Heating and cooling innovation catalogue

2019

THERMOS

Accelerating the development of low-carbon heating & cooling networks

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Heating and cooling innovation catalogue

Local heating and cooling networks can offer a number of benefits. They can, for example, contribute to targets for the deployment of renewable energy and alleviation of fuel poverty. They can also provide the opportunity to improve efficiency through the utilisation of waste heat and better matching of local heat demand and supply.

However, planning the development of a district heating and cooling (DHC) network is complex and local authorities often do not have the capacity to carry out their own feasibility work in-house. This means that the process can be expensive and time consuming, and may also lack transparency.

The THERMOS (Thermal Energy Resource Modelling and Optimisation System) project will develop the methods, data and tools to enable public authorities and other stakeholders to undertake more sophisticated thermal energy system planning far more rapidly and cheaply than they can today. This will amplify and accelerate the development of new low carbon heating and cooling systems across Europe, and enable faster upgrade, refurbishment and expansion of existing systems. Specifically, the project aims to put local decision makers in a position where they are able to identify the right areas and routes for different types of thermal system quickly and accurately by automating questions about possible system configurations and economics.

The purpose of this booklet is to raise awareness of the potential benefits of using advanced heating and cooling mapping as part of the process of planning DHC networks and to showcase innovative work in this area as well as more widely across the sector.

Fifteen case studies are presented that describe projects across a number of European countries and that cover a range of technology types, system configurations, ownership models, and political and economic contexts. These examples clearly demonstrate the need for tools that can help public authorities and other stakeholders to understand and evaluate options for the development of heating and cooling networks. They also provide valuable learning that will be used to inform the work of the THERMOS project team.

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Case study 1

Bunhill 2, London

Extending an existing network and utilising an innovative heat source and a smart control system

The Bunhill 2 project will see the Bunhill heat network expanded to supply a further 500 to 1,500 homes, with the additional heat supplied by a new energy centre converting warm air discharged from London Underground tunnels into hot water. During the summer months the system will also provide cooling to the London Underground tunnels by reversing the air flow and using ambient air to provide the heat.

In addition, a smart control system will be installed to control the two energy centres – one using gas CHP unit to generate the heat and the other using an electric-powered heat pump. The system will monitor real-time electricity prices and generate heat for the network using the most cost effective method; during periods of high electricity prices, the CHP will be prioritised in order to generate electricity and boost income, whilst the heat pump will be deprioritised; any heat generated above the level of demand will be stored in thermal storage. During periods of low electricity prices, the heat pump will be prioritised and the CHP deprioritised, with any heat produced above the demand level stored.

Background and objective

One of Islington Council's main priorities is to reduce fuel poverty within the borough. The Bunhill heat network, launched in 2012, was one way for Islington to deliver on this agenda, as it allowed the council to reduce heating bills by 10% for council tenants connected to the network. The expansion project is designed to deliver the same saving to the newly-connected tenants.

Computer generated image of what Bunhill 2 will look like to passers by. Bunhill 2 will supply a further 500-1,500 homes with heat discharged from London Underground tunnels.

The council also has a target to reduce the borough's carbon emissions by 40% by 2020 compared to a 2005 baseline. Around 20% of Islington's carbon emissions are from domestic gas use, the vast majority of which is for heating. The first phase of the Bunhill heat network delivered a 2,000 tonnes/year saving, with the second phase expected to deliver a further 500 tonnes/year.

From London Underground's perspective, cooling the tube is a major priority due to the issues from excess heat. This is particularly pressing on the Northern Line (on which the heat extraction point is located), as the number of trains per hour is expected to increase by 50% as a result of upgrade works.

The council's experience of delivering district heating networks will be used to inform the THERMOS model, helping ensure that cost estimates and timescales are realistic.

The project is also designed as a demonstrator for the viability of using heat from the underground and the smart control system.

Project programme and outcomes

The project is still in progress and is expected to be complete in late 2018.

The main challenges have laying district heating pipework in an inner-city area (in one 25 metre stretch of Central Street nearly 90 different services were found to be crossing the road) and aligning project timelines between the council and its partners to ensure that different parts of the scheme are built at the correct time.

Scope for replication

The project is theoretically replicable in any location where an underground railway/metro is exhausting heat. Islington have already engaged with organisations in South Korea and Romania that are considering similar schemes, hosting a visit from a Korean delegation and presenting to a Romanian audience as part of the Reuseheat project.

The front of Islington council's Bunhill Energy Centre

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www.islington.gov.uk/energy-and-pollution/energy/bunhill-heat-network
www.youtube.com/watch?v=UUaMtHzatT4

Case study 2

Parc de L'alba, Spain

A model of sustainability in Cerdanyola del Vallès

The Parc de l'Alba (also known as Directional Centre) is a new urban development located in Cerdanyola del Vallès, a town of 50,000 inhabitants near Barcelona. It covers 340 ha, of which around half will be green spaces. The total built area of 146 ha will include the Science & Technology Park and Synchrotron light laboratory (particle accelerator) plus, office buildings, three data centers and a commercial area. There will also be a 45 ha residential area of 4,000 dwellings.

One of the strategic goals of Parc de l'Alba urban plan is to excel in environmental quality, minimising the impact of the urban development.

In particular, it aims to be a model of sustainable growth with electricity, heat and cooling produced by a highly efficient energy system.

The expected total energy demand of the park is high: electricity, 281 GWhe: cooling: 214GWhc; heating and DHW: 123 GWhh. Therefore, in order to minimise the consumption of primary energy, a high-efficiency energy supply system, based on polygeneration technologies and a district heating and cooling network was specified.

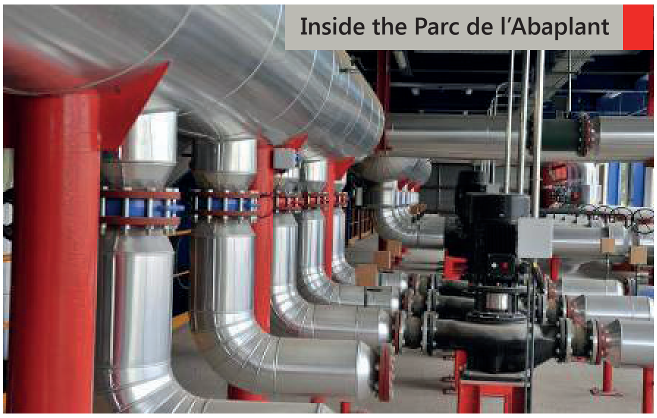
This network will comprise three natural gas cogeneration plants with thermal cooling facilities (single and double effect absorption chillers) and a 32 km district heating and cooling network within the Science & Technology Park. The residential area has not been included in the DH&C network, since its demand profile does not justify the additional investment.

The total expected capacity of this polygeneration system is as follows:

- Electricity: 47 MWe
- Cooling: 51 MWc
  (of which 33 MWc from absorption chillers, and 18 MWc from compression chillers)
- Heating: 45.5 MWh
  (of which 30 MWh heat recovery from engines, and 15.5 MWh from conventional boilers)

The system has been designed to be as modular as possible, to accommodate its gradual implementation into the urban development, with an expected timescale of about 20 years. The first plant has been in operation since 2010, with a total installed capacity of 10 MWe is run by a public-private company under a 30-year concession contract. It is also compatible with

Alba Synchotron laboratory



Inside the Parc de l'Abaplant

renewable energy sources, and a solar thermal plant and a gasification biomass plant will be integrated in the future.

Besides back-up systems, the plants include chilled water storage systems, used to take in variations of cooling demand.

The innovative energy measures being installed at Parc de l'Alba are similar to those under consideration in the cities of Turin and Stuttgart, and were included in the Polycity, a specific Concerto project within the Sixth Framework Programme of the EU.

Project progress and outcomes

So far, the energy service company that uses the Parc de l'Alba DH&C network, supplies energy to five of the six existing buildings within the park: Alba Synchrotron (heating, cooling and electricity), two office buildings (heating and cooling) and two data centres (just cooling).

The thermal energy sold during 2017 was 25,300 MWh of cooling and 3,400 MWh of heating. The electricity produced was either sold to Synchrotron (23,300 MWh) or exported to the grid (28,500 MWh).

The main challenge that the energy service company has faced, especially during the first few years, was to convince building managers of the reliability of the system. This is because of the lack of familiarity of these systems, as there are few large-scale DH&C networks in Spain. It helped that the first customer was Alba Synchrotron - a company which requires a stable supply of large amounts of energy and was willing to describe its experience to other potential customers.

Subsequently, it has been relatively easy to gain new customers who see several advantages of outsourcing heating and cooling supply: the ability to focus on core business; the lower space requirements for equipment; and reduced initial investment and operating costs (around 20% savings compared to conventional systems).

It also helps that Parc de l'Alba specific ordinances make it mandatory for new buildings on land initially owned by any public administration to be connected to the DH&C network where there is an available connection.

Data centres represent a special case. They require a very high 24x7 cooling capacity along with sufficient internal back-up in case of a power cut or cooling system failure. The most widely used data-centre certification organisation (Uptime Institute) does not recognise external energy sources as a back-up, so in order to comply with their standards data must maintain their own stand-by chillers. This makes a connection with a DH&C less advantageous, but despite this, two of the three data centres in Parc de l'Alba are connected to the DH&C network.

Scope for replication

In Parc de l'Alba's urban plan the DH&C network is expected to grow from the current 16.8 km of pipework to 32.3 km, in order to reach all the future non-domestic buildings in the park (industrial, offices, commercial, equipment).

In addition, the ESCo's contract obliges it to offer its services - and extend the network - to any user that lies within a distance of up to 600m from the existing network if its total needs are higher than 5 MW of cooling and 4.3 MW of heating.

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Case study 3

Parque das Nações, Portugal

District heating and cooling as a means to cut carbon emissions and improve the urban landscape

The Parque das Nações district heating and cooling system – the only large-scale one in Portugal – serves a new neighbourhood in Lisbon. Its 85 km of pipes and 135 energy transfer stations supply heating and cooling to over 3,000 apartments, a number of office buildings, hotels and schools along with several very large structures, such as a shopping mall, an oceanarium, the Altice indoor sporting arena, the Lisbon Exhibition Centre (FIL), Lisbon Casino and the Gara do Oriente railway station.

The network is powered by a high efficiency natural gas trigeneration system and has an installed capacity of 29MW for heat and 35MW for cooling. The overall efficiency of the plant is above 85%, since all waste heat is recovered to produce chilled water (4°C) and hot water (90°C).

The design, construction, financing and operation of the entire plant is managed, under a concession contract, by Climaespaço, a subsidiary of ENGIE Group and a world leader in district heating and cooling.

Background and objectives

The Parque das Nações DHC system was built between 1996-98 alongside the extensive developments of the 1998 World Fair held in Lisbon.

The main objective of the project was to reduce energy consumption and emissions. But an important secondaray aim was to protect the city's unique architecture and set high standards for urban planning and design by eliminating unsightly air conditioning equipment.

Project progress and outcomes

For a country with no culture of district heating and with no legal framework favouring DHC, and where, generally speaking, decision makers were not aware of the benefits of thermal networks, the Parque das Nações system was a major challenge.

However, the project is now a success story and an inspiration for many of similarly scaled projects around the world. Over its 20 years of operation, the scheme is reckoned to saved around 105,000 tonnes of CO_2 emisions and to have used around 35% less gas than if the area would have been heated and cooled conventionally.

In addition to the reduction in energy consumption and CO_2 emissions, the benefits are considered to include the elimination of air conditioning equipment from buildings, free rooftops, lower noise levels, lower space requirements for plant machinery, no cooling

Planners' visualisation of Lisbon's Parque das Nações on the Tagus estuary

The Parques das Nações district heating system serves the Lisbon Oceanarium and the Gara do Orinte (below)

towers needed in the area, reduction of the load on the electricity grid, and higher reliability.

The first years were challenging, because after EXPO'98 the area partially emptied, leaving a huge private investment with a very limited number of customers. Yet the project survived and started growing. A DHC system is a capital intensive investment, with very long payback periods, that only some investors are ready to accept. Among the list of challenges for the future, isa need to renovate the infrastructure, which is now 20 years old. There is also a need to progress towards energy transition and to improve data sharing with users.

Scope for replication

A project like Climaespaço could be replicated in new urban areas with high thermal energy needs (office buildings, hotels, hospitals, data centers, shopping malls etc). Smart DHC - based on high efficiency technologies, renewable energies or waste heat - is an excellent way to provide a comfortable environment in dense urban areas.

A large number of projects like this are being planned and built throughout the world, especially in regions with high cooling needs. However, Climaespaço is still the only large scale DHC existing in Portugal, 20 years after EXPO'98. Climate is not the reason for this disappointing picture, because cooling needs are huge and rapidly growing. The main barriers are a lack of awareness about DHC and a lack of district energy culture. There is an obvious need to work with mayors, urban planners and other decision makers, so that DHC benefits can be fully understood.

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Case study 4

Aalborg, Denmark

Towards a fossil free heat supply

Aalborg District Heating is a council-owned utility company that supplies around 40,000 heat consumers. Currently, the heat is supplied from a variety of sources, including waste incineration and excess heat from Aalborg's huge Portland cement factory.

Around 70% of the heat is produced by a coal-fired CHP plant with a heat capacity of 490 MW and an electric capacity of 410 MW. In 2016, the municipality bought the CHP plant from its private owners, and are now seeking fossil free alternatives to coal. These need to be in place by 2028 by which time the plant's coal-firing equipment will have reached the end of its useful life. The plan is to supply the plant with a variety of sources of power - including renewables and excess industrial heat - hence the installation at the start of 2018 of a 35 MW electrical boiler, enabling the utilization of electricity in hours with high wind production and low prices.

Background and objectives

The success of the project is based on the reduced CO_2 emissions from future energy supply that supports business and consumers in an economically feasible way. These aims support Aalborg council's goal of cutting greenhouse gas emissions by 40% in 2020 and becoming fossil free by2050.

The overall aim of Aalborg District Heating is to create a diversified strategy incorporating several technologies and smaller units, to minimise risks in the system. Another aim is to to utilize the local resources available from companies, industries, cooling units, waste treatment etc. In March 2017, Aalborg District Heating released an extensive study in which seven different future-planning scenarios (to 2035) were examined, each one focusing on various degrees of implemention of the following: large heat pumps, biomass, industrial excess heat, solar thermal and large thermal storage.

Project progress and outcomes

All seven scenarios showed that annual emissions can be reduced by 58% from 185 kilotonnes in 2016 to 75 kilotonnes in 2035, where the remaining emissions are from waste incineration plants.

The economics of the plant in each scenario is cost neutral in a planning period of 20 years, with a total net present value of around €800bn. Importantly, consumers are not expected to be affected by the change to renewable energy sources. The socio-economic impacts were also calculated and the study concluded that the scenarios can be implemented without adding additional costs for society as a whole.

In regards to the local economy, the project is estimated to create jobs in the construction phase, which will have a negligible impact on local taxes. The calculation neglects benefits of increased use of industrial excess heat and establishment of new production capacity elsewhere in the electrical system. Sensitivity analyses of the scenarios were also carried out, showing that the results are robust in regards to heat storage investments, biomass prices, discount rate, electricity taxes on heat pumps and changes in coal and electricity prices.

Another outcome of the project has been a technology catalogue, describing the various technological options by their pros and cons in regards to the Aalborg district heating network. This technology catalogue will be used in the forthcoming decision processes, when replacing investments in new technologies. The next decision is in regard to the large scale electrical heat

Aalborg's large district heating network is supplied by this coal-fired CHP plant. The city plans to convert this plant to fossil-free before 2028.

pumps, where there are already specific suggestions from heat pump manufactures. The project is divided into three phases. The first is a 100 MW electrical heat pump that runs in combination with the large CHP plant. The second phase is 150-200 MW electrical heat pumps designed to capture the excess heat from industrial and waste incineration facilities. And the third is a further150-200 MW electrical heat pumps to be installed in combination with biomass CHP and wind power.

Scope for replication

There are many district heating systems across Europe and beyond that are in the same situation as Aalborg, where the old fossil-fuel supply (especially coal) needs to be replaced by alternative (especially renewable) sources. Hence, this case study is a good example of how such a change can be approached - with the proviso that Aalborg's situation is ongoing and that detailed experience with specific technologies is not available yet. The case study shows how to incorporate various different heat sources into the same network, adding renewables and keeping the costs of the system stable.

Case study 5

Graz, Austria

System Change: District Heating Graz

The City of Graz faces a particular combination of energy-related challenges:

- Increasing levels of air pollution levels caused by the city's position in a valley basin.
- A large stock of historic housing with a low refurbishment rate (Graz is a Unesco world heritage site).
- 70% dependence on a single coal-based combined heat and power (CHP) plant for its heating and cooling which was supposed to be partially phased out by 2019.

Furthermore, the city's geographical position leads to a significant divergence between peak demands of heat between summer and winter months with a ratio of up to 1:10 to 1:20.

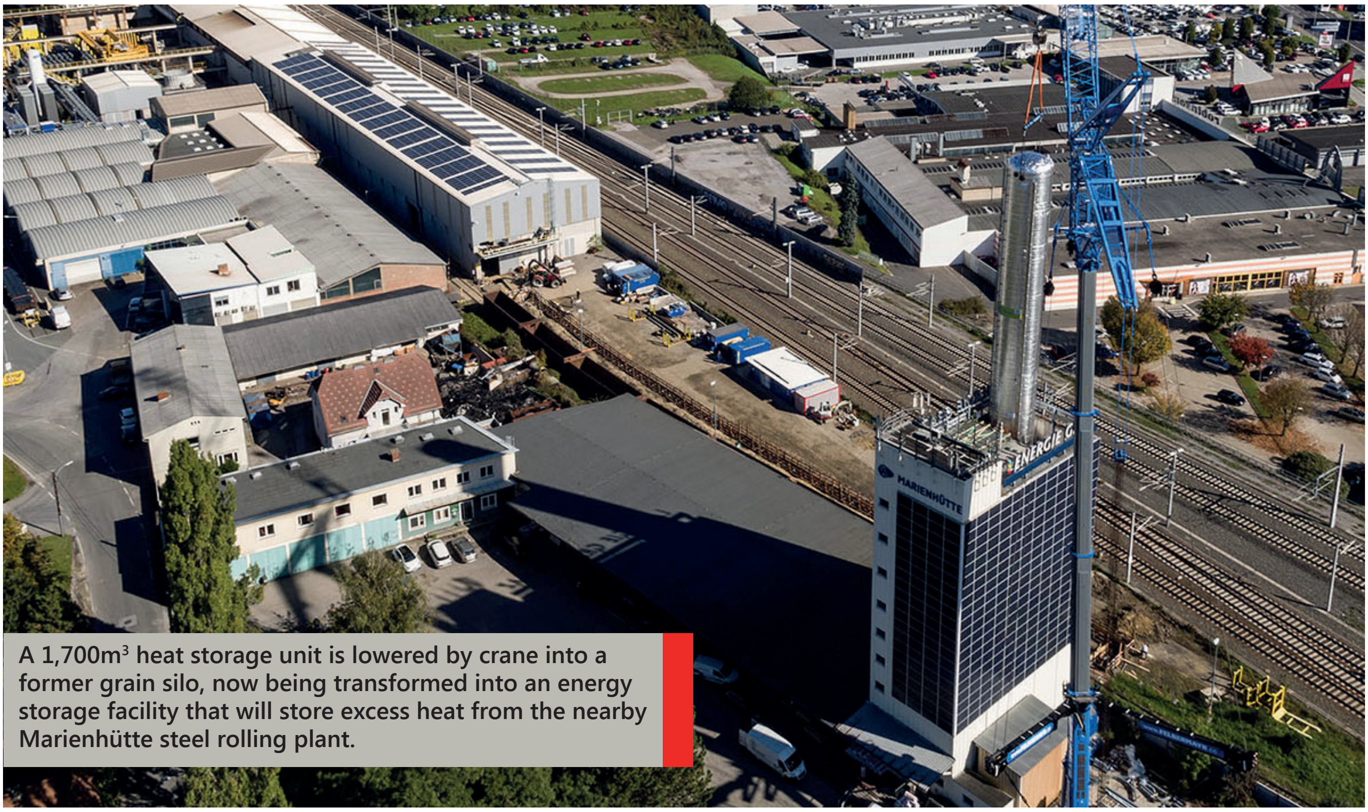
To address these challenges, in 2013 Graz launched a large scale DH strategy process aiming to transform the city's heat supplies to 2020 and beyond.

At that point, Graz's district heating peak load was at 530 MW and its annual heat supply was 1,200 GWh (average standardized value). This represents just over half of the city's overall heat demand of approximately 2,300 GWh.

The strategy was formulated as an integral part of the 'Urban Development Concept 4.0' framework, aiming to make Graz an energy-efficient, resource-conserving, low-emission, sustainable and livable smart city.

To start with, a core working group, Heat Supply Graz 2020/2030, was formed consisting of a variety of key stakeholders including the city authorities, regional energy supply companies and the Graz Energy Agency. The group has subsequently published a heating supplies green paper - an oversight of the city's energy needs up to 2030.

Furthermore, Graz sought to establish an integrative process by engaging citizens, experts and stakeholders



A 1,700m^3 heat storage unit is lowered by crane into a former grain silo, now being transformed into an energy storage facility that will store excess heat from the nearby Marienhütte steel rolling plant.

in energy talks and "calls for contributions" on over a dozen different subjects. This led to 38 innovative action proposals up to 2016.

The efforts of Heat Supply Graz 2020/2030 have concentrated on:

- Raising the share of renewables in the energy mix of the district heating system from 25% by 2017 to 50% by 2025 and finally to 100% by 2040.
- Expanding the district heating network to up to 60% from initially 36%.
- Diversify the mix of suppliers, from seven at the beginning including one main supplier covering 70%, to 20 different suppliers tapping on a broad mix of different energy sources.

In short, the outlook study, the core working group and the calls for contributions were essential to designing the approach and operationalising the task of redesigning Graz's district heating and cooling network.

Project progress and outcomes

Up to now, local utility companies in Graz have successfully integrated an increased share of 22% renewable energy sources and waste heat sources into their heat supply network. Moreover, the city has made progress in diversifying the number of suppliers – it currently stands at 11 – while at the same time expanding its district heating network to 790km.

Redesign of the DH energy supply mix

The diversification of thermal suppliers has proved particularly challenging as the city has been largely dependent on a single coal-based supplier.

Graz took efforts to redesign its energy supply network system by focusing on energy efficiency (new buildings, building stock and district heating network) and identifying a mix of alternative sources:

- Biomass *(local potential up to 15% of Graz's DH volume)*.
- Waste heat from an electric steel plant, a paper factory and a waste water treatment plant *(up to 30%)*.
- Solar energy *(up to 20%)*.

To realise the renewables potential, smart grids, a smart district heating system, the integration of storage capacity, and hybrid solutions such as power-to-heat (P2H) are regarded as necessary facilitating technologies. Gas is seen as 'bridging technology'.

Waste heat recovery in action at the Sappi paperworks near Graz

Photo licensed by Arbeitsgruppe Wärmeversorgung Graz 2020/2030 and © Bioenergie/Jakob Edler

Left: some of Graz's large stock of historic housing. Right: Waste heat recovery at Marienhütte (Foto Fischer)

In order to start the redesign, the City of Graz engaged the University of Graz and local industry companies with whom they launched consumers' partnerships on energy efficiency, for different temperature levels and individual heat production.

Like many urban authorities which undertake large-scale developments, Graz has had to reconcile its long-term investment planning with the shorter-term planning of private companies. Thus when negotiating with private industry concerns to tap into their excess heat potential the city had to develop innovative business models, for example the industrial waste heat contract agreed with Sappi paper factory. The excess heat from the plant - located in a neighbouring municipality 9km away - now contributes up to 150,000 MWh of heat, or 15%, of the Graz's district heating system needs.

The individually developed business models have proven to spur progress in moving away from just one main supplier, and could serve as a role model for other cities.

In order to overcome the obstacle of covering for contingent liability the city established an intermediate company.

Conclusion and scope for replication

Several conclusions can be drawn from Graz's district heating development:

- Approaching the redesign of the energy system as part of an integrative concept for urban development benefits both.
- The creation of a core working group (in Graz's case, Heat Supply Graz 2020/2030) as well as the broad public and private stakeholder and expert consultations ensured the translation of targets into concrete actions.
- District heating can be a good option for areas of historic buildings.
- A prior 'energy feed simulation' is vital for realistic planning with multiple energy sources.

Graz's example shows a high degree of transferability. It showcases good practices and provides valuable lessons, particularly for municipalities which meet their heat demand largely with coal and gas. The following areas are particularly worth noting:

- The importance of developing an integrated urban development concept to guide energy system change within a 'holistic transformation' of all aspects of city life.
- The need for proper analysis of the available potential of each renewable energy source and an adequate mix of sources
- The identification of waste heat sources and establishment of partnerships based on regular dialogues with industry
- The identifying and raising awareness of public and private interests in the process of system change.

The approach and success of Graz demonstrates that, particularly for investments in existing heating networks, cities can identify opportunities to combine more public and private funding. Here the THERMOS capacity module 5 can provide further assistance.

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Case study 6

Tartu, Estonia

District cooling system

In May 2016 Fortum opened the first district cooling plant and network in Tartu, Estonia. The scheme aimed to significantly reduce carbon emissions in the city by implementing an innovative and high performance solution that included the use of river-cooled chillers, solar panels to meet the electricity demand of the plant itself, and a heat pump to transfer residual heat from the cooling system to warm water in the existing district heating system.

The Tartu district cooling system currently has a maximum capacity of 13MW and the network is 1.8 km long. The total cost of investment to date is €5.7m.

Fortum received a special award from the Global District Energy Climate Awards 2017 organisation for the expansion of its district heating and cooling (DHC) system in Tartu, Estonia. See www.bit.ly/2slZsth

Background and objectives

Estonia's energy mix is carbon intensive, with around 80% of electricity being generated from oil shale. In this context, Tartu's Sustainable Energy Action Plan (SEAP) 2015-2020 sets three general strategic objectives: to decrease CO_2 emissions, to consume less energy in final consumption and to increase the share of renewable energy (www.tartu.eu/data/SEAP_Tartu_ENG_2015.docx). The plan also includes specific targets to produce at least 52,000 MWh/yr of cooling from renewable sources and to reduce CO_2 emissions in the sector by 70% by the end of the plan period.

Pre-works for the construction of the Tartu district cooling system began in 2014. The first customer was connected in April 2017, and the system was commissioned in the following month. The DHC system is owned and operated by AS Fortum Tartu, a private holding company who have been responsible for running the city's district heating system since 2004. Underneath AS Fortum Tartu, two separate companies are responsible for its day to day management:

- AS Tartu Keskkatlamaja is responsible for the system's operation and maintenance, as well as its customer interface.
- AS Anne Soojuse is responsible for production of heat, electricity and cooling.

The municipality is not involved in the ownership or operations of the Fortum Tartu, but influences its business development through city planning. External consultants from Sweden were contracted to support Forum Tartu with the initial feasibility work.

The Tartu distric heating plant

Water for the cooling system is cooled in a centralised plant and is then distributed through the network to consumers. Energy is exchanged at an energy transfer station, and the warmer water then returns through the network back to the production plant where it is cooled again. During the winter (October to April) cold water from the river Emajõgi is used as a source of free cooling. When the water becomes too warm for free cooling it is used to cool the chiller condenser. In co-operation with the SmartEnCity project, solar panels were installed to produce electricity to meet the plant's own energy needs. The performance of the system is closely monitored with comprehensive smart metering, and the information that is collected will be used to thoroughly evaluate the success of this pilot project.

For more information about the market for district heating and cooling in Estonia, see www.bit.ly/2H6Qdlf

Project progress and outcomes

The first customers of the cooling system were a new shopping centre and a hotel located in the city centre, and the network will supply other buildings as it grows. Most of the district cooling customers are expected to also be district heating customers. One of the key challenges that has arisen so far is the need to encourage customers to connect to this network when they already have a local cooling solution.

Forum Tartu have identified four areas across the city for future network development. The current total potential of the city centre is close to 15 MW, with a short-term target of 11 MW (before 2019) and an additional 4 MW in the longer term (2019 to 2021). This corresponds to an estimated cooling demand of 18GWh/y. Following the latest publication of urban plans by the municipality, a possible additional 5 MW has been identified in the area. Other potential development areas include the Lõunakeskus trade park, which has a potential of 8.4 MW cooling capacity (classic centralized cooling production plant). Work on this project began in June 2017.

The table provides an overview of the modelled benefits of the Tartu district cooling system compared to a scenario where only local cooling solutions are deployed.

Scope for replication

District cooling systems are very beneficial in areas with dense population and high cooling demand. The factors that contribute to the solution's success in Tartu include:

		Local cooling solutions	Cooling plant	Savings	
Need of electricity	GWh/a	6.0	1.8	4.2	70%
Primary energy	GWh/a	24	7	17.2	71%
CO_2 emissions *	t/a	8,500	2,500	6,000	71%

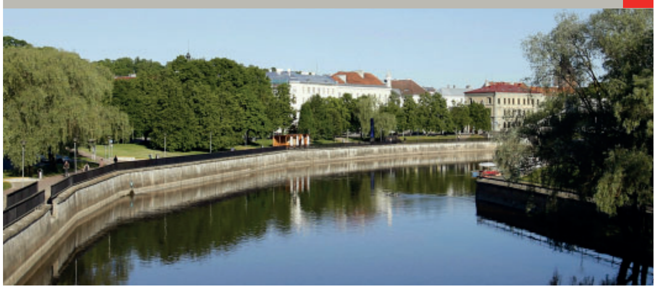
*** based on 2012 data. In this year 85% of electricity was produced from oil shale.**

- Tartu's city center is sufficiently populated;
- New buildings ensure the area's high energy density (ca. 7 kW/m);
- Fortum Tartu owns a riverside property;
- The river water can be used for cooling from autumn to springtime and for cooling turbo compressors in summertime.

The Tartu's downtown DC network is expected to grow. Negotiations with potential customers are held regularly and several contracts for new connections have been signed. The future plan is to connect the downtown and Lõunakeskus networks. A similar solution could be beneficial in other cities with a dense cooling demand, and preliminary research has been already begun in Parnu on the Estonian coast.

It is intended that the Thermos tool will assist organisations such as Fortum Tartu to produce fast and low cost estimations of business potential without the need to involve external experts in the early planning stages.

The Emajõgi flowing through the old centre of Tartu



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Case study 7

Barcelona & Sant Adrià de Besòs, Spain

Districlima

The Districlima network currently provides heating and cooling to 102 clients in Barcelona. The network is served by two production plants: one in the Forum area that uses steam from an urban waste-to-energy plant and that refrigerates equipment using sea water, and another in the 22@Barcelona district (and area of ambitious urban renewal)that guarantees supply in periods of high demand and includes an advanced ice storage system to store energy produced when demand is low.

This case study is an example of the implementation of a DHC system as part of a wider regeneration scheme, as well as an example of how a network can be developed and managed through a successful partnership between the private and public sector.

Both the Forum and 22@ areas are characterised by post-industrial decline and the closure of factories. The city council has developed a plan of urban and social long term transformation to revitalize the area and attract new businesses, particularly sectors such as medical research, new technologies, and media that are compatible with housing and can provide work and opportunities for younger people.

As part of the strategy, first class infrastructure such as district heating and cooling was put in place. The energy network itself was constructed as part of the celebration of the Forum of Cultures in 2004 and the technical infrastructure is located next to the Forum main installations. The network is run by ENGIE, which has invested, operated and managed the project since 2004 through Districlima SA, of which it is the major shareholder.

Districlima, SA, is owned by five shareholders: ENGIE, Aguas de Barcelona (AGBAR), TERSA, ICAEN and IDAE. Each contributes to the project and provides added value that makes the partnership unique:

Exterior of the Tanger plant

- ENGIE's experience in these kinds of projects includes the developement of the Paris district cooling network, the largest in Europe and connected to iconic buildings such as the Louvre.

- TERSA is a public capital company and the shareholder representative of the local government. It manages the urban waste-to-energy plant and supplies the steam that Districlima uses to produce heat and a large part of the cooling.

- Aguas de Barcelona is the city's water distribution utility.

- IDAE is a public corporation under the Ministry of Industry, Tourism and Trade. It carries out communication activities, technical advice, and development and financing of technological innovation projects.

- ICAEN is the Catalan Energy Institute under the Government of Catalunya, which promotes energy efficiency projects, rational use of energy and development and innovation of energy technology.

In addition to shareholders' equity, the support received from other local institutions should be noted. The companies 22 @ Barcelona (a company belonging to the City Council of Barcelona) and Besos Consortium (Barcelona and Sant Adria de Besos councils), both as system regulators and promoters of urban and economic development of their areas, provide a definite boost for the successful implementation and development of the network from an innovative and environmentally committed city point of view.

The current key figures are:

Number of clients:	102
Supplied roof surface (m^2):	1,000,000 (approx)
Contracted heating power	72 MW
Contracted cooling power:	104 MW
Network length:	18.6 km
Installed cooling power (MW)	215.4 MW*
Installed heating power:	46.8 MW
Total investments	>€63m

** 45.4 plus a 40 MWh water storage tank and a 120 MWh ice storage tank*

Forum Plant:

Almost all the heat and some of the cooling is produced by making good use of the steam produced by the incineration of urban waste in the nearby treatment plant (TERSA). The rest of the cold is produced through industrial electric chillers that are seawater cooled. In this way, high performance is achieved and the installation of cooling towers is avoided. The system is completed with a cold water storage tank of 5,000m^3.

Exterior of the Forum plant

	Heating power (MW)	Cooling power (MW)	CO_2 savings (Tn)	Clients (no. of buildings)	Network extension (km)
2008	28.72	45.02	4,600	37	10.8
2009	35.41	54.73	7,000	50	11.5
2010	44.06	67.64	10,100	59	13.0
2011	46.71	69.17	10,961	67	13.4
2012	51.43	73.22	17,127	78	15.0
2013	52.26	73.77	17,502	81	15.2
2014	54.63	77.8	17,525	84	15.4
2015	54.85	79.21	17,628	87	15.6
2016	62.00	93.00	18,903	89	16.8
2017	72.00	103.80	20,287	102	18.6

Tanger Plant:

Initially conceived as a peak plant, its function is to guarantee the supply of energy in periods of high demand and to provide contingency. An advanced ice storage system that allows the production of energy in periods of low demand and stores it until needed. The gas from the boilers is exhausted by the historical chimney of the nineteenth-century Ca l'Aranyó textile factory.

Project progress or outcomes

After providing the service during the Forum of Cultures in 2004, the project has continued to connect new customers in the Forum area and expanded the network in the Peri III and 22@ areas. Subsequently, the project has experienced an explosion of new contracts with clients in the Tanger and Glories areas, a segment of the network at the opposite end of Central Forum. This, along with other considerations, led to the decision to build a new power plant in this area, which began in 2010.

After years of continuous growth (see table below) within the concession limits, an oportunity arose in 2016 when the Hospital del Mar requested a connection to Districlima's network. The hospital was about to begin major development works, including the construction of a brand new area and remodelling of existing buildings, and decided that connecting to the network would be a good servicing option after learning of the benefits experienced by existing Districlima customers. The hospital was connected through a new concession agreement in 2017. The table above demonstrates how the system has grown since 2008 and the impact that this has had in terms of carbon emissions reductions.

Scope for replication

The project has already been replicated in the Meandro de Ranillas of Zaragoza, the capital city of Aragon. In 2006 the company Districlima Zaragoza was set up as part of the remodelling project underaken as part of Expo Zaragoza 2008. Sustainability and energy efficiency is an underlying element of the entire scope of the project and a centralised heat and cooling system will help to achieve these aims. After the event, the area was re-converted into a business park. For more information, see www.districlimazaragoza.com.

Despite the success of Districlima, as well as other smaller projects developed in the country, DHC solutions are often not well known within the Public Administrations, who would be best placed to promote the execution of new networks. DHC networks like Districlima can only work where there is a good relationship between the public and private sector, and so it is very important that they, and in particular their technical staff, are aware of DHC networks and the execution process. The THERMOS project aims raise awareness of the benefits of district heating and cooling and to provide local authorities with tools to assist their development.

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Case study 8

City of Dubin, Ireland

Spatial energy demand analysis for the Dublin District Heating System

In 2015 Dublin's Energy Agency, Codema, produced a Spatial Energy Demand Analysis for the Dublin City area. This was the first of four such reports modelling the potential for the development of district heating networks across the city.

District heating is not yet well established in Ireland and there is a lack of culture around the technology as a utility. This case study is a good example of the role that comprehensive spatial demand mapping can play in creating an environment in which heat networks are encouraged and effectively deployed.

The Irish Government is committed to reducing emissions at a national level and, due to the importance of Dublin City in the Irish economic landscape, there is an urgent need to develope of a more sustainable energy system at a local level.

Centralised high-efficiency district heating networks have the potential to make a considerable contribution to the integration of low carbon energy sources in densely populated areas in particular, however Ireland currently has one of the lowest shares of district heating in Europe at less than 1%. 39% of Ireland's total final consumption of energy is used to meet its demand for heat, and at present this is primarily supplied by individual gas or oil boilers.

Spatial demand mapping work such as that carried out by Codema can provide the evidence that is needed to encourage the development of policies that are more conducive to the growth of this sector, and can help to address the lack of interconnection between traditional planning practices and planning for sustainable energy use at a local authority level. The mapping also provides a useful visual resource to enable effective engagement of stakeholders, and forms the basis for more detailed feasibility work.

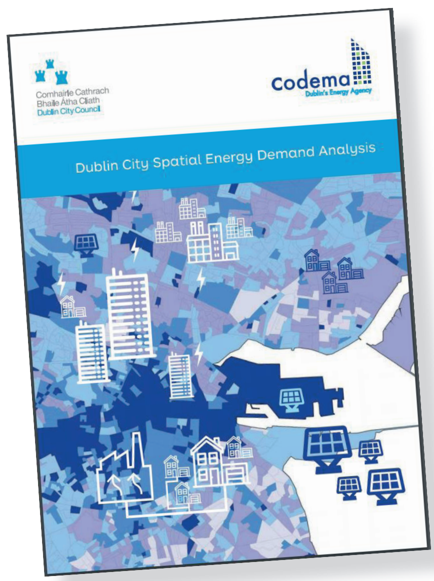
This study was carried out by Codema as part of the ACE project, which received European Regional Development Funding through the INTERREG IVB NEW programme, and it draws on the experiences of network development in other European countries (Denmark in particular).

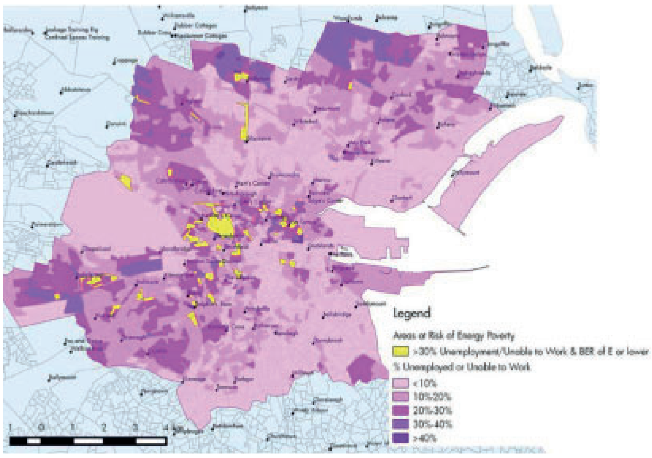
Project progress and outcomes

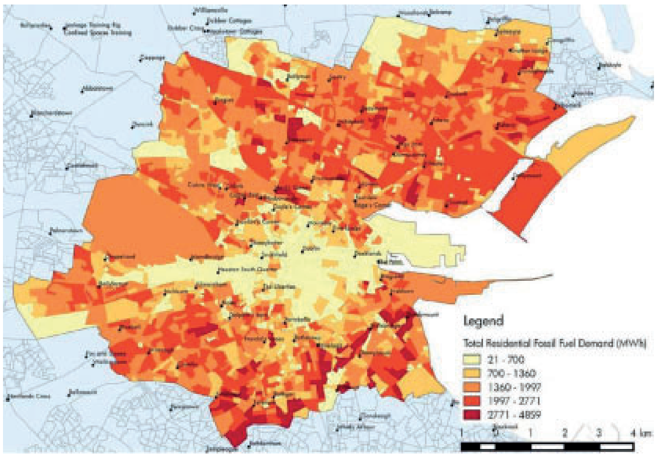
The Dublin City Spatial Demand Analysis (pictured overleaf) modelled the annual demand for energy from over 200,000 dwellings, 20,000 commercial properties and 1,000 local authority buildings across the city. The lack of existing data or modelling methodology meant that the task of collecting all of the information needed for the analysis took a considerable amount of time. Codema's methodology involved calculating and mapping the following variables:

- Total energy demand
- Total heat demand
- Heat demand density
- Total electricity use
- Total fossil fuel use
- Total annual energy costs.

Each of these was broken down by sector – i.e. residential, commercial or industrial and municipal – and additional maps were created to show the average BER (Building Emission Rate) in each area and to highlight the areas most at risk of fuel poverty (see pictures). Possible anchor loads and waste heat resources were also identified.







The analysis demonstrated that 75% of the Dublin City local authority area has a heat demand density that is suitable for district heating, and encouraged the Council to consider opportunities for deployment outside of just the Docklands, which was previously the only area under active consideration.

On completion of the spatial demand mapping, Codema carried out a Financial Appraisal of the network in 2017, followed by a Market Research Report in 2018. A technical Information Pack for Developers was produced by RPS in early 2018.

Dublin City Council has begun to invest in elements of the network. For example the Liffey Services Tunnel has been widened to accommodate two district heating pipes, and infrastructure has been installed under the new Mayor Street Upper LUAS (light rail system) and its surrounding area.

The council is in the process of reviewing options for managing, developing and financing a system in the Docklands and Poolbeg areas which will recover and distribute the waste heat from plants located primarily on the Poolbeg peninsula. Once a preferred strategy has been identified, the council will engage with a selected operator to install, manage and maintain the network, including extending it to increase customer numbers. This entity could be public or private, local or central government, a Public Private Partnership, commercial entity and/or community not for profit.

Codema have an ongoing role in the development of the Dublin District Heating System and regularly provide technical and planning advice to the local authority. They have since completed spatial demand mapping for the other three local authority areas in Dublin and the detailed reports are publicly available on Codema's website (www.codema.ie/publications).

Scope for replication

This example is highly relevant to any local authority looking to encourage district heating or cooling network development in their area, particularly in regions where the local DHC industry is in its infancy. Spatial demand mapping is an important tool to assist in the identification of areas that are suitable for DH systems, and can help planners to consider the socio-economic impacts of schemes. It can also be a useful means to visually demonstrate the potential of this type of system to stakeholders that do not have experience of the technology.

This case study also highlights the value of sharing knowledge, experience and best practice across geographical boundaries in order to stimulate activity and increase the pace of change that is necessary to achieve low carbon goals.

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Case study 9

Odense, Denmark

Using waste heat from a data centre

Odense district heating system currently supplies around 90,000 housing units. Two-thirds of the heat supply is based on biomass fuel in the form of straw, wood chips and organic waste, while the remaining third is from a coal CHP plant. At the end of 2017, the district heating company came to an agreement with Facebook to allow the utilization of waste heat from their newly constructed data centre in order to supply around 6,900 households.

Aheat pump will be installed next to the data centre that can utilize electricity from renewable sources and boost the temperature of the waste heat for use in the district heating system. This will replace the coal production in the area. The project is expected to be completed in 2020.

The measure of success will be that the waste heat for the data centre can reduce the volume of heat produced by burning coal and thereby the environmental impact of the heating system. At the same time the solution should maintain the current low heating costs. Data centres are attractive sources of waste heat for use in district heating systems due to their steady output around the clock.

It is a precondition that the electricity used in the data centre and for the heat pumps is from renewable sources making the heat production CO_2 neutral in line with the municipality ambitions in the area.

This solution is also beneficial to Facebook as it contributes to their corporate responsibility goals and

could help to ease any concerns about the impact of the data centre on the local community.

Project progress/outcomes

Negotiations between the Odense district heating company and Facebook are on-going but few details are currently available to the public.

In May 2018 Facebook announced that they had entered into long-term power purchase agreements to purchase 100% of the energy for the data centre from three wind farms. These wind farms will consist of approximately seventy 4.2 MW turbines, which are expected to provide 294 MW of capacity to the Nordic grid by the end of 2019. As well as providing power for the day to day functioning of the data centre, the turbines will provide power to the heat recovery infrastructure that will be installed to capture the waste heat.

Temperatures in most data centre hot aisles are usually in the region of 27 to 46 degrees Celsius, which can be quite low for some heat recovery systems. At Odense, air heated by the servers will be directed over water coils in order to recover the heat by increasing the water temperature. The heat pump will then be used to further raise the temperature of the water before it is delivered into the heat network. This system is expected to recover around 100,000 MWh of energy each year.

The establishment of the heat pump system began in 2018 and all nine heat pumps are expected to be in place by the end of the third quarter of 2019. The first heat to be delivered to consumers is expected in early 2020. This heat pump system is to be the largest of its kind in Denmark.

This project is in line with the Odense Municipality's ambition for the city's heat supply to be carbon neutral by 2030.

Scope for replication

The utilization of waste heat from the cooling of data centres in district heating networks is being investigated several places in Denmark. One other example is Viborg where Apple is currently establishing a data centre and investigating the possibility of providing heat for the local district heating grid.

Further information at
www.fjernvarmefyn.dk

Photos Peter Kiaerbye

Case study 10

Bristol, UK

Coordinating the development of heat networks in the City of Bristol

Bristol City Council is committed to delivering heat networks in order to reduce the cost of heating homes and businesses in the city and as a means to meet its environmental targets.

This case study is an example of how a mapping tool that is based on modelled heat demand can be used by a local authority to encourage the development of heat networks at scale. In this particular case, the National Heat Map provided a starting point for the development of a city-wide strategy for heat infrastructure, and formed a basis on which more detailed studies could build.

Background and objectives

The development of heat networks across Bristol is in line with the Council's objective of achieving "carbon neutral" status by 2050. The Council sees heat networks as an opportunity to progressively lower both the carbon content and the cost of delivering heat by making it possible to switch to low and zero carbon sources as they become more and more financially attractive.

The Council began exploring the feasibility of installing district-scale heat networks in 2009. As part of this, a city-wide sustainable energy study used the National Heat Map tool to analyse existing heat loads alongside those expected from planned new developments.

The National Heat Map, which was commissioned by the UK's Department for Energy and Climate Change (now the Department for Business, Energy and Industrial Strategy) was built from an address-level model of heat demand that was based on published sub-national energy consumption statistics and benchmarks, without making use of metered energy readings (except for public buildings, for which this information is publicly available via Display Energy Certificate data). Examples of specific datasets used to construct the National Heat Map included the English House Condition Survey 2008, the National Land and Property Gazetteer 2010, the National Energy Efficiency Data Framework (NEED), Experian consumer data, DECC sub-national statistics and census data.

The purpose of using the National Heat Map in this study was to help the Council to identify neighbourhoods where district schemes might be appropriate (i.e. where the density of heat demand is highest) and to prioritise these for further investigation.

Project progress and outcomes

The heat mapping work led to the identification of Heat Priority Areas, in which conditions were considered likely to favour larger scale, more economic and effective forms of sustainable energy generation and distribution. The combined Heat Priority Area identified for Bristol captured around 70% of total heat demand in 45% of the city area.

Once these areas had been identified, the Council procured a number of more detailed and site-specific technical feasibility studies to further investigate options. The Heat Priority Areas were also incorporated into Bristol's Core Strategy, which is part of the local authority's planning policy. Within Heat Priority Areas major development is now expected to incorporate, where feasible, infrastructure for district heating, and will be expected to connect to existing systems where they are available.

In the last few years, the Council's coordinated approach to network planning and delivery has led to the creation of a number of new schemes within the priority area. This includes networks such as the Rowan Heat Network, the Temple and Redcliffe network, and the City Centre Phase 1 network.

The Rowan Heat Network began delivering heat to five blocks of social housing in 2016, fuelled by a 360 kW wood pellet boiler and a 10,000 litre thermal store, alongside two new 1MW gas boilers to provide auxiliary and back up heat to the network. The first part of the Temple and Redcliffe network is operational, and work on the design of further sections is underway. This scheme currently serves over 700 flats and its energy centre consists of 3.6 MW capacity provided by gas boilers and 1 MW from biomass. Combined, these two schemes alone are expected to save over 1,700 tonnes of carbon every year. The City Centre Phase 1 network is at design stage. At the time of writing, the Council is also in the process of exploring potential new and innovative sources of low carbon heat, including the use of water source heat pumps to capture energy from the city's floating harbour.

The strategic oversight provided by the Council has helped to address some of the challenges associated with developing heat networks in high density urban areas. For example it is able to better manage the construction of schemes in fragmented stages so that they can align with other utility works to minimise disruption, as well as coordinate projects that need to overcome significant physical obstacles such as crossing the river Avon and passing pipework underneath Bristol Temple Meads railway station.

Paul Barker, Energy Infrastructure Manager at Bristol City Council, has no doubt about the benefits of heat mapping to local authorities. *"Town and city councils have the long-range vision and joined-up thinking which is necessary to the development of significant low-carbon infrastructure like heat networks. But what they also require is tools like interactive heat maps that make the initial planning stage process cheaper and quicker as well as credible - the public needs to be sure that the investment and potential disruption will be worth it in the end."*

Scope for replication

Bristol City Council is committed to further expansion of heat network infrastructure in the city and encourages opportunities for connection through their Core Strategy (specifically policies BCS13 and BCS14). The Council's Energy Service has produced guidance documentation on heat networks for developers, building owners and architects, as well as for designers of building services.

The National Heat Map was decommissioned by BEIS in April 2018, however prior to this it was used to underpin similar feasibility studies by a large number of local authorities and their consultants across England.

A more advanced mapping tool, such as that being developed as part of the THERMOS project, has the potential to fulfil a similar role to the National Heat Map, but with added functionality to allow for early estimation of the technical feasibility of network route options and of costs.

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Case study 11

Hennigsdorf , Brandenburg, Germany

A laboratory for a more renewable future of heat supply

Background and objectives

Hennigsdorf is a town of some 26,000 inhabitants on the north-western edge of Berlin. It includes a high proportion of multi-storey housing, which has been almost completely refurbished after German reunification.

The town wants to increase the climate-neutral share of heat in its district heating network to 80 percent within five years. To achieve this, Hennigsdorf 's utility company plans to integrate waste heat from a local steelworks and newly generated heat from large solar collector fields into the heating network. A large multifunctional heat storage tank should create the necessary flexibility.

The implementation of the project - dubbed "Heat Platform" - started in 2017, and through this project will serve as a laboratory for a more renewable future of heat supply in Europe.

With the connection of new customers as well as expansion of the existing heating network, the municipal utility supplies 9,500 residential units, municipal facilities and 54 commercial and industrial companies with district heating, including large metal-producing and processing companies. The necessary thermal capacity is provided by heating plants and cogeneration plants and amounts to 82.5 MW. Renewable energy sources already provide half of the local district heating.

For operation of an existing biomass cogeneration plant and a bio methane combined heat and power plant, a connected hydraulic network out of four single heating networks with a route length of 50 km was created in 2009 and 2010. Base and medium loads of

With the commissioning of the biomass cogeneration plant in 2009, the share of renewable energy in heat generation in Hennigsdorf has increased to around 50 percent the heating network can thus be covered by renewable sources during the whole year.

In order to be able to increase the share of climate-neutral heat generation to 80 percent, two additional sources for the heating supply will be developed:

1) Waste heat from industry, in particular from a steel and rolling mill which is located in the heat supply area, and

2) Solar thermal systems, centrally through collector fields of the municipal utility as well as decentralized installed solar collectors near to the customers.

This requires a fundamental restructuring and further development of the existing district heating network and its metering, controlling and operation. The implementation of the complex project will be completed in 2021. The existing network is typical of a medium-sized German town and can thus serve as a model for the further development of such networks towards a more climate-friendly district heating supply.

Project progress/outcomes

Multifunctional large heat storage unit

From the local steelworks, only waste heat accumulates intermittently. At the same time, decentralized production of heat from small CHP plants or solar plants, must be fed into the grid at all times. In order to integrate these heat sources efficiently, it must be possible to decouple them from each other and from the current heat consumption. For this purpose, a multifunctional heat accumulator is planned that combines the capabilities of day, month and long-term heat accumulators: it can absorb heat that is not currently needed, store it seasonally and at the same time can compensate peaks of heat demand in the network.

Also, for the existing biomass cogeneration plant and the bio methane CHP a large heat storage system creates improvements. Both have been heat-operated so far, the generation of electricity depends on the heat demand of the customers. If this dependence did not exist, the production of renewable heat and electricity could be increased overall and electricity could be produced more flexibly on demand.

Dynamic simulation calculations of the district heating network and the heat sources to be integrated over the long term helped to design the storage unit. It is designed with 22,000 m^3 of water volume as a non-volatile storage tank with a maximum temperature of 98 ° C. Since the groundwater in Hennigsdorf is very high, it will be realized above the ground from pre-stressed reinforced concrete prefabricated elements.

The network as a heat platform

The envisaged heating network in Hennigsdorf should form a coherent system with regard to static network pressure. The multifunctional heat storage is integrated in the return flow of the system and serves as a central pressure maintenance. In the event of a high heat requirement in winter, both the biomass cogeneration plant and the steelworks and solar thermal large-scale plant feed into their shared, open network area.

Coupling of industrial waste heat

At concept stage, the coupling of industrial waste heat was carefully calculated and the project developers examined the available waste heat potentials from the local steelworks in detail. In order to use the hot exhaust gases from the melting process, the installation of additional exhaust gas heat exchangers would have been necessary. This variant would only be possible with very high technical and financial effort and therefore was eliminated. As a result, the walking beam furnace came into focus as a further waste heat source, in which steel is brought to a required rolling temperature.

The furnace can be operated very flexibly with the help of natural gas. Within a short period of time the output fluctuates between 0 and 80 percent - this is a particular challenge when using the waste heat. However, it is currently known that a thermal output of approximately 6 MW can be used on average via an exhaust gas heat exchanger for direct coupling into district heating. A detailed measurement programme will determine the temporally fluctuating exhaust gas volume flows and temperatures. The strong load fluctuations and production cycles must be compensated by appropriate heat storage.

Solar Thermal

A solar thermal system with 854 m^2 of collector surface already feeds into the district heating network. How solar thermal heat generation should be further developed was determined by a scientific consultant. In order to achieve the goal of 80-percent climate-neutral district heating, the assumptions regarding the dynamics and scope of waste heat from the steel mill resulted in a collector area of approximately 20,000 m^2.

However, as it is not yet possible to exactly predict the quantity and the timing of the waste heat generation, in the first stage an installation of 3,000 m^2 of collector

Here is the future location NORD II (open space) in the immediate vicinity of the steelworks (in the background). At this site, a heat storage facility with a capacity of around 22,000m³ will be built. It is intended to absorb industrial waste heat from the steelworks and the energy of a large-scale solar thermal plant with a collector surface of approximately 20,000 square meters. The solar plant is to be erected on the open space in the photo above (left side).

surface is planned in Hennigsdorf. Further system simulations during the implementation phase are used to determine how much solar collector area needs to be built to reach the set 80 percent mark. In addition to a few private roof areas, the former slag heap of the steelwork (approx. 30,000 m^2 in size) is available for the construction of solar thermal collectors. It offers the best conditions and is next to the site on which the large heat storage is to be realized.

Further steps

The planning and tender process for the extraction of heat from the steelworks and the construction of a district heating route from the steelworks to the district heating network took place in 2018. Commissioning took place during the heating season 2018/19 in order to be able to precisely size the large storage unit with the help of concrete measured values. This will be built from 2020, which will allow the gradual expansion of solar thermal energy. At the same time, work is being carried out on the hydraulic and control engineering optimization of network operation in order to enable the locally distributed heat energy feed-in and also the reversal of flow directions in the district heating network.

Scope for Replication

This project is a model for new flexibility for district heating networks. For existing district heating networks, the decentralized supply and storage of volatile energies, such as solar heat or waste heat, with fluctuating energy generation, which is usually delayed in terms of consumption, is a major challenge. It not only affects the network and storage management as well as the thermal hydraulics, but also the technical components.

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Further information (in German):
youtube: www.youtube.com/watch?v=drfiDPcRi5U
Web: www.swh-online.de/aktuell/forschungsprojekte

Photo: Leszek Kozlowski, reproduced under creative commons

Case study 12

Poznań, Poland

Recovery of waste heat in Poznań network

This case study relates to the nstallation of a heat recovery system, which enables the use of waste heat from a foundry in the district heating network in Poznań. Water cooled compressors were replaced with the newer units that included recuperation modules. Cooperation between the operator of the network (Veolia Energia Poznań S.A.) and the owner of the foundry (Volkswagen Poznań S.A.) resulted in a reduction in the amount of cooling water needed in the foundry and effective use of waste heat for the district heating network.

Background/objectives

The idea for the project was created as a response to the global aspiration to reduce the production of carbon dioxide and to increase energy efficiency in industry and beyond. The Volkswagen Poznań Foundry uses compressor systems as part of the manufacturing process and these devices are characterized by a significant production of waste heat. This project is using this heat thanks to cooperation with the heating network, and this will result in significant savings for both the foundry and the heating company. In addition, it would be the first such project implemented in this part of Europe, which could encourage the emergence of further similar solutions elsewhere.

The generation of waste heat from the Volkswagen Poznań foundry and its use by the Poznań heating network required the replacement of the compressor system with a system that enables heat regeneration, and in order to bring heat to the users of the heating network, it was necessary to install new heating nodes and pipelines. Conceptual work began in 2011 and the work lasted for three years, ending in 2014.

Project progress/outcomes

The key measure of success of the implemented project is that it is functioning in accordance with the assumptions made and the resulting savings estimated by the involved parties. The residual heat sold by Volkswagen Poznań to the heating network supplies about 30 buildings in the vicinity of the foundry.

Volkswagen Poznań estimated the amount of effectively managed heat at 37000 GJ per year, which for a heating system means obtaining a heat source with a capacity of approximately 6 MWt, without burning fuel. The result is a reduction in the heat demand produced at the local heat and power plant, and thus a reduction of CO_2 emissions of 1070 tonnes per year. The foundry has shown a reduction in water demand for cooling purposes of 17m litres per year, and thus a reduction in production costs.

Bringing the concept of heat recovery into life was a difficult task, due to the need to carry out work in the plant's operations department, working in a continuous mode. As a result of the implementation, the compressor system was replaced with a new system enabling recovery of the residual heat produced during compressor operation. The supply of heat to the network users also required the implementation of two heating nodes and over 2 km of new pipelines with a volume of several cubic meters.

The use of waste heat, which until now was an inconvenience for the foundry and was lost to the environment, means increasing the efficiency of the heating system and increases the reliability of heat supply. The beneficiaries of the project are an industrial plant and a heating network as well as end users.

Scope for replication

The concept implemented by Veolia Energia Poznań and the foundry of Volkswagen Poznań can be a model of waste heat management for industrial plants located in the vicinity of local heating networks. The benefits of this type of solutions include improving the operation of industrial plants, modernizing heating systems, as well as reducing the harmful effects on the environment. Due to the need to reduce carbon dioxide emissions and the trend of effective energy management, this idea could certainly find widespread use.

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Case study 13

Riga Technical University, Latvia

Waste water heat recovery from multi-apartment residential buildings

This project is an example of the installation of waste water heat recovery (WWHR) equipment in a multi-residential apartment complex.

Heat recovery technology can help to reduce the amount of heat that would normally be wasted when warm water is discharged into the sewerage system. The technology can significantly reduce the need for heat from other sources (for example from the combustion of fossil fuels), and is particularly suitable for buildings that have a high demand for hot water. In this multi-apartment student hostel complex at Riga Technical University WWHR has made it possible to reduce the demand for heat by up to 60 percent.

Background/objectives

Waste water heat recovery technology was introduced at the student hostel complex of Riga Technical University in Ķīpsala in 2013. The complex is large, with a total heated floor area of 17044 m^2. In co-operation with the organisation Menerga Baltic, two 'Menerga AquaCond' units were installed, each of which has a built-in heat exchanger and heat pump with the capacity of 2.4 m^3/h for water heating.

- One of the main objectives of the project was that it should act as a technology demonstrator for the use of WWHR, including the use of heat pumps and ICT. In particular, the project aimed to replace fossil energy resources with heat recovered from low potential waste water flow.
- Reduce CO_2 emissions.
- Rationalise heat consumption and provide economic benefits by increasing the overall energy efficiency of the building.

The stakeholders involved in this project include the University, who own the building, along with the Riga Energy Agency and waste water heat recovery and service companies.

Project progress/outcomes

Thanks to the pilot, approximately 627 MWh of heat energy savings for water heating is made per year, resulting in an annual cut of 93 tonnes of CO_2 emissions. The measures play a part in achieving the Riga Smart City Sustainable Energy Action Plan 2014-20 CO_2 emission targets, as well as complying with national legislation under EU energy efficiency policy (Energy Performance of Buildings Directive)

The project also has social and economic benefits, with lower heating costs for tenants and improvements in comfort.

The cost of initial investment is high and can be a barrier to implementation, however It has been calculated that, for example, if such technology is installed in a dormitory, the pay back period for the technology is half a year but the payback period for whole system development is four and a half years. It is calculated that for a public building the payback period would be five years, and for a swimming pool it would be three years.

Another barrier to the installation and performance of this type of system is that building owners and tenants have insufficient information about the technologies and about the economic considerations of their application.

Scope for replication

Heat recovery from waste water is suitable for buildings with a significant quantity of sewage and hot water demand, such as laundries, dry cleaning enterprises, schools, hospitals, dormitories, etc.

There are several examples of this type of technology already in place in Latvia. It is considered to be highly replicable, particularly in the case of new build properties where the technology can be incorporated into the design of the building at an early stage.

Contact details and links to further information

www.rea.riga.lv/en/energy-efficiency/catalogue

www.diena.lv/raksts/sodien-laikraksta/atgust-siltumu-no-notekudeniem-14120066

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Case study 14

Warsaw, Poland

Warsaw Smart Heating Network

The Warsaw heating network is the largest system of this type in the EU, covering nearly 1,800 km of network, 19,000 facilities and almost 80% of the capital's heat demand.

Such a large system requires management at a very high level, including forecasting of heat demand, monitoring and remote control of equipment operation and anticipation as well as management of emergency situations. The project of smart heating network meets the needs posed by the Warsaw heating system, and its uniqueness is in the complexity and scale of the enterprise.

The project includes the development of an smart telemetry system, modernization of system components such as pumping stations, as well as implementation of photovoltaic installation. The smart system uses comprehensive support of decision-making process based on historical and harvested in near real-time data. Veolia Energia Warszawa, the owner of the heating network, through the implementation of the smart district heating project, brings Warsaw closer to the smart city model.

Background and objectives

The smart heating network project was created to reduce losses through more effective control and anticipation of future demand. Limiting losses allows to reduce CO_2 emissions. The activities undertaken in the scope of the project were to improve the quality of system heat supply, improve the management of the heating network and more efficiently respond to customer needs.

The main activities delineated by the project were the modernization of pumping stations and heating chambers, equipping them with devices enabling remote monitoring and management, and the creation of tools for collecting and interpreting data from network monitoring. The capital heating network has 4,000 chambers. For modernization within the smart heating network 79 most-important objects on magistral pipelines for the entire system were selected. The project also included the implementation of the photovoltaic system on the roofs of the Golędzinów and Marymont pumping stations in order to partially cover the own pumping station's needs. Work on the implementation of the project began in 2014. Due to the ecological effect of the project, the investment received financial support from the National Fund for Environmental Protection and Water Management (NFOŚiGW) of nearly 30% of the value. Implementation activities ended in 2017.

Project progress and outcomes

The project was completed according to the planned date. As a result of the implementation of smart heating network 3 pumping stations, 27 key heating chambers and 2,500 heating substations were equipped with telemetry and telecontrol systems. Another 52 chambers were equipped with temperature and pressure sensors to monitor network parameters. Another upgrade of the heating network is the DCS Ovation system responsible for controlling and visualizing the entire process. It operates on the basis of the Central Data Repository database, created to collect information in nearly real time. This database is also used to generate analyses and network forecasts

using dedicated applications. The most important and the most innovative one is the Decision Support System. On the basis of current and historical data, the algorithms predict the residents 'demand for heat and propose to the dispatcher an optimal network control scenario that will allow for the supply of heat in line with residents' expectations while minimizing it's losses. The value of the investment amounted approximately to PLN 47 million, whereas the NFOŚiGW contribution was 30% of this value.

According to Veolia Energia Warszawa, the result achieved in the first year after the project was a reduction in CO2 emission of 22,700 tons. In further years the savings was estimated at 123 TJ of energy on heat losses by penetration, and thus avoiding the emission of 14,500 tons of CO2 per year. Photovoltaic installation implemented on the roofs of two pumping stations produces 45 MWh per year in on-grid system. This energy is used to cover own needs and to transfer surplus energy to the power grid.

The measure of the undertaking's success are also the awards granted to Veolia in connection with the smart heating network project. During the Polish Nationwide Economic Summit Veolia was awarded the Amber of the Polish Economy 2017 by the European Business Centre. Additionally, in 2017, Veolia was awarded the prize in the field of "The most innovative project in the Power industry" during the conference of users of the Ovation system in Pittsburgh (USA).

Scope for replication

Contact details and links to further information

www.ogrzewamyinteligentnie.pl

Warsaw Smart Heating Network can be an example for other heating systems how to bring cities closer to the smart city model. Smart city is an idea being in interest of all agglomerations, whose aim is to provide residents with an increasingly comfortable life and to care for the environment.

The project implemented in Warsaw by Veolia contributes to energy savings and reduction of CO_2 emissions, and at the same time increases the quality of services provided to residents of the capital. The benefits therefore lie both on the side of the enterprise that manages the heating network, as well as on the side of customers and the natural environment. Veolia implements technologies used in Warsaw also in other Polish cities such as Łódź and Poznań.

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