



DISTRICT ENERGY IN CITIES MILAN CASE STUDY

OVERVIEW

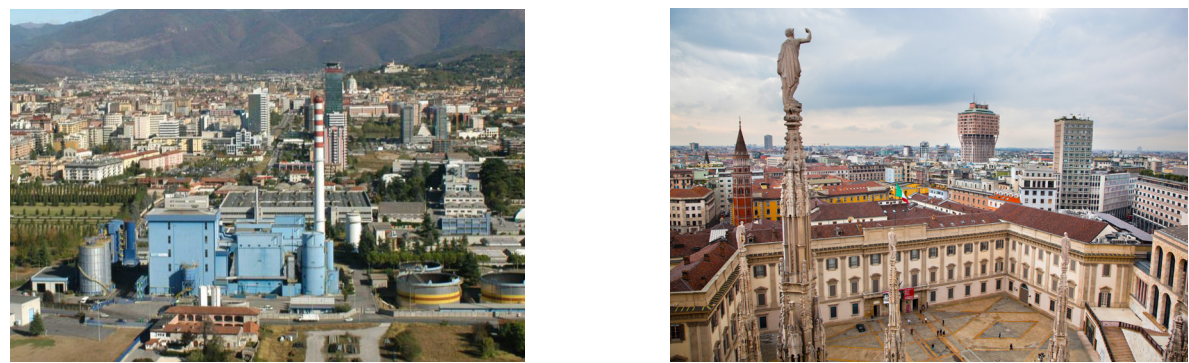
Milan has a large district heating system providing over 5% of the city's heating demand in buildings. The city also has a small district cooling network serving 800,000 m³ of cooling demand. The city is using district energy to replace to switch the heat consumption of the city from predominantly gas boilers and oil boilers to renewable heat and cool consumption of the city from inefficient air conditioners to waste heat from power plants and ground water sources (through absorption chillers). In 2011 thanks to district heating about 70,000 tons of CO₂ emissions were avoided (with reference to a "no district heating" scenario) and by 2020 this is expected to be 139,000 tons of CO₂ avoided annually. This case study references to best practices defined in the District Energy in Cities publication .

MW thermal of heat production connected to a DES	MW Electric of electricity production from DES connected CHP	MW of Cool Production connected to a DES	MWh of Heat production per year on DES	MWh of Cool production per year on DES	Kilometres of heat network	Kilometres of cool network
622MW_{th}	113 MW_e	17.5 MW	642,023MWh	7,492 MWh	136 km	11km

Benefits of district energy

RESILIENCE-RELATED	ECONOMIC	ENVIRONMENTAL
<ul style="list-style-type: none">■ Through the use of waste heat and renewables, district heating in Milan is far more resilient to external price shocks on fossil fuel markets.■ By reducing the number of diesel oil fired and natural gas boilers in Milan district heating has improved the safety of heat delivery in the city.■ Milan is in a region that is a net-importer of electricity from more southern regions which can lead to grid constraints on the national electricity transmission system. By increasing local production of electricity from CHP and waste-to-energy plants Milan has helped reduce grid constraints and can reduce the peak electricity demand in Milan through the use of thermal storage.	<ul style="list-style-type: none">■ District heating is far less expensive than diesel oil heating and has comparable prices to heating through individual gas boilers saving residents, businesses and the city money on heating costs.■ In 2011, district heating saved Milan 20,000 tons of oil equivalent in energy expenses■ Milan's partial ownership of its district heating system provides share dividends and concession payments every year to the city.	<ul style="list-style-type: none">■ Milan's use of CHP, thermal storage, heat pumps and boilers contributes to the balancing of the national electricity system. Such balancing increases Italy's ability to incorporate higher shares of renewable electricity now and in the future, for example higher levels of solar PV and wind (see page 38 of District Energy in Cities publication).■ District heating is enabling an acceleration of the substitution of diesel oil boilers which are still present in the city, and more polluting than gas boilers.■ District heating is enabling the use of renewables and waste heat in heating which would otherwise not be available to buildings.■ By being more efficient and renewable, Milan's district heating network in 2011 avoided the emission of 2.5 tons of particulates, 70,000 tonnes of CO₂, 50 tons of NO_x and 25 tons of SO₂.

Local government as planner and regulator



ENERGY POLICY OBJECTIVES, STRATEGY AND TARGETS

ENERGY POLICY OBJECTIVES, STRATEGY AND TARGETS (section 2.2.1 of the publication)	Energy strategy linking the benefit of district energy and broad policy targets: CO ₂ and greenhouse gas emissions, energy intensity, fossil fuel consumption, energy efficiency and renewable energy targets.
	District energy related target or goals: can be for the future share of district heat/cooling/power; the share of district energy in specific buildings (e.g., public buildings); or the share or absolute numbers of buildings connected.

As a member of the European Union (EU), Italy must contribute to the EU's objectives concerning energy and climate change that are to be achieved by 2020: 20% reduction in EU greenhouse gas emissions from 1990 levels; renewable energy share in energy consumption of 20%; a 20% improvement in the EU's energy efficiency.

Such national and international targets prompted Milan to become a signatory of the Covenant of Mayors, a voluntary agreement launched by the European Commission. Covenant signatories are committed to reduce their CO₂ emissions by at least 20% by 2020 (Milan chose 2005 as a reference year). Milan officially adhered to the Covenant of Mayors with a local government decision in 2009. This means Milan's CO₂ target is in-line with the EU's 20% reduction in EU greenhouse gas emissions from 1990 levels.

Milan released a Sustainable Energy and Climate Action Plan in 2009 that detailed the pathway to reducing emissions by 20% by 2020. This is being further elaborated into a Sustainable Energy Action Plan (SEAP) which will include specific actions that Milan's local authority will implement in order to achieve the emissions reduction target and will include an in-depth analysis

of Milan's energy system including building efficiency, waste-to-energy plants and district heating (see Box 1 on SEAP). By specifically analyzing the heating and cooling sectors within its overall energy strategy, Milan has identified that district heating alone could contribute almost 10% of the city's 2020 target of 20% less CO₂ emissions.

Milan's energy strategy provides long-term benefits to the city by providing investor confidence and the analysis being developed in the SEAP will provide the validation and direction needed for district energy development. Every action of the municipality administration, be it a plan, a single project, a regulation or a policy, is designed in coherence with the EU objectives concerning energy and climate change and the city's own CO₂ emissions target. In addition, Milan is planning and developing district heating to be coherent with European and national legislation requiring development towards high efficient district heating. As such, Milan will be investigating new energy sources such as waste heat from industrial sites that can increase the efficiency of the system.

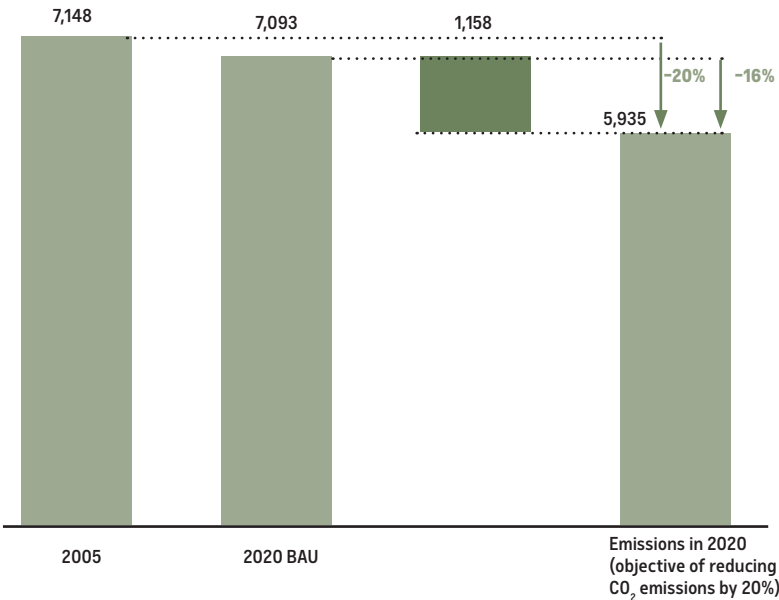
BOX 1

THE SUSTAINABLE ENERGY ACTION PLAN

Milan's Sustainable Energy Action Plan will detail a pathway to reducing emissions to 20% below 2005 levels by 2020 by analysing potential contributions from different sectors in Milan. The Plan only considers CO₂, as it constitutes the majority of city emissions (92%) and the reduction of other GHGs is dealt with in regional and national policies. In 2005 overall emissions were 7418 ktCO₂ and by 2020 these will have been reduced to 5935 ktCO₂ as shown in Figure 1. In the Plan,

future improvements to Milan's extensive district heating network are expected to contribute 139ktCO₂ in emission reductions.. The improvements to the district heating network were expected to be an enlargement, with an increase of heat distributed from the current 642 GWh/year to the expected 1180 GWh/year

FIGURE 1 Emission reductions relative to Business as Usual scenario (BAU) – overall emissions (direct and indirect) (ktonCO₂/year)



● ENERGY MAPPING AND HOLISTIC ENERGY PLANNING

ENERGY MAPPING AND HOLISTIC ENERGY PLANNING (section 2.2.2 and 2.2.3 of the publication)	Energy mapping: local heat/cool demand mapping the city to understand energy use, infrastructure, emissions as well available resources.
	Holistic energy plan: integration of district energy in land-use and infrastructure planning; guidelines for urban development plans to contain energy vision; required energy assessments for new developments.

Milan uses various mapping tools and studies to direct district energy development to optimal demand areas, to help identify interconnection routes and where potential heat sources could be connected. For example, Milan has developed several studies and plans to evaluate the potential utilization of groundwater for heating (see Box 2 on groundwater heating)

BOX 2

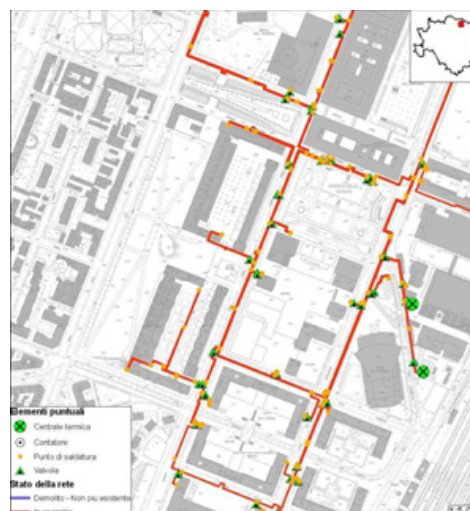
USING GROUNDWATER FOR HEATING

Milan has a large thermal resource in the form of a deep aquifer that can be exploited for heating uses in the city through the use of heat pumps connected to extraction wells. Milan is currently investigating how to connect this groundwater resource into the district heating system and individual buildings. Previously, a publicly funded study was developed to identify the potential use of groundwater heat pumps for public buildings. This study is being built on today as the city assesses the potential utilisation of groundwater heat by evaluating the proximity between existing wells extracting water from the aquifer

and demand. These existing wells permanently extract water from the aquifer in order to control the level of the water table and would be ideal to connect heat pumps to. Mapping exercises identifying the spatial relationship between supply and demand could lead to district heating and/or cooling development to connect existing wells, or to the development of new wells that would be better placed to heat areas of high demand.

As the operator and developer of district heating in Milan, A2A Spa works in coordination with urban planning instruments such as the urban master plan. A2A Spa shares its plans for district heating with the City Administration and the result is that future developments are outlined in the PUGGS (the Plan for Underground Services). This is essentially a holistic energy plan specifically for network development, that sets out the future development of underground networks including district energy and other energy networks such as gas and electricity. Whilst the city is a minority shareholder in A2A Spa it does not dictate exact district heating expansion plans to A2A Spa but will help the operator ensure that development is line with broader urban planning and the city's CO₂ target.

PUGSS was developed as a result of regional legislation requiring municipalities to develop plans for underground network development. The plan accounts for changes in population distribution and coordinates different infrastructure developments to minimize disruptions in the city. The vision of the district heating network is described in PUGSS and in the long term the multiple networks will be interconnected to create a large single network forming a ring around the city center (see page 6).



Extract from PUGGS showing existing network and valve points in a neighbourhood of Milan

● CONNECTION POLICIES

CONNECTION POLICIES (section 2.2.4 of the publication)	Connection policies that encourage connection where it is economically and technically feasible and minimizes load risk
	Zoning by laws that allow, encourage or require district energy developments

Milan does not have a mandatory connection policy requiring buildings to connect to district energy networks however legislation exists in a new building code approved in 2014 that effectively promotes connection to district heating. The building codes stipulates specific minimum energy efficiency requirements for new and retrofitted buildings. In practice this means any new building being constructed and any existing building undergoing a significant retrofit. These energy efficiency requirements do not only look at the building but also the supply of heat and hot water and so can be met by connecting to the district heating network in combination with other building efficiency measures. As such, buildings are being encouraged through the city's building code to connect to district heating. Furthermore the new building code allows news buildings to exceed standard building size requirements in planning conditions if higher energy efficiency levels than the minimum are met.

BEST PRACTICE

Milan has used its planning authority to implement a building code that actively promotes district energy by requiring higher levels of energy efficiency performance than national standards and incorporating district heating into energy efficiency assessments of buildings.

This is effectively a density bonus for developers in the city that are developing high efficiency buildings, and further encourages connection to district heating. A pre-requisite to meeting the standards of the building code is for a building to not have a diesel boiler, eliminating this carbon intensive and expensive heating technology from all new and retrofitted buildings.

This building code has a higher threshold for energy efficiency than national standards and this is because in Italy cities are able to adopt climate and energy related measures into their planning instruments. This can include the introduction of higher standards at the local level, such as energy performance standards in local building codes, that exceed national legislation.

Local governments as facilitator: enabling actions to leverage finance

FINANCING AND FISCAL INCENTIVES (section 2.3.1 of the publication)	Debt provision and bond financing, loan guarantees and underwriting , City-financed revolving fund .
	Grants, low-cost financing/loans, rebates, subsidies.
	Tax credits and exemptions within tax systems: for example, sales, property taxes, permitting fees, and carbon taxes.
CITY ASSETS (section 2.3.2 of the publication)	Using local government land/property/buildings for district energy installations or connections or anchor loads (leasing/selling/permitting).
DEMONSTRATION PROJECTS (section 2.3.3 of the publication)	Pilots, testing emerging technologies — often hybrid, such as: low-grade waste-heat recovery from sewage or metro, renewable energy integration and storage.
	Pilot new policies for district energy systems.

● FINANCING AND FISCAL INCENTIVES

City authorities have an important role to play in financially supporting the development of district energy. Milan's district heating network is extensive and is partially owned by Milan through the multi-utility company A2A Spa, which is the largest company in the Italian district heating sector. The large balance sheet of A2A Spa means direct loans and grants are not required from the city of Milan for development of district energy, however the city provides specific financial incentives that support the business model of district energy in Milan directly or indirectly.

In 2008, Milan allowed a reduction in infrastructure charges for new and retrofitted buildings that respect fixed standards concerning energy efficiency and/or renewable energy sources, including connection

to district heating. District heating does not represent a compulsory requirement for the reduced infrastructure charge, but can represent one of the elements that allow the achievement of the fixed standards. The absence of diesel oil as a fuel in heating is a pre-condition in order to benefit from the incentives provided by the infrastructure charge reduction measure and as such switching from diesel oil boilers to other sources such as district heating is indirectly subsidized.

Furthermore, Milan previously provided incentives for district heating in the form of a direct subsidy to buildings to switch from diesel oil boilers to district heating to overcome initial capital costs. However, the payback period of this switch is today so low at 4-5 years that the city no longer incentivises this as building owners will switch anyway.

Local government as provider and consumer

City-owned or -operated utilities (section 2.4.1 - 2.4.3 of the publication)	Utility mandates and incentives.
	Interconnection policies and incentives.
	Waste-heat tariff regulation and customer protection policies.
	Investment in, or partnership with, other utilities.
Procurement, purchasing, investment	Investment in district energy for government buildings, schools, public transport. Purchase or joint purchase of district heating/cooling or power (cogeneration) with other cities. Green public procurement.

As a provider of infrastructure and services a city can shape the low-carbon pathways of these services, capture synergies across the different business segments and direct the local district energy strategy towards social and economic objectives.

Milan owns 27.2% of the company A2A Spa which provides district heating and cooling in the city as well as distributing gas and electricity. Whilst A2A Spa operates independently of the city, Milan is able to use its ownership to help direct the company's strategy to be in line with the city's carbon reduction target and efforts to improve efficiency and renewables levels.

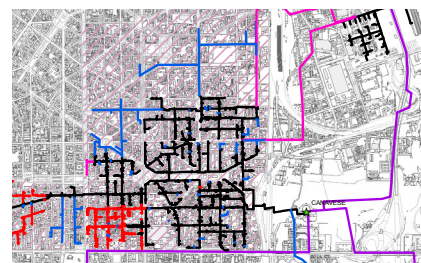
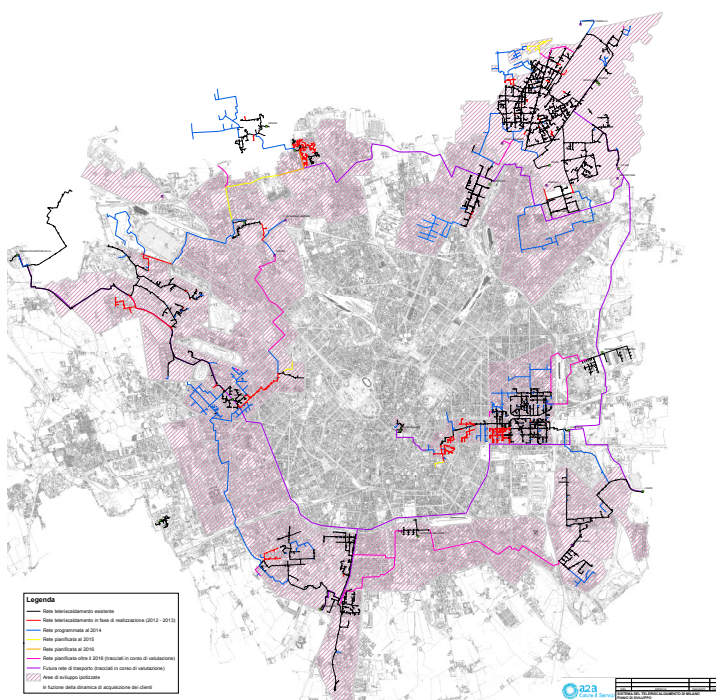
● INTERCONNECTION POLICIES AND INCENTIVES.

Local governments can direct the expansion and integration of district energy networks through network connection plans that often rely on a degree of municipal ownership to progress. Milan has an ambitious plan for connecting its segregated nodal networks into one large network with a transmission ring around the city. It is unlikely that without the strong support of the city, and the partial ownership of A2A Spa by Milan that such an ambitious interconnection plan would be achievable. The future network development in Milan is described in detail below.

There are five main networks in Milan and they are called Milano Sud, Gallaratese/San Siro, Città Studi/Tribunale, Santa Giulia Mecenate and Bicocca. The heat delivered by the district heating network within the city of Milan will almost double from 2014 to 2020 to be over 1TWh per year and the heat demand on the whole network including neighbouring municipalities will increase by approximately 60% by 2020. Such increases in heat demand will be made possible by the interconnection of networks which the city of Milan supports through its partial ownership of A2A Spa.

The network will be slowly interconnected to create three large networks from five: the first interconnecting Milano Sud and Gallaratese/San Siro to produce Milano Ovest to be completed in 2015, the second covering the eastern part of the territory, connecting Santa Giulia and Città Studi and the third extending Biococcaca in the north of the city. This interconnection will allow the city to use the most efficient plants more (CHP and waste to energy) and renewable energy sources and waste heat where available and to use boilers only to cover peak loads and as a backup in case of breakdown. The vision in the long term is to create a large single network by interconnecting the three large networks into a ring structure around the city's centre. Figure 2 illustrates the planned expansion of the network as envisaged in 2012 from five individual networks, to three networks, and finally to one large network.

FIGURE 2 Development of Milan's district heating system



A portion of Milan's district heating network, connected to the Canavese CHP plant. Milan's segregated networks are undergoing interconnection and expansion to form three large heat networks by 2016, which will then be interconnected via a ring around the city.

Red, black and blue lines show network development up to 2014. Yellow lines show development in 2015. Orange and purple lines show future development

● CITY AS A PROVIDER

Milan is facilitating investment in groundwater heat pumps by allowing A2A Spa the free use of the Province of Milan's extraction wells which are currently used to keep the level of the aquifer at a level that will avoid flooding.

Optimizing district energy systems to ensure efficient use of resources and to realize the diverse benefits requires working with various actors outside of the standard heating/cooling utility and end-user model. Milan's ownership of A2A Spa, which is also responsible for electricity, gas and telecommunication installations, allows the business model of district energy to benefit from multiple synergies with these utilities. In particular, the development of the network in the city is coordinated with the other utilities within the A2A Spa group to minimise disruption from earthworks and reducing costs of network delivery by developing networks at the same time. Also, A2A Spa is able to strategically optimise the development of the gas and district heating networks, which would otherwise be competing, to lower costs for end-users by not increasing gas network capacity in new district heating areas, for example.

● CITY AS CONSUMER

The city is also using its own building stock to accelerate expansion of the network and in 2013 the City Administration approved the decision to connect about the 10% of its buildings to the district heating network. The works, operation and management were entrusted to A2A, in coherence with the contents of the Concession



Local Government as a Coordinator and Advocate

Raising awareness of the working principles and benefits of district energy is often a largely "invisible" solution among society at large. Cities and community organizations are essential to catalyzing discussions of district energy systems and for advocating for their incorporation into city strategies. Milan, has a municipality-run Energy Help Desk that promotes fuel switching, provide technical and financial information on energy efficiency and renewables, and strongly promote district heating to consumers.

In Milan, many existing buildings already have a centralized heating system. In these cases, besides substituting the existing boiler with a heat exchanger and the connection to the network, no other significant infrastructural works are needed.

Energy suppliers offer retrofitting through energy service contracts. However, communication is a key ingredient to obtaining the energy service agreements. The current building owners need to be educated on the benefits and reliability of being a customer of a district energy system. This is strongly promoted by the municipality through its Energy Help Desks (EHDs), as fuel switching from diesel oil boilers is one of the priorities of the municipality, due in large part to the resulting local air quality improvements.

EHDs are run by the municipality and provide an information service regarding energy issues to end-users and residents. Energy experts are available according to a fixed schedule in the institutional offices of the city's districts, to address any questions and to provide information on potential interventions, available incentives and financing instruments on district heating, energy efficiency and renewable energy. A new central office was launched in September 2014. Since its conception, district heating has been promoted through information campaigns relating to its environmental benefits.

In addition to EHDs, Milan's Environment Policies Department, Energy and Sustainable Development Service, is in charge of developing energy policies and coordinates with other city units engaged in topics related to energy generally to advance an integrated policy approach. The Municipality of Milan created the 'Mobility, Environment and Territory Agency (AMAT)' as a public company which supports local planning activities concerning climate change mitigation, energy efficiency and renewable energy as well as to undertake environmental assessments, data collection and indicator development.

Milan's District Heating System 🔥

Milan has a large district heating system which serves both Milan and neighbouring municipalities. The network has operated since 1997 and has been developed in segregated networks that will be interconnected in the future.

Network and demand – Current situation

The network connects approximately the 5,3% of existing building volume within the City of Milan. In 2013, the system delivered 590GWh

of heat to consumers in the city from waste-to-energy plants, gas CHPs, heat pumps, and gas boilers. The total network (including connections to neighbouring municipalities) is approximately 238 km long and serves approximately 166.000 flats equivalent (1 flat = 80 m²). The network consists of five main distribution networks and 6 minor networks creating individual 'nodes' of district heating. Some of the main distribution networks cover part of the territory of neighboring municipalities which may in addition have their own network. The long-term interconnection of Milan's heating networks is described on page 6.

BEST PRACTICE

Milan has a nodal network made up of individual networks in high potential areas. These individual networks will be interconnected by transmission lines in the future to create one large network. By developing individual starter networks in high-potential areas, cities can ensure early stage development of district energy is lower-risk and the city is able to test the policies and technologies appropriate to district energy. Once starter networks have been established, and some capital expenditure paid off and local government capacity developed, cities can begin to expand these networks and eventually interconnect them. Expanding networks allows larger energy plants such as CHPs and waste-to-energy plants to have a sufficient load factor. Interconnecting networks aggregates heat demand, reducing the peak-to-baseload ratio which reduces the use of boilers.

Heat production – current situation

The development of Milan's district heating system has been nodal with multiple small networks developed in the city as described above. The first large plants built in Milan were 'Tecnocity' on the Bicocca network in the north of Milan and 'Famagosta' on the Milano Sud network in the

south of Milan, both gas CHP plants (in Famagosta a groundwater heat pump was installed later). Later 'Silla 2' was added in the west of Milan in the Gallarate area, this is a waste-to-energy plant, which incinerates municipal solid waste from Milan and the surrounding region. The district heating in the east of Milan was then powered by the 'Canavese' plant, a progressive CHP to heat-pump plant (see Box 3).

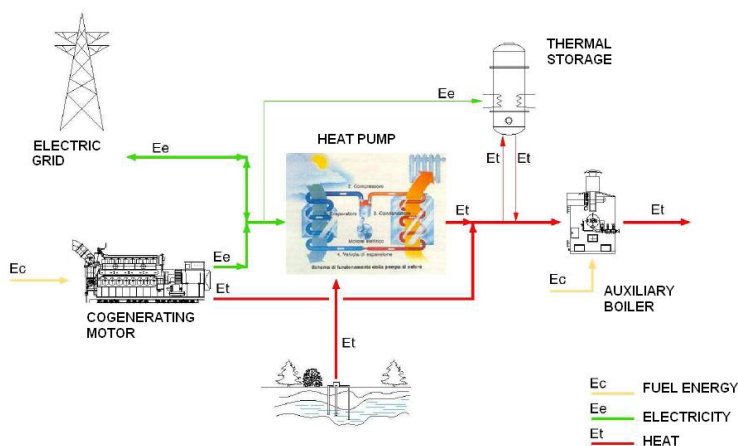
BOX 3

CONNECTING CHP AND HEAT PUMPS

'Canavese' is a CHP plant in the east of Milan which uses natural gas to produce electricity and heat. Dependent on the relative demands for heat and electricity, the electricity from Canavese can be used to power heat pumps connected to an aquifer under Milan. In combination

with on-site heat storage and auxiliary gas-fired boilers, the 'Canavese' plant is capable of meeting peak load demand for the network in the east of Milan. The 'Canavese' plant was awarded a Certificate of Merit by the International Energy Agency and Euroheat and Power in 2011.

FIGURE 3 Diagram showing electricity and heat production at Canavese plant



The Canavese DH system has been designed specifically to enhance the use of the geothermal energy from ground water, a renewable energy resource which is plentiful in the area of Milan.

Source: A2A Calore & Servizi

Heat production – future situation

In order to meet the huge growth in demand for district heating in Milan described above large increases in heat capacity will be required. By 2020 at least 70% of heat will be produced by waste-to-energy, gas CHPs, renewables and third party waste heat and the remaining 30% by gas fired boilers. Milan has a significant potential for using its groundwater resources for district heating. Already extraction wells draw water from an aquifer to prevent the water table being too high in the city. The city is studying how to combine these existing wells with heat pumps to capture the thermal energy of the groundwater. Spatial maps are used to understand the spatial relationship between supply and demand and could lead to district heating and/or cooling connections for groundwater or just to the exploitation of the existing wells for the heating of buildings located nearby.

Milan's District Cooling System ❄️

Currently there is only one district cooling network in Milan and it is based around the Tecnocity CHP in the Bicocca area of Milan. The district cooling network uses absorption chillers and electric chillers with a total power of 17.5 MW. Typically, residential buildings in Milan do not have centralised cooling systems, limiting the expansion of the network to existing residential developments. However, future development of the district cooling network will focus on connecting existing tertiary buildings such as offices and new developments which could include centrally cooled residential buildings.

Business model for district energy

In a similar business model to that of Paris, utilities in Milan operate under a concession contract from the city including gas, electricity, district heating and district cooling networks.

History of Milan's district heating company

The district heating and cooling systems in Milan were initially developed by AEM Milan which was originally fully owned by the city of Milan and had operated as an energy utility since 1910. AEM Milan became a joint stock company called AEM Spa Milan in 1996 which was then floated on the Milan Stock Exchange where the city sold 49% of its shares. In 1996 the city of Milan signed a concession contract with AEM Spa Milan for the development of district heating and gas networks and district heating began in 1997.

In 2004 a further tranche of the company was sold so that the city of Milan owned 33.4% of AEM Spa Milan. AEM Spa Milan then merged with ASM Spa Brescia in 2007 to form A2A Spa, a utility which today Milan owns 27.2% of shares and the nearby city of Brescia also owns 27.2% of shares. A2A Spa also incorporated Amsa, Milan's and other towns' waste collection company and Ecodeco.

The construction and operation of Milan's district heating and cooling systems, which include five main distribution networks and 6 minor networks, is carried out by A2A Calore e Servizi, a subsidiary of A2A Spa. Today A2A Spa is a public-private, multi-utility company responsible for distribution of electricity and gas in Milan and other nearby cities, laying district heating and cooling. A2A Spa is the largest company in the Italian district heating sector.

The city of Milan maintains control of the district heating and cooling development through the concession contract for district heating and local planning and approval policies. The gas distribution network will be put to public tender for a concession contract soon and the concession regarding district heating will be updated to be in coherence with the PUGSS.

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For further information on authorship, contributors, interviewees, survey respondents and reviewers please see UNEP's District Energy in Cities publication.

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