turn, the volume of residual heat from these data centers has been growing too. Bearing in mind the European objective of having a built environment which is carbon-neutral by 2050, data centers are likely to play a key role by reusing the waste heat they generate as an important heat source for buildings.

In 2017, data center capacity stands at 1,247 MW. 1 With an average 20 GJ of heating needed for a well-insulated home, it is theoretically possible to heat around 2 million households with the heat generated - and those are the current figures.

How can we turn the gas taps off?

Over the last few years, large cities like Amsterdam and Nijmegen have been making pledges to become carbon-neutral within the foreseeable future. However, one of the biggest issues of the day is how to reach a sustainable solution by turning off the gas taps. Solutions do exist, at both a building-specific and a neighbourhood-specific level. In densely populated neighbourhoods, a neighbourhood-specific solution would seem to offer the best option. Currently, the energy industry is looking at major heat sources, such as geothermal heat and residual heat from power stations and waste incinerator plants. In addition, present-day regulations are aimed

[1] *Dutch Data Center 2017 Report – Room for Growth*

mainly at the supply and reduction of energy. So far, only tentative proposals have been made for using residual heat as part of an integrated solution. However, with the need to cut down drastically on carbon emissions, it will only be a question of time before the use of residual heat becomes statutorily regulated. By reusing waste heat now, data centers can work proactively towards delivering this energy transition and ensuring corporate social responsibility and, in so doing, consolidate the important role that they have in society. What's more, it provides a new business case for the data centers.

New business cases for data centers

In terms of energy use, the ICT sector occupies 4th position in the Netherlands: this stood at 16.6 PJ in 2015.[2] Data centers have a big share in this consumption because they house many servers which have to be kept cool. As a result of the sector having already undergone years of efficiency improvements and energy savings, the savings potential with data centers themselves is slowly reaching its conclusion. For example, applications in the field of high-temperature cooling of data rooms and the use of heat-cold storage systems, the Power Usage Effectiveness (PUE) has been approaching the ideal value of 1.0. Further improvements are becoming thin on the ground, and returns per improvement are decreasing all the time. For alternative business cases, it will be necessary to look beyond the confines of the data center. The supply of residual heat may unlock this potential.

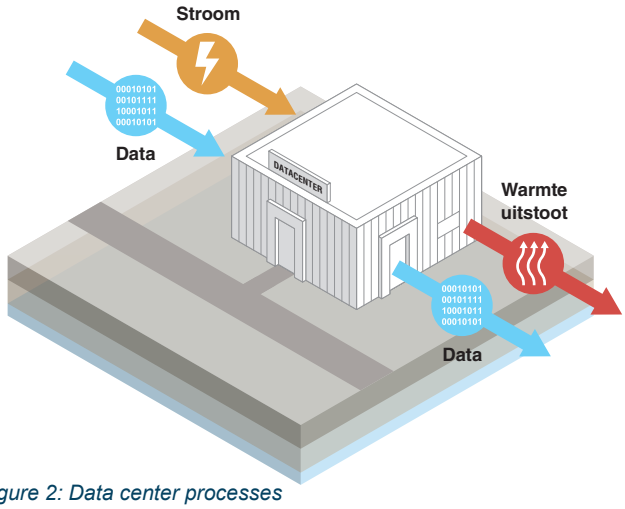


Figure 2: Data center processes

Taking into account the supply of residual heat to buildings in their vicinity, the exact location of a new data center takes on even greater significance. At some point in the future, the statutory authorities will be subject to more carbon-emission reducing targets. The importance for local authorities to locate new energy sources in the right places gives a data center a new negotiating position with respect to the terms and conditions of location.

2 million households heated by data centers in 2030

With the growth in data and in the number of data centers, the potential of reusing residual heat is only set to increase. With the right strategy in place, the possibility of creating new earning models and taking the right steps, the ambition of having 2 million homes heated by data centers is a viable one.

[2] *MJA – sector report 2015 ICT.*

[3] *This is the relationship between the overall energy use of a data center and the energy use of the IT equipment.*

2 The potential of residual heat

The heat generated by data centers has a relatively constant temperature between 25oC and 33oC. This low-calorific heat can be effectively increased to a temperature required by the consumer by means of a heat pump. This results in a heating concept which is extremely sustainable and can provide an interesting alternative for existing energy systems, such as gas-powered central heating systems.

Heat grids

To enable reusing, the heat will have to be transported from the source (i.e. the data center) to the consumer. This is done by means of a transport and distribution network (otherwise known as a 'heat grid'), so that large capacities of constant heat from data centers elsewhere can also be used. What's more, this means that a data center, which delivers heat to this grid, will take back the return flows to help cool its processes.

Thermal energy storage

For an industry which needs a continuous and stable supply of heat throughout the year, a constant heat supply from a data center provides new opportunities. Peak demand for heat in the built environment is in the winter, whilst in the summer a surplus of heat may exist. By making use of heat storage in the summer months, for example, using a thermal energy storage system, in addition to direct heat supplied by the data center, in the winter months it is possible to deliver an even larger capacity from the heat storage. At the current time, a data center's thermal energy storage system is used mainly to store cold. By storing extra cold in the winter months, the data center can be more efficiently cooled from the cold storage.

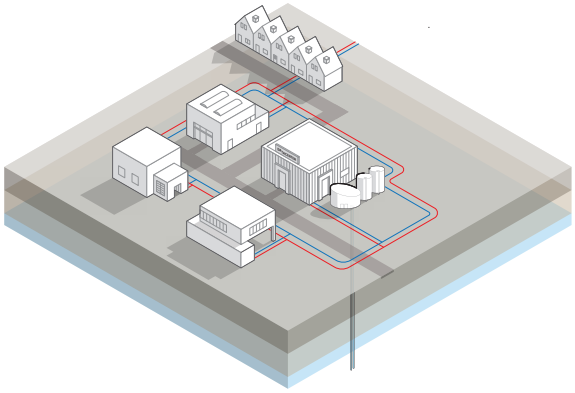


Figure 3: System overview in which heat and cold are stored for the benefit of the data center and the environment

Low-temperature heating

The Netherlands has next to no infrastructure when it comes to heat grids. The existing 230 grids supply heat to 317,000 homes as well as offices, glasshouses and industrials users. A substantial number of these are high-temperature (>100°C) heat grids. This heat is derived primarily from gas-powered plants and waste incinerators. In a carbon-neutral, circular future, it is highly unlikely that fossil fuels and waste will continue to be used for this end. Low-temperature heat grids will assume responsibility for part of this heat demand. 4 The Netherlands Environmental Assessment Agency expects that the current demand for low-temperature heat will grow from 50 to 350 PJ per year by 2050, whereby the potential for residual heat is estimated to be 100 PJ. 5 In 2017, data center capacity is said to be 1247MW, which means a heat production of 40 PJ.

[4] LT stands for 'low-temperature' and for the purposes of energy statistics, this means temperatures lower than 100 degrees Celsius.

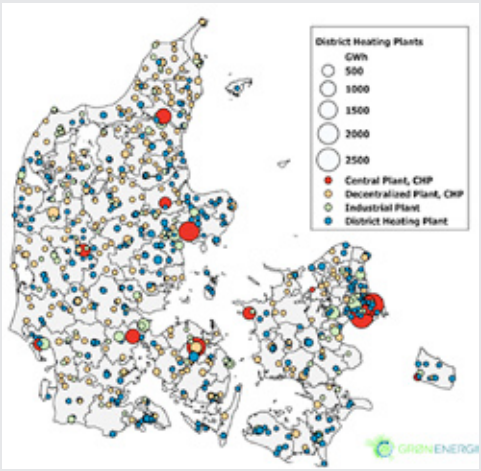
[5] Netherlands Environmental Assessment Agency: Toekomstbeeld klimaatneutrale warmtenetten in Nederland.

Investment in heat grid the biggest obstacle

The biggest obstacle to heat exchange at a neighbourhood level is investment in and development of the heat grid. When a heat grid infrastructure is in place, this significantly facilitates the possibility of heat exchange. The construction of a heat grid infrastructure is an expensive undertaking, with financing and investment requirements seen as the biggest obstacle to their growth (Nationaal Warmtenet Trendrapport 2017). Nevertheless, stakeholders in the Dutch market for heat expect that the development of heat grids and specifically, the reuse of residual heat, will grow rapidly over the next five years.

Specific role of government

Statutory authorities can play a crucial role in stimulating the recycling of heat, for example, by drawing up a consistent policy and taking into account the construction of grids when planning new areas for development. In Denmark, the state has made the use of residual heat a compulsory requirement with the effect that almost 100% of the potential has already been realised. In Sweden, local government has initiated the Stockholm Data Parks to heat large areas of the city with waste heat from data centers. So why not Amsterdam too, the mainport for data centers in the Netherlands? Or why not in the proximity of other regional data centers?



Case: Denmark

After the oil crises in the 1970s, the use of heat (as opposed to fuels) was made compulsory at a national scale. Instead of constructing gas grids, a decision was taken to develop heat grids. The upshot of this is that overall supplies of heat in 2014 were 122 PJ, heating no fewer than 1.7 million (64%) homes. Although many existing grids have a supply temperature of 80 °C, operators of the heat grids are focused on lowering the temperature. The main reason for this is to reduce the loss of heat in transport and the possibility of connecting up other low-temperature sources such as data centers.

Case: Sweden

The ‘Open District Heating’ initiative in Stockholm has opened up the existing heat grid to third parties who have large volumes of residual heat at their disposal, such as data centers. The city aims to be fully self-sufficient by 2040 and free of fossil fuels, so several Stockholm Data Parks are now being created. These are intended for data centers, on the condition that they supply their residual heat to the city. In Stockholm, residual heat can deliver almost 8,000 tons of carbon reductions per 10 MW data center. In this way, green data centers can contribute to positive climate gains in net terms. And, more importantly, as a result of the initiative, in 2016 more than 20,000 households were being heated by residual heat from data centers.

3 Challenges

Technically speaking, connecting up heat supply pipelines from data centers is always possible. The main obstacles to the efficient reusing of residual heat are matching supply to demand. These organisational and financial challenges mean that data centers will have to take on new responsibilities and roles. In addition, there are challenges to organising the demand side and the development of a heat grid infrastructure. By taking these key factors into consideration at an early stage, the chances of success will increase.

Priorities for data centers

Assuming the role of heat provider also means taking on obligations with respect to heat as a product and its supply. The key priorities are:

1. Influencing the primary business processes

The data center's task is to focus on managing and ensuring the safety and continuity of its core processes. The supply of heat must have no influence on these.

2. Responsibility for the supply of heat

In the highly competitive data center market, the priority is to focus on internal activities. The role of the heat producer and supplier are separate to this, so that responsibility for heat supply lies with a third party.

3. Guaranteeing the supply of heat

If, for whatever reason, a data center is temporarily unable to supply heat, a back-up system will be required. By connecting up several heat sources into one system, the responsibility can be shared.

Furthermore, one of the parties will have to take responsibility for installation of the pipes and systems in the data center, as well as for the consumers. Finally, for the supply of heat to smaller-scale customers, such as households, a special licence (ACM) will be required, based on the Heating Act.

Priorities for customers

For heating buildings, heat is a different commodity to gas and, in comparison to these energy sources, has a number of pros and cons. When switching energy systems, consumers must take the following into account:

1. At the most, the price of heat is equal to, or even lower than traditional heat sources

The heat grid is an infrastructure in much the same way as a gas or electricity grid. Whereas for gas and electricity there are several market players and freedom of choice, in principle, this is not the case for a heat grid. The Heating Act gives protection to consumers. In most cases, the company producing the heat, is also the owner of the heat grid and responsible for the supply to consumers. However, a 'No-More-Than-Elsewhere' principle exists, which means that the cost of heat can be no more expensive than the maximum price for heat generated by a gas-powered system. For smaller customers with a capacity of <100 kW, the maximum price is regulated in the Heating Act. The Heating Act protects consumers against the monopoly enjoyed by the heat provider.

2. The supply of heat is reliable with long-term safeguards

The heat supplier and the customer sign a supply contract which sets out the terms of the services and the reliability of supply. Again, with regard to this reliability of supply, the Heating Act provides the guiding principle for consumers.

3. Conversion of the heating system in a building or household

For existing buildings, perhaps the biggest obstacle are the one-off costs involved in converting the heat system (for example, central heating boilers), such as the costs of installing a heating pump, the switch to low-temperature heating in the home, and/or connection to the heat grid. Furthermore, in order to transition to a new heating system, structural alterations are often required, such as improved insulation. These changes however, will bring about reductions in heat consumption, so in turn leading to lower energy bills.

4 The integrated solution

In order to reuse residual heat from data centers successfully for the purposes of energy transition, an all-round solution needs to be drawn up on the basis of four key factors: heat demand; heat supply; heat storage; and the heat grid.

The integrated solution
1. Heat demand
2. Heat supply
3. Heat storage
4. Heat grid

By joining together the four factors at a neighbourhood level, a success can be made of heat exchange. Unica offers an approach which combines the technical and the organisational expertise it has with respect to data centers and its knowledge of energy supply to arrive at an integrated solution.

The location of the data center is likewise essential. The expectation is that demand will grow for new data centers to be used to provide heat in an effort to bring about greater sustainability in existing neighbourhoods. With the growth in data and data centers, more regional data centers can also be developed. If developments can be built up around residual heating, it will be vital to build as close as possible to consumers so that heat losses can be minimised and the investment in heat grid infrastructure reduced.

Cases Unica

Unica operates a number of energy systems in which residual heat from data centers can be provided. Feasibility studies, focusing on access to the four most important factors, have been made at three locations in Amsterdam, Groningen and Ede. This is indicated in the form of a table below.

Required for success	Science Park Amsterdam	Zernike Campus Groningen	BTA12 Ede
1. Heat demand	0	+	+
2. Heat supply	+	+	-
3. Heat storage	+	+	+
4. Heat grid	-	-	+

\+ = present 0 = present in limited form - = not present

In the case of Amsterdam, there is a heat supply of 7 MW and the data center uses a thermal energy storage for cooling, but there is no heat grid. Demand for heating in the vicinity is high, but potential customers, consisting of thousands of private consumers, are located around 1.5 kilometres away from the data center. The situation in Groningen is comparable, but has the added advantage that heat demand is somewhat more favourable. In Ede, the analysis showed that only the supply side is missing. This can provide a fantastic opportunity for the location of a new data center.

These examples indicate that it is not easy to achieve a perfect combination of the four factors. In order to maximise the effect of the residual heat potential, it is essential to develop an all-round energy vision with respect to the neighbourhood on the basis of a local area plan.

5 Unica's Approach

Unica's approach is to identify possibilities for connecting up heat grids to data centers on a phased basis and then to set out and implement a programme that provides long-term guarantees.

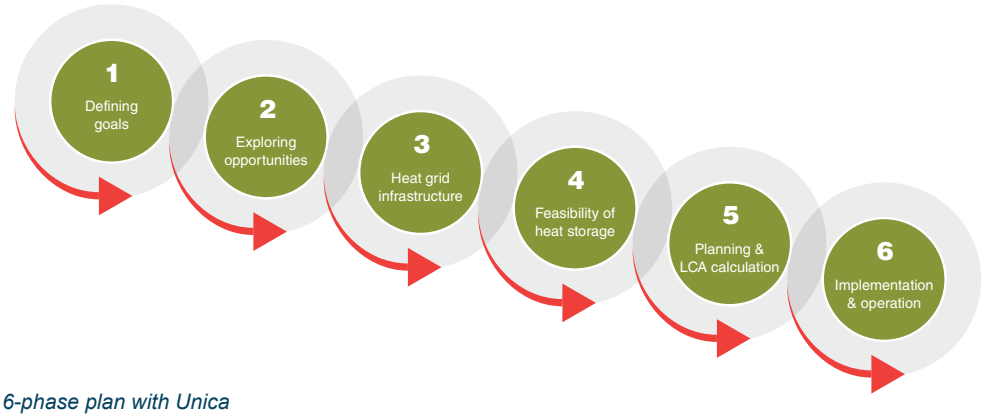


Figure 4: 6-phase plan with Unica

1. Defining goals

As a starting point, Unica first talks to the data center's owners in order to define the goals. Each case is unique, so Unica - together with the party in question - will evaluate the possibilities of reusing residual heat. To do this, Unica combines its specialist expertise of data centers with its experience of energy supply and building sustainability. It is important to identify the expectations and the ambitions of the data center. What are the reasons for wanting to use this residual heat externally? What sites will be investigated, are new or existing ones involved? How will Unica guarantee that the primary processes of the data center are not inconvenienced by these plans? What financial benefits will the data center get from supplying residual heat?

2. Exploring opportunities

Different consumers have different needs and these can serve as a starting point for other opportunities. By talking through the options with these parties, and thus identifying the expectations and the options available, an assessment can be made as to whether demand and supply in a specific local area are matched. Usually these talks are carried out with partners, such as grid operators and building owners. In addition to matching supply and demand, we also examine whether the integration of residual heat is consistent with the asset management of the property owner. Premises might get sold, redeveloped or even demolished a number of years down the line.

3. Heat grid infrastructure

Identifying a possible infrastructure for the heat grid starts by sharing information. A number of facts and figures are relevant:

Relevant factors to determine project feasibility
• Number of customers, the density and proximity of these
• Capacity on both the supply and demand side
• Building characteristics, such as insulation, engineering systems and functions
• Temperature level
• Possible routes
• Party responsible for each part of the grid/infrastructure

During this phase, Unica will work with partners who have a knowledge of this horizontal infrastructure.

4. Feasibility of heat storage

To ascertain the storage possibilities other, different factors are relevant:

Relevant factors to determine the feasibility of heat storage
• The matching of supply and demand throughout the year
• Defining the type of storage, such as thermal energy storage, (underground) water tanks, etc.
• Environmental factors and available space
• Temperature levels and losses in the storage system

Given the many innovations in this field, to this end, Unica is currently working with a range of partners.

5. Planning & LCA calculation

Once the infrastructure lay-out has been decided and responsibilities have been allocated, a plan can be made with respect to effectuating connections and any possible heat grid and heat storage. This planning is complemented by a life-cycle analysis (LCA) which takes into account a number of different scenarios. For example, an assessment is made of a heat grid that will heat existing houses and will gradually establish more connections in response to the heat price, or a heat grid that is integrated with other grids.

6. Implementation & operation

In this phase a start is made on the infrastructure and technical modifications carried out on systems, which are necessary to achieve heat exchange. Once Unica has implemented the plan, there will also be the possibility to organise operational management and to deliver residual heat to the customers.

6 Trends

Unica has identified a number of trends when it comes to the heating of buildings through the recycling of residual heat from data centers.

High output temperatures
Over the past few years, the established capacity of servers in a data center has risen. As a result, more heat is released, which means that cooling must take place differently. The cooling process shifts from an air-cooled system to a water-cooled one. This way more heat can be captured. Over the last few years, this has resulted in output temperatures for residual heat rising from 20 oC to 30 oC. This is more than enough to heat a well-insulated home.

Better insulation
Homes are better insulated so that demand for heat is smaller. Using the same heat source, a larger number of houses can be heated more sustainably.

Low-temperature heating becomes the standard
New or renovated homes need to be designed for low-temperature heating. This way they become future-proof so that any kind of sustainable heat source (such as solar power, geothermal power with a water pump, air-to-water heat pumps, residual heat from a data center or a technique still to be developed) can be connected.

More local data centers and therefore heat sources
With the exponential growth of data, local storage and rapid access to information will become increasingly important. Additionally, buildings are becoming smarter through the application of ICT for smart buildings and the Internet of Things. The nearer data is stored, the faster the availability so that software decisions can be made. At a household level, it will soon be possible to have a separate server for home ICT applications generate all the heat for household heating. Tap water will be activated electrically in situ via small-scale boilers or booster heat-pumps.

Stricter regulations to prevent ‘dumping’
Legislation to prevent the ‘dumping’ of residual heat is set to become tighter. For example, in the Netherlands, if you want to discharge residual heat into watercourses, a license will be needed. In almost all non-residential buildings or data centers, valuable residual heat is currently discharged into the air without restriction, for example, via a dry cooler. For residual heat to take on an increasingly important role in the energy transition process and to reduce carbon emissions, stricter regulations are anticipated.

All these trends show that there will be multiple winners from the use of residual heat from data centers: for data center operators, for customers and for the environment!

7 Thinking, acting, guaranteeing

Unica has many years' experience in the design, construction, management and operation of building engineering systems, and, together with the owners and operators of data centers, aims to deliberate, act and above all guarantee that residual heat is used effectively to help make good on the promises to reduce carbon emissions in the Netherlands. Unica is able to effectuate integral solutions by combining its specialist know-how of data centers, the safety requirements associated with the industry, and the specialist knowledge of energy systems and heat supply.

Unica Energy Solutions is the lynchpin when it comes to all energy and sustainability activities at Unica. The reduction of carbon emissions is essential in this. Unica Energy Solutions is a specialist in energy systems and building engineering systems and offers integrated solutions on the basis of long-term performance contracts. Its team of committed staff are able to think outside the box. Unica Energy Solutions has a close working relationship with other driven partners to make the built environment energy-neutral via a process of 'thinking, acting & guaranteeing'.

For all issues relating to data management look no further than Unica Datacenters. Unica Datacenters specialises in the technical infrastructure of data centres. Throughout the Netherlands, Unica Datacenters is responsible for providing consultancy, design and construction services for reliable, safe and hi-tech web hosting centres, computer rooms and data centres.

Unica believes in a future in which the entire built environment is carbon-neutral. Would you like to know more about how Unica can help your data center become more sustainable? If so, just contact Unica Energy Solutions, Unica Datacenters or your contact person at Unica.

More information

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