THERMOS

Heating and cooling innovation catalogue

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 of Islington delivering 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 both for 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 of which the Synchrotron light laboratory (particle accelerator) will be its main landmark, 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 high efficiency 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.

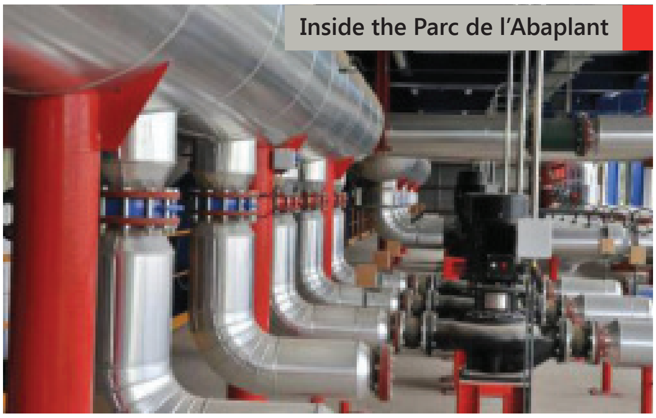
This will comprise of three natural gas cogeneration plants with thermal cooling facilities (single and double effect absorption chillers) and a 32 km district heating and cooling network within the Science & Technology Park. The residential area has not been included in the DH&C network, since its demand 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 to the urban development, whose expected timescale is about 20 years. The first plant has been in operation since 2010, with a total installed capacity of 10 MWe 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 it will integrate in the future a solar thermal plant and a gasification biomass plant.

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 ESCo 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 has faced the ESCo, especially during the first 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, which requires a stable supply of large amounts of energy and which was willing to explain their experience to potential customers.

Subsequently, it has been relatively easy to gain new customers, who see the advantages in outsourcing heating and cooling supply (and so are able to focus on their core business), in needing less space for equipment, and in the reduced initial investment and operating costs (e.g. 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 of 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.

Regarding replicability, it is important that urban planners be aware of the global benefits of DH&C networks in countries with warm climate conditions such as Spain, so that they can favour their future implementation.

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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 energy 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 testing, 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, there will be a 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 measures of success is that the future supply solutions will reduce fuel-use CO_2 emissions and be feasible from both a business, social and consumer-economic point of view. These aims support Aalborg council's goal of cutting greenhouse gas emissions by 40% in 2020 and becoming fossil free in 2050.

The overall aim of Aalborg District Heating is a diversified strategy aiming at 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 storages.

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 investments in new technologies are to be replaced. The next decision is in regard to the large

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.

scale electrical heat pumps, where there are already specific suggestions from heat pump manufactures. The suggestion is divided into three phases, where the first is a 100 MW electrical heat pump that runs in combination with the large CHP plant, the second phase is to install 150-200 MW electrical heat pumps in relations to the industrial excess heat and waste incineration facilities and the third is to install 150-200 MW electrical heat pumps 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 until 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 7 at the beginning including one main supplier covering 70%, up 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 parts for approaching 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

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 when undertaking large-scale developments, Graz has 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 i s 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). This document 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 would 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@ district 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 is appropriate to this. 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.

Contact details and links to further information

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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 has 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 encourage the development 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.

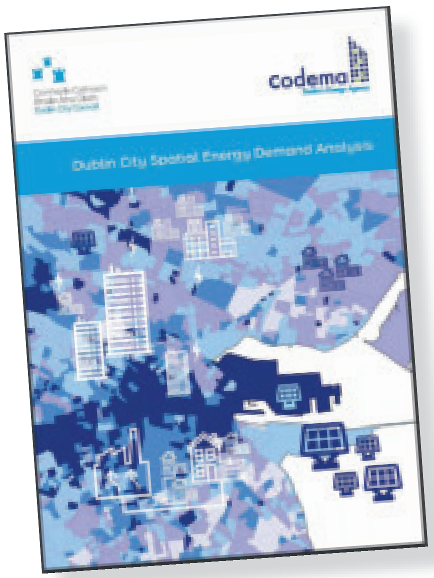
This study was carried out by Codema as part of the ACE project, which received European Regional Development Funding through the INTERREG IVB NEW programme, and it draws on the experiences of network development in other European countries (Denmark in particular).

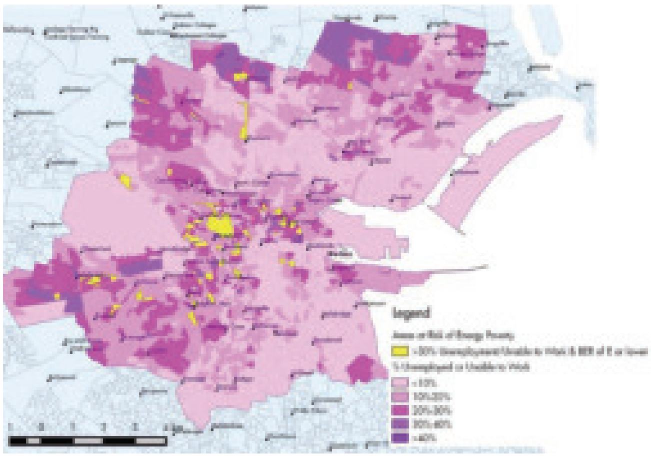
Project progress and outcomes

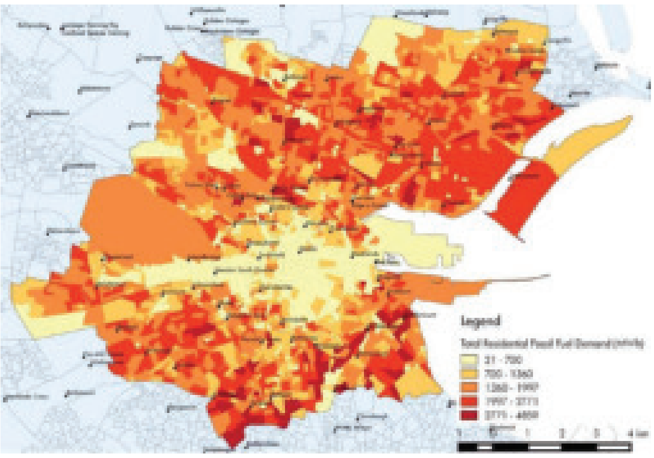
The Dublin City Spatial Demand Analysis (pictured) modelled the annual demand for energy from over 200,000 dwellings, 20,000 commercial properties and 1,000 local authority buildings across the city. The lack of existing data or modelling methodology meant that the task of collecting all of the information 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 investing 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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THERMOS