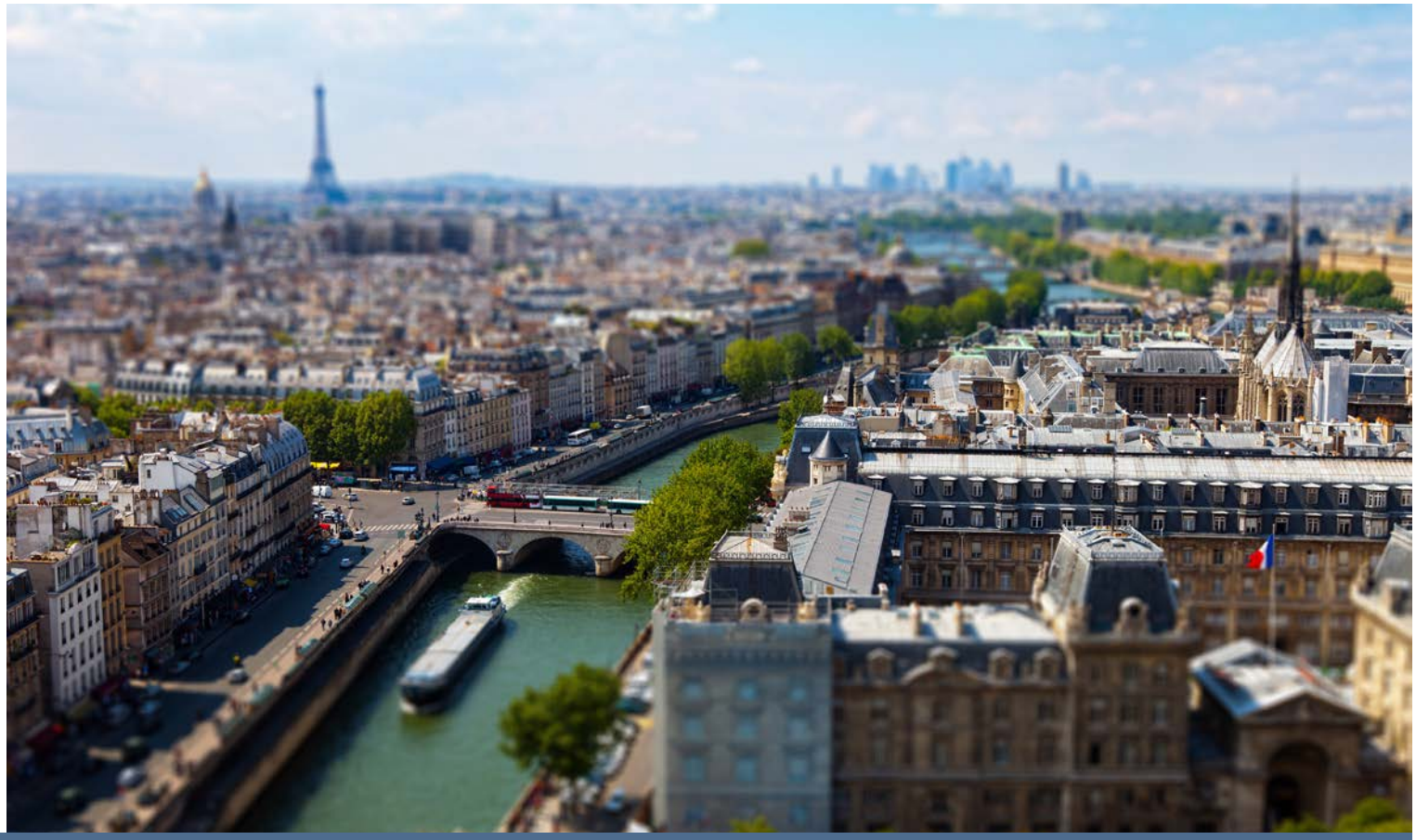


DISTRICT ENERGY IN CITIES PARIS CASE STUDY

OVERVIEW

Paris is a densely populated, energy intensive city that is making real progress and commitments to reduce its impact on the environment. In 2004 the territory emitted 25 million tCO_2^{eq} and in 2009 a reduction by 2% has been noted. The city is now looking to increase efforts post-financial crisis to bring emissions down to 18.8 million tCO_2^{eq} by 2020, a targeted reduction of 25% on 2004 levels. District energy has played an important role in Paris historically in reducing coal consumption and today is expanding to connect social housing, improve energy efficiency and increase the renewables share. From now and into the future, district energy will play an important role in carbon reduction commitments, through the reduction of primary energy use and as an enabler of large scale renewable energy systems inputting into district energy networks.

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
> 2000 MW_{th}	**250 MW_{el}**	**330 MW**	**5,500 GWh**	**412 GWh**	**475 km**	**71 km**

**Values for CPCU district heating network and Climespace district cooling network only*

Paris is a densely populated city with 21,900 inhabitants/km^2 many of which are housed in multi-storey flats and apartments. Paris has a large commercial sector with high energy demands that are often spatially integrated with residential housing. The density of Paris' population does create opportunities for district heating, cooling, gas and electricity: from the level of a block of flats having collective heating to a large district heating network serving half a million people. Paris also has a relatively large amount of social housing with 1 in 5 people in social housing and a higher proportion in some suburbs. Social housing is easier to connect to district heating networks as it is often controlled by the city, with investments in upgrading heating systems made by the city as well.

Structure of energy market

The city of Paris currently produces only 3% of its own energy requirements, while the surrounding region of Ile de France produces 11%. The City of Paris is the granting authority for the public distribution of energy in the Paris area and grants concession contracts for electricity, gas, heating and cooling supply. Cities in France legally own all the underground networks that run through them (including electricity, water, telecommunications, heat, cool). Cities can manage and maintain these pipes, as the City of Paris does for the water network, or instead they can grant concessions to public or private parties to manage and maintain these networks.

Electricity, gas, heating and cooling distribution networks are granted concessions by the city of Paris and controlled through concession contracts. The city is obligated to provide concessions to ErDF (French Electricity Distribution Networks) and GrDF (French Gas Distribution Networks) for electricity and gas network management and maintenance. For heating and cooling networks no such obligation exists. The Paris Urban Heating Company (CPCU) is 33% owned by the City of Paris and under a concession contract both distributes hot water or steam and maintains and manages the district heating pipes throughout the city (see page 5). There are no other district heating companies that operate under concession in Paris but CPCU does have many competitors heating buildings not connected to CPCU's network (e.g. gas boilers, electric heaters, heat pumps etc.). CPCU is responsible for approximately one third of the total heating supply in the city, making CPCU the largest district heating network in France. Cooling supply and district cooling network maintenance is provided in a similar concession model by Climespace, a subsidiary of GDF Suez (see section on Climespace, page 7)

District Energy Strategy of Paris

The current main district energy objective written into the concession contract of CPCU and in the city's Climate Action Plans is to increase renewables and recovered heat in the energy mix and to develop the district energy networks to new areas. These actions will be vital for Paris to meet its commitment to a 75% reduction in C02 emissions by 2050. The territory emitted 25 million tCO_2^{eq} in 2004 meaning that projected emissions in 2050 should be 6.25 million tCO_2^{eq}.

Paris have produced two Climate Action Plans in 2007 and 2012 that set out the city's energy and environmental strategy including specific targets and the pathways towards achieving these targets. Between these two Paris Climate Action Plans the broad strategy and targets of Paris did not change although the pathways to achieving these targets were updated. The city recognised that in order to catalyse city-wide development towards these targets the city authority would need to be more ambitious and fast-acting in reducing its own greenhouse gas emissions, and consequently developed more ambitious targets for the city authority to achieve in its buildings and operations. The broad energy and environmental targets in Paris are:

TARGET TYPE	PUBLIC BUILDINGS, PUBLIC TRANSPORT AND PUBLIC LIGHTING 2020	CITY OF PARIS 2020	CITY OF PARIS 2050
Greenhouse gas emissions	30% reduction compared to 2004 levels	25% reduction compared to 2004 levels	75% reduction compared to 2004 levels
Energy consumption	30% reduction compared to 2004 levels	25% reduction compared to 2004 levels	Unspecified
Renewable or recovered energy use	30% of energy mix	25% of energy mix	Unspecified

Both Paris Climate Action Plans included measures and targets for the district heating sector that were adjusted over time, such as targets for the proportion of heat from renewable or recovered energy sources.

2007 PARIS CLIMATE ACTION PLAN

The 2007 Paris Climate Action Plan accelerated district energy development in four key areas:

TARGETS

The 2007 Paris Climate Action Plan set out the targets for the city seen on page 2 and also focused on district energy by requesting that the CPCU move to 60% renewable or recovered energy by 2012 in order to receive the reduced VAT rate set out in the National Housing Commitment Act of 5.5%. For 2020, CPCU's target was to increase the share of renewable or recovered energy to 75%. This is in the context of the Waste Prevention Plan of Paris which is seeking to reduce the amount of waste incineration in the city (which in 2013 provided 39% of the heat for the district heating network). As such, higher shares of other renewable or recovered energy sources will be required to meet the targets.

REGULATIONS

The 2007 Paris Climate Action Plan called for revisions to regulations relating to the co-ownership of buildings to allow them to have easier access to a local heating network. Furthermore, while compulsory connection of buildings to the district heat network was already possible in urban development zones (see page 4) the 2007 Paris Climate Action Plan indicated the willingness of Paris to apply stricter efficiency regulations more generally that could make connection compulsory outside of these zones.

STUDIES

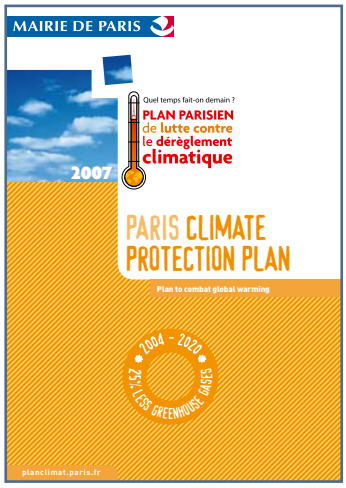
The 2007 Paris Climate Action Plan called for a detailed study on the potential of geothermal energy to be completed and if necessary for boreholes to be drilled. If the potential was significant then a geothermal energy development plan would be produced. In addition to this geothermal development plan, wind and solar plans would also be created. The 2007 Paris Climate Action Plan also announced the ongoing development of a study providing details of the 96,000 residences in Paris, including wall thickness, age, solar gains, building materials and an expected analysis of each building's thermal performance. These studies were designed to help identify the optimal areas for energy efficiency improvements, and could be used by CPCU to direct network development and highlight inefficiencies in the CPCU network.

DENSITY BONUSES

New constructions are able to have a 20% higher 'land-use coefficient' if they meet high efficiency standards or are developed with renewable energy production facilities.

The 2007 Paris Climate Action Plan led to the direct development of:

- a geothermal well in the Claude Bernard urban development zone (also called Paris Nord Est – see Box 5, page 9);
- extension of 10km of district heating in the north-east of the city; and
- significantly large arrays of solar PV (6300m^2 across two large arrays).



2012 PARIS CLIMATE ACTION PLAN

The 2012 Paris Climate Action Plan took stock of what had been achieved since the 2007 Paris Climate Action Plan and reiterated Paris' commitments to the majority of the targets set out in the 2007 Paris Climate Action Plan. The development of the CPCU heat network to be heated by 60% renewable or recovered energy by 2012 was not realised and so the ambition of this target was reduced. The CPCU are now targeting heat networks having 50% renewables or recovered energy by 2015 and 60% renewable or recovered energy by 2020.

The 2012 Paris Climate Action Plan also focused efforts on urban development zones with specific energy policies being applied to these areas to encourage renewable energy and energy efficiency and to increase connections to district energy (see page 4).

The 2012 Paris Climate Action Plan also highlighted the city's recognition of heat recovery from systems such as sewage and the metro as high potential to be explored along with geothermal in specific urban development zones such as Clichy-Batignolles and the existing geothermal development in Paris Nord Est (see Box 5). The Plan indicated that geothermal production would double in the city over the period 2012-2022.

Planning for district energy

Paris uses its land-use planning and city-zoning to promote district energy, as well as energy efficiency, in specific, high-potential areas of the city. In addition, the city is helping catalyse efforts to expand and interconnect district heating systems in and around the city.

URBAN DEVELOPMENT ZONES

The urban development zones are being used to test technologies and policies that will help the city meet long-term energy and environmental targets. These development zones have special regulations and are required to try to connect to district heating if possible. Occasionally, the city of Paris pays for the extension of the district heating network to a new zone in order to ensure connections. This is achieved by the city providing a direct, low-interest loan to CPCU for the development of this extension. The city creates specific clauses in building developers' planning permission that requires connection to district heating or cooling. Paris is now studying the possibility to have new zones with mandatory connections when the energy mix of the district heating is more than 50% renewable or recovered energy. This mandatory connection will be written in a coming city planning document and will also focus studies on the potential for local energy production within these new zones, as well as connection to the CPCU district heating and Climespace district cooling networks. Two urban development zones are described below: Bruneseau Urban Development Zone (see Box 3) and Paris Nord Est (see Box 5)

DISTRICT HEATING MASTER PLAN

The City of Paris has control over district energy through the concession contracts that are in place for the heating and cooling networks. In July 2012, the city authorities included a requirement for the creation of a 'heating master plan' in addendum number 10 of the heating network concession contract for all new developments. This heating master plan will be drafted together with neighbouring authorities and may seek to interconnect some of the heating networks in the wider metropolitan area and also to pool investment for heat production facilities. Interconnection of networks can increase efficiency by pooling demand and maximising baseload across multiple networks. Pooling investment is not a new idea in Paris, the city has already pooled investment with neighbouring cities to interconnect other networks with CPCU.

For the future, with the creation of the Metropolis of Grand Paris, which will include Paris and 123 surrounding cities totalling 7 million inhabitants, there will be a significant opportunity to further interconnect networks and maximise regional resources. This may be through the creation of a global pool of investment, for the whole Metropolis of Grand Paris region, specifically focused on increasing the share of renewables in the heat supply and to interconnect networks.

CPCU – Ninety years of district heating

BEST PRACTICE

Paris uses its partial ownership of CPCU and the concession contract to: set a maximum heat tariff, set a special low tariff for social housing residents, and require development of renewable and recovered energy in the heat network.

The Paris Urban Heating Company (CPCU) serves 16 towns in the Paris metropolitan area, including the city of Paris, with hot water and steam. The heat from CPCU is mostly used for space heating and hot water in buildings, although steam is sometimes used in industrial processes. Box 1 shows the progression of CPCU from 1927 to the modern day.

BOX 1 HISTORICAL DEVELOPMENT OF THE PARIS URBAN HEATING COMPANY (CPCU)

- **1927:** The City of Paris creates a concession for the delivery of steam through a district heat network to national and public buildings. CPCU, a private company, starts developing district heating under a concession contract. District heating was seen as the solution to improving the city's air quality as the majority of heating was from decentralised coal and wood. District heating would also help to reduce the risk of fire and the need for thousands of fuel deliveries through the city's centre.
- **1930:** CPCU activities begin with providing heat for a factory and pre-heating trains in Gare de Lyon station. Twenty neighbouring buildings then connect to the network in order to benefit from uninterrupted and secure heat.
- **1939:** The network has expanded across the centre of Paris to be 13.5km long and has 190 clients including many major public and administrative buildings such as the Louvre, Hotel de Ville and Palais Royal and many department stores, libraries and hotels.
- **1949:** After World War 2 the City of Paris purchases 33% of CPCU making CPCU a public-private joint venture. The city bought this share to help the post-war reconstruction of the network and to help connect new social housing being developed in the reconstruction.
- **1966:** The network has expanded through existing metro lines and pipes and now is 120km serving 1700 clients.
- **2015:** Today CPCU is 33% owned by the City of Paris, 64% by Cofely and 2% is traded publicly. The network serves the equivalent of 500,000 households and distributed 5.5TWh of heat in 2013 through its 475km of network.

PEAK REDUCTION WITH HOT WATER LOOPS

The network consists mostly of a steam network with individual heat exchangers at each delivery point but also includes nineteen 'Hot Water Loops' that distribute hot water through small neighbourhoods or developments and have heat delivered to them via a heat exchanger with the main steam network. Steam was used since 1927 as this was the technology available at the time. Today when new areas are developed, 'Hot Water Loops' are preferred due to the higher distribution efficiency of distributing hot water (distribution efficiency is approximately 95% in the 'Hot Water Loops'). Furthermore, as hot water can store heat better than steam, the 'Hot Water Loops' can reduce peak demand on the steam network, reducing the carbon intensity of heat (which at peak demand is normally provided by fossil fuel boilers).

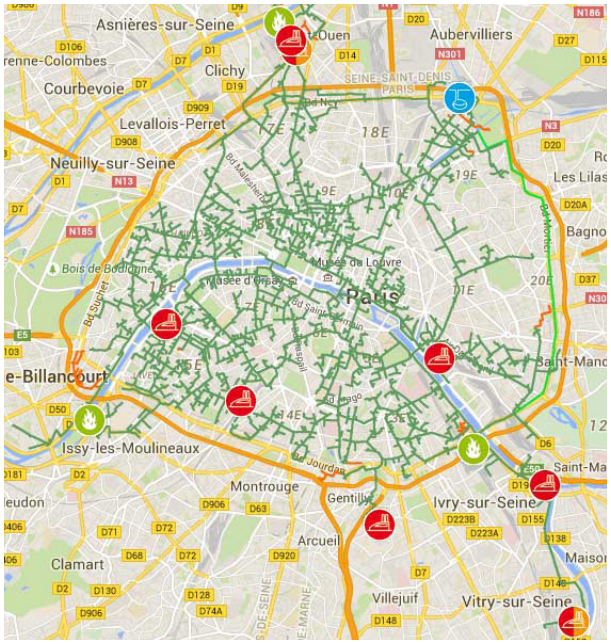
CPCU CURRENT ENERGY MIX

CPCU has a wide range of different heat sources that deliver steam into the district heat network, the relative proportions of these can be seen in Figure 2. The baseload heat production comes from 3 waste incinerators that provide 39% of heat to the network and combined reduce the carbon emissions of heat by 800,000tCO_2. These waste incinerators are not owned by CPCU but are owned by Syctom, the waste agency of Metropolitan Paris. CPCU purchases steam from these three waste incinerators which have a combined thermal capacity of 397MW_{th}.

CPCU also owns two gas combined heat and power (CHP) plants, each with an electrical capacity of 125MW_{el} that produce 1TWh of electricity per year (approximately 160,000 households*) for the local distribution network. Gas and coal boilers also provide significant amounts of heat with a combined thermal capacity of 982 MW_{th}. and five fuel oil boilers provide peaking demand for the network. In total, a thermal capacity of 4GW_{th} is connecting to CPCU's network.

These sources of heat can be seen in Figure 1 showing CPCU's heat network in Paris. Three of the fuel oil boilers are within dense areas of Paris and so CPCU is one of the few remaining industrial companies based in the city and must meet strict emissions standards. The three waste incinerators owned by Syctom are fully equipped to reduce air emissions significantly below legal thresholds.

FIGURE 1:
Network map of CPCU showing heat production plants



Source: CPCU, 2015

** Assuming average French household consumes 6343kWh of electricity per year (average for year 2010). Source: World Energy Council, 2014*

CPCU FUTURE ENERGY MIX

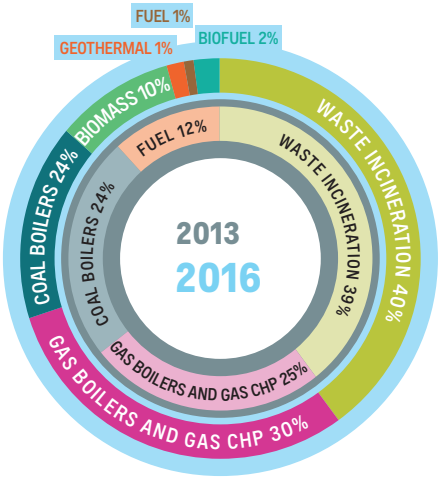
The future energy mix of CPCU's district heating network is driven by the city's energy strategy through the city's part ownership role in CPCU and through the concession contract. By the end of 2015, CPCU will have reached a 50% renewable energy share allowing it to reduce VAT from 20% to 5.5% under the National Housing Commitment Act (2010) which is estimated to save approximately €35 million a year. By 2016, CPCU's energy mix will have increased to a 53% renewable or recovered energy share and by 2020 this will be 60%.

Paris also has a good geothermal resource which is particularly useful for district heating purposes although accessing this resource can be difficult in such a dense city. Paris is a growing city with new housing developments on the periphery taking over previously industrial land such as the 19th arrondisement. Such new developments are significantly easier to implement district energy in as pipes and networks can be considered before construction begins. The Paris Nord Est urban development zone (described in Box 5) will deliver enough geothermal heat by 2016 to meet 1% of CPCU production.

CPCU is looking to create large biomass plants near the city with a thermal power of 200MW$_{th}$ so that biomass can provide 10% of the fuel mix. However challenges for CPCU include addressing air quality issues and finding good quality biomass for the plant.

If the CPCU achieves the 2020 target of 60% renewable or recovered energy then the net reduction in greenhouse gas emissions could be around 350,000 tCO$_2^{eq}$. In addition, the CPCU will have lowered primary energy consumption, insulated Paris from fossil fuel energy price increases, closed-the-loop on waste production in the region and also helped reduce fuel poverty.

FIGURE 2:
CPCU's current and future energy mix



Source: CPCU, 2015

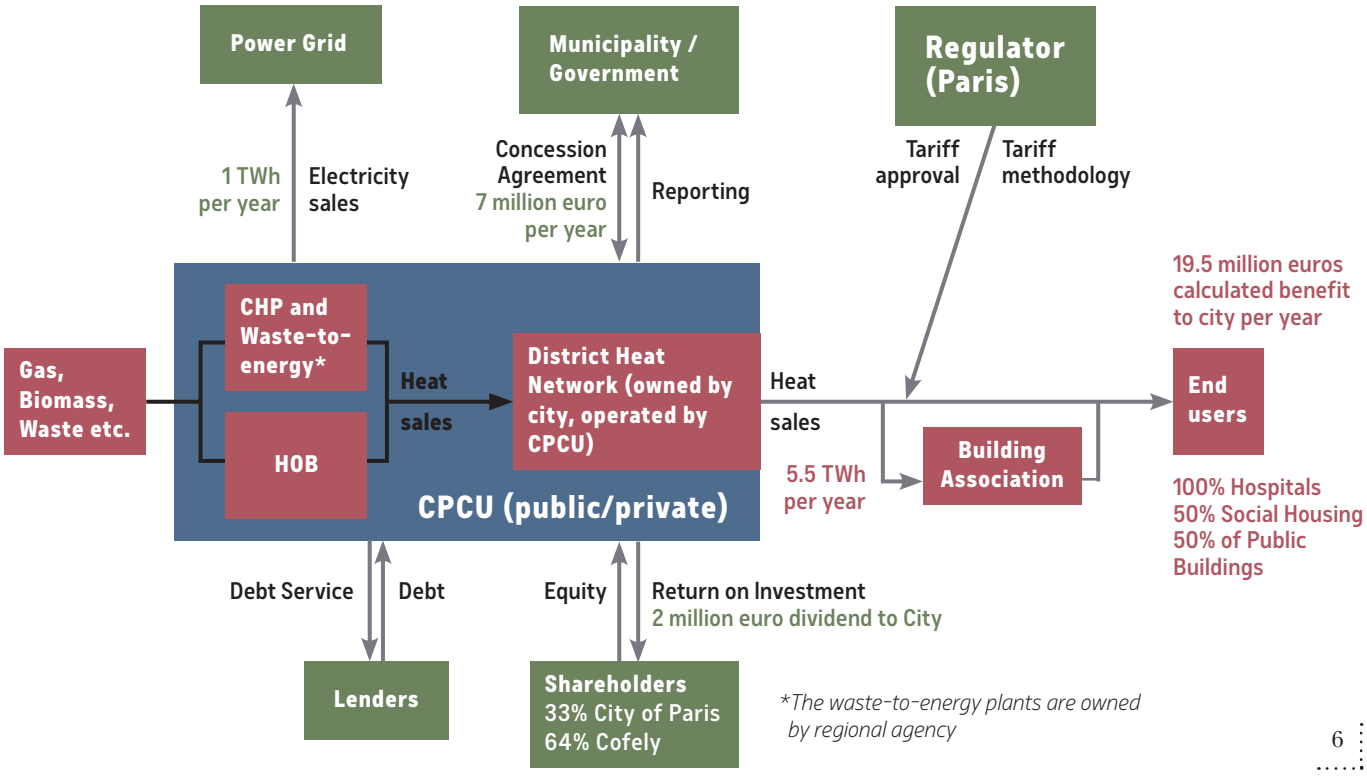
CPCU CONNECTIONS

The CPCU meets the equivalent heat demand of 500,000 households and this includes 100% of hospitals, 50% of social housing and 50% of publicly owned buildings. The client base of CPCU comprises of 28% private residential buildings, 17% social housing with the remaining being businesses and public buildings. The city authority has used its assets to provide anchor loads to the CPCU which increases the load certainty on the network. The city also benefits from heat with a high share of renewables, which is critical to the city meeting its renewables targets for public buildings (30% renewable energy share by 2020). Through the city's 33% stake in CPCU, the city has directed the district heat company to focus on connecting social housing projects. The city also uses its ownership to require a special low tariff for all those in social housing, ensuring that affordable heat is provided. CPCU is also targeting to reduce the energy consumption of its users with a 'heat demand reduction plan'. This includes the installation of individual meters, development of building insulation and heat leakage reductions in the distribution network.

CPCU BUSINESS MODEL

CPCU has operated under a concession from the city of Paris since 1927. CPCU was originally a private company until the city of Paris bought a 33% share to make it a public-private joint venture (see Box 1 on historical development of CPCU). This model has enabled Paris to maintain a high degree of control over network development and over heat tariffs, for example 4 of the 10 directors on CPCU's Board of Directors are nominated by the city of Paris. The concession contract specifies a maximum heat tariff that the CPCU can charge. This maximum heat tariff is indexed by the proportion of renewable energy sources used to encourage CPCU to switch to renewables. The business model also allows CPCU to benefit from the expertise of the private sector, Cofely. Cofely are able to leverage their international expertise and large balance sheet to improve and invest in CPCU's networks. CPCU delivers significant returns to the city with estimated annual benefits to the city of €19.5 million, an annual dividend for the city of €2 million and an annual concession fee of €7 million. An overview of the CPCU's business model can be seen in Figure 3.

FIGURE 3. Business model of CPCU: A split asset concession model with public/private concessionaire



Climespace – The largest district cooling network in Europe

Paris has a large cooling network that operates under a concession model from the city of Paris, called Climespace. This network is the largest district cooling network in Europe and operates in the centre of Paris. Isolated other networks include two district cooling networks in La Défense, a large business district in the west of Paris, operated by IDEX and Dalkia (see page 10 for more information on the cooling of La Défense).

District cooling has been operated by Climespace in Paris under a concession since 1991. The district cooling network is extremely innovative and was the first cooling network in Europe and today it is the largest. The network replaces air conditioning and chillers for many offices, shops and hotels as well as some of the most famous buildings in Paris, such as the Louvre, by pumping cold water around the city.

BEST PRACTICE

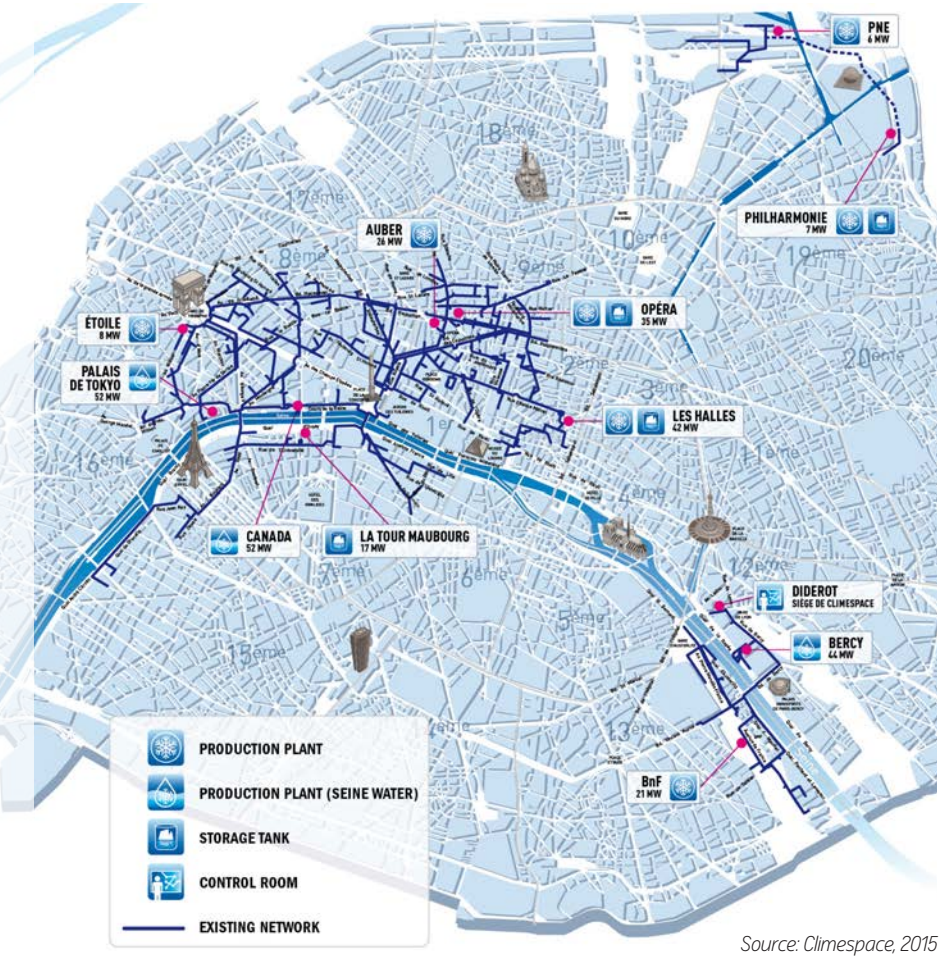
Climespace uses the basement and roofs of existing buildings, underground connections to the River Seine and runs 60% of the network through the city's sewage system to minimise costs of network development and impact on the city.

THE CLIMESPACE NETWORK

Climespace's district cooling network is over 71 km long with the majority of the network in the centre of the city and two, separate smaller networks exist in the North East and South West of Paris as shown in Figure 4. The scale, and rapid growth, of the district cooling network in Paris has been achieved, in part, by running 60% of the network through the existing sewage system. In a dense city such as Paris this significantly lowers the costs and disruption of network development as roads do not always have to be dug up in order to expand the network. When roads do have to be dug up in Paris it is the responsibility of the city authorities to coordinate and reduce this disruption and the city may coordinate with other utilities such as ErDF to ensure that roadworks can occur at the same time. The network is expanded based on new demand with a large consumer identified and the network expanded to meet this consumer and to connect other consumers along the new pipe's route.

The network flows cold water through energy transfer stations that often sit in the basement of buildings and contain a heat exchanger to cool the building's internal centralised cooling system. These energy transfer stations have different capacities dependent on the estimated maximum demand of the building and take up only a small amount of space (20 square-meters) compared to the building's previous electric chillers and cooling towers.

FIGURE 4: Network map of Climespace showing extent of network and production sites



Source: Climespace, 2015

CLIMESPACE PRODUCTION

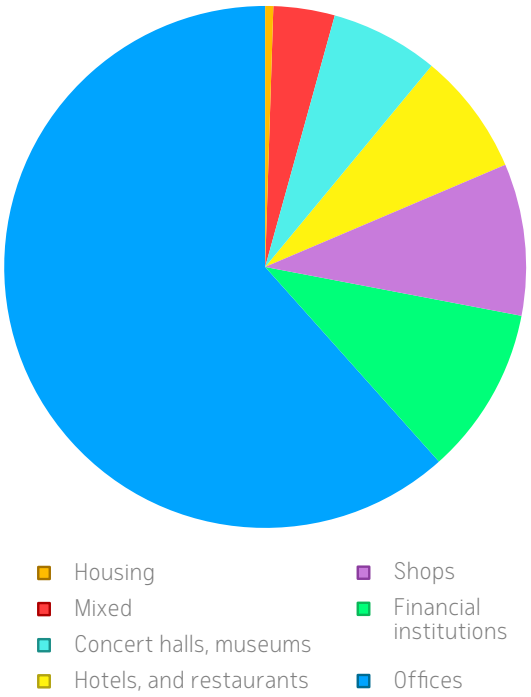
Climespace's network has nine cold water production sites (from five in 2007) with 330MW of cool capacity delivering 412 GWh per year of cooling. The district cooling network makes use of the city's free cooling' through three production sites that take cold water from the Seine River to provide cool. These sites use this cold water to pre-cool water before it enters electric chillers. In this way electricity consumption of the electric chillers is much lower, improving costs, energy efficiency and CO_2 emissions. The three production sites connected to the Seine are the largest production sites on the network, totalling 148MW. The control room of the district cooling network works to maximise the use of this 'free cooling' and uses these three production sites as the baseload supply of the network, meeting 75% of the network's cooling demand over a year enabling the district cooling network to use 35% less electricity than normal centralised cooling in buildings. The other production sites on the network help meet peak periods of cool demand and are highly-efficient electric chillers with cooling towers.

The supply temperature of the network is approximately 4°C and the return temperature can be up to 14°C. The network also has three cold water storage sites that can instantly provide more power to the network and also can shift the electricity demand of production sites.

BOX 2 DEVELOPED UNDERGROUND AND IN BUILDINGS

- Climespace's network and production sites are almost entirely underground. This is an economically efficient solution in such a dense city. The three production sites connected to the Seine are entirely underground and do not need require cooling towers as warmer water is pumped into the Seine. The other production plants on the network rent underground space from existing buildings and have cooling towers on top of the building. For example, the Philharmonie de Paris building was constructed in coordination with Climespace so that an electric chiller and cold storage was installed during building construction as well as a cooling tower. The space is rented by Climespace and the network developed will be interconnected in the future to the Paris Nord Est development (see Box 5).

FIGURE 5: Climespace clients by capacity connected



Source: Climespace, 2015

DISTRICT COOLING DEMAND

- Climespace has more than 570 clients with an equivalent demand of 5 million m^2 of office cooled and is steadily growing the network by connecting 25-30 new clients per year (approximately 14MW of cool capacity). Clients that are connected already have centralised cooling systems and are normally replacing individual stand-alone chillers and cooling towers or undergoing large building renovations.

- The network serves mostly offices, commercial and public buildings including the Louvre museum and the Forum des Halles as well as many restaurants, hotels and shops. Customers connect for many reasons including: the significant space saving, the ability to use the roof space (as no cooling towers are needed), improved environmental credentials for the building, the need to replace existing equipment and the long-term cost saving of district cooling. Climespace has a range of customers with varied needs for cooling even during winter. Large server rooms in banks, as well as storage areas in museums and concert halls all have a significant demand for cool throughout the year.

- Climespace does not connect to residential users in Paris as the cooling season for residential customers is too short, approximately two months, and the cooling demand is too low as many Parisians leave the city for holidays. Some urban development zones in the city are focused on residential development and Climespace does not connect to these, however, Bruneseau (see Box 3) and Paris Nord Est (see Box 5) are two urban development zones that have led to significant expansion of Climespace's activities.

BOX 3 BRUNESEAU URBAN DEVELOPMENT ZONE

- This new Bruneseau development in the east of Paris, on the left bank, was developed close to Climespace's existing and separate, Bercy network, which has a 44MW production facility cooled by the river Seine on the right bank (see figure 4). The city of Paris approached Climespace to consider connecting to the new Bruneseau development in order to improve the environmental credentials of the new development. This connection with Climespace would require the development of a new production facility on the left bank as the district cooling pipe across the Seine would not be wide enough to serve the Bruneseau development and additional cooling capacity would be required on the left bank in Summer.

- Climespace has approached the national public library (Bibliotheque National de France) on the left bank, to develop a production facility based on electric chillers and cooling towers in the library. This will be developed in three phases with electric chillers added in parallel as demand increases. The first phase is already in place and Climespace rents a 2000 square-metre underground space from the library.

- As such, the development of the Bruneseau Urban Development Zone was the catalyst for Climespace to continue expanding the Bercy network on the left bank, which required a large new development to justify creating a new left bank, production facility.

BUSINESS MODEL

Climespace is 100% owned by the GDF Suez Group through its affiliate Cofely. The city does not financially support Climespace and investments are financed only by Climespace with the original equity for Climespace provided by the GDF Suez Group.

Climespace operates under a 30-year concession contract from the city of Paris which ends in 2021 and will be renegotiated then. This concession contract specifies tariffs that Climespace can charge to its customers. These tariffs vary dependent on time-of-use and also the size of the energy transfer station that a building requires. Climespace has 124 employees and provides an annual revenue to the city of approximately €1 million per year with an annual turnover of €74 million.

ENVIRONMENTAL BENEFITS

In comparison with an equivalent pool of stand-alone units, the district cooling network is better economically, environmentally and aesthetically as shown in Box 4. Climespace allows users to save space as buildings no longer need individual air conditioning units or chillers and the network benefits from reduced land costs by having many plants and, all the network's pipes, underground. The use of highly efficient chillers and free cooling from the Seine allows the dramatic reduction of electricity consumption and CO_2 emissions.

BOX 4 MULTIPLE BENEFITS OF CLIMESPACE*

**Compared to an equivalent pool of stand-alone cooling units*

- 50% improvement in energy efficiency
- 50% less CO_2 emissions
- 80% less chemical products used
- 65% less water consumed
- 90% less refrigerant emissions
- 35% less electricity consumed
- In combination with other wet cooling systems, Climespace, reduces the urban heat island effect in a heatwave by 1-2°C.

Many clients connect to Climespace because this improves the building energy label making it easier to sell or rent offices and other commercial buildings. These energy labels include LEED, HQE and BREEAM* and account for full system efficiency rather than just efficiency of the building envelope, a key best practise for the development of district energy.

** LEED: Leadership in Energy and Environmental Design. HQE: Haute Qualité Environnementale. BREEAM: Building Research Establishment Environmental Assessment Methodology*

BOX 5 CLAUDE BERNARD URBAN DEVELOPMENT ZONE (PARIS NORD EST)

- The Claude Bernard Urban Development Zone is a new development in the North-East of Paris comprising of 12,000 flats and 1 million m^2 which will be partially supplied with renewable heat and cool from a new geothermal well developed at the same time as the new development. The project will extract 60°C water from a geothermal well bored into the Dogger aquifer at 1600-1700 meters deep and return water into another borehole. This hot water will be used to meet some of the heat demand for the development and in summer will be used to produce cooling for the development through absorption chillers.
- The 2007 Paris Climate Action Plan called for a detailed study on the potential of geothermal energy in Paris to be completed and if necessary for boreholes to be drilled. The 2007 Paris Climate Action Plan also specified the Urban Development Zone of Claude Bernard to meet specific requirements in relation to energy including 20% lower energy consumption levels than existing thermal regulations an effort to become energy self-sufficient, to use at least 25% renewable energy and to aim for the BBC Effinergie Rénovation certificate (see section on Building Efficiency page 11). In this way the Climate Action Plan has directly led to the innovative scheme being developed in Claude Bernard.
- A new company Géométropole was created in December 2013 that is 44% owned by CPCU, 22% owned by Climespace and 34% by the public financial institution: Caisse des Dépôts et Consignations. This company will supply heat to CPCU's network in the Claude Bernard development and cold water to Climespace's network in the development.
- This project is estimated to cost €15 million and will have one-tenth of the CO_2 emissions compared to normal gas heating. The heat production capacity of the plant will be 11MW. The estimated cost is €21 million for the construction of the geothermal plant and €32 million for the geothermal wells and to the deployment of the district heating network.

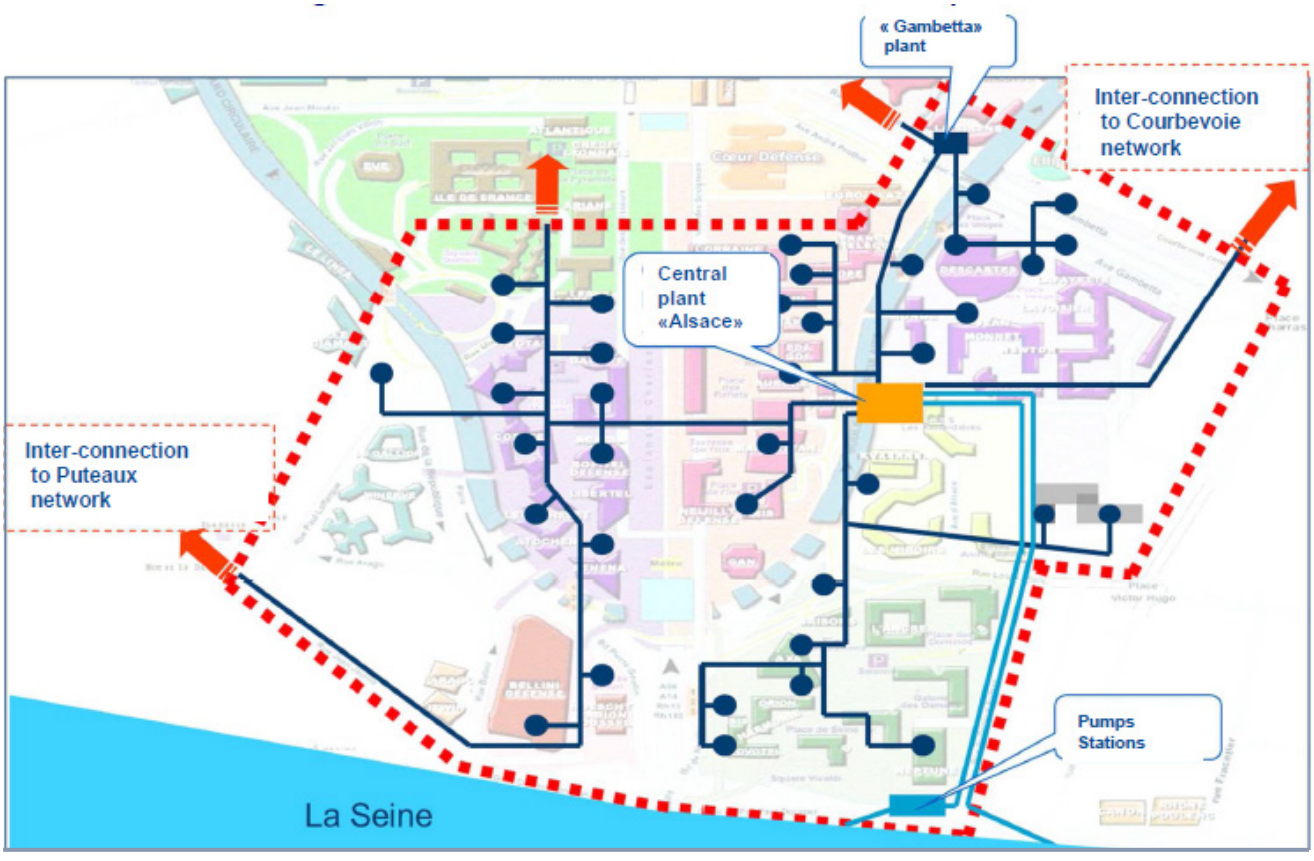
Cooling the La Défense Business District

La Défense is a large business district to the west of Paris, located on the adjoining cities of Puteaux, Courbevoie and Nanterre, cities that have formed with their Department Council a Joint Association - SICUDEF - responsible for their district cooling networks. Business districts typically have extremely high and dense cooling demands making them ideal for district cooling development, which is best achieved during periods of construction in the business district. The SUC (Société Urbaine de Climatisation) network in La Defense operates under concession from SICUDEF, this concession zone is shown in Figure 6. SUC is owned by Dalkia and serves 70 high rises through 6km of network and directly or indirectly cools the equivalent of 1 million square-metres of office and hotel space through interconnections to 2 adjacent networks (see Figure 7). SUC has a cooling capacity of 85MW providing 80,000MWh of cold water per year.

The SUC network uses the 'free cool' of the river Seine through a river connection to provide a large proportion of the cold water. Electric chillers are able to provide cool during periods of peak demand. The SUC network does not use cooling towers freeing space on roof tops in the district for other uses.

FIGURE 6: SUC network concession zone

Source: Dalkia



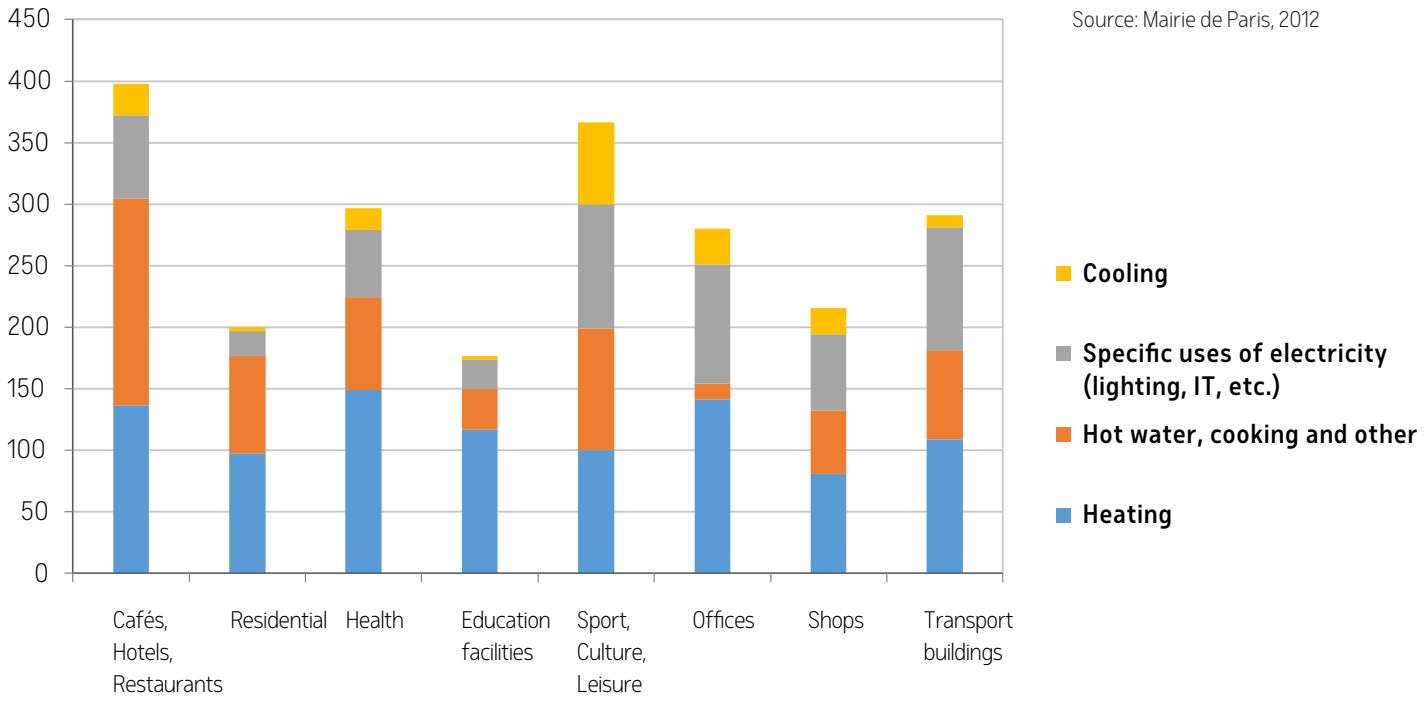
Source: Dalkia

Building Efficiency and District Energy

Paris has large amount of older housing stock, which can present challenges in renovating them or improving thermal efficiency or connecting then to district heating networks. Like many cities Paris will need to focus on both new and old build housing stock in order to meet carbon targets. Development of district energy in new and existing buildings will enable Paris to lower its exposure to energy prices unilaterally and also to improve its carbon emissions.

Paris is a city that requires heating, cooling and hot water. The demand for cooling and hot water varies significantly by building type, however, the demand for heat is more constant (see Figure 8). To put the energy levels in perspective the BBC Effinergie Rénovation certificate (a national building certificate for energy efficiency) requires that primary energy consumption for new construction must be less than 104kWh/m^2/year in the Ile-de-France region while average buildings in Paris consume 275kWh/m^2/year.

FIGURE 8: Energy consumption by building type in Paris

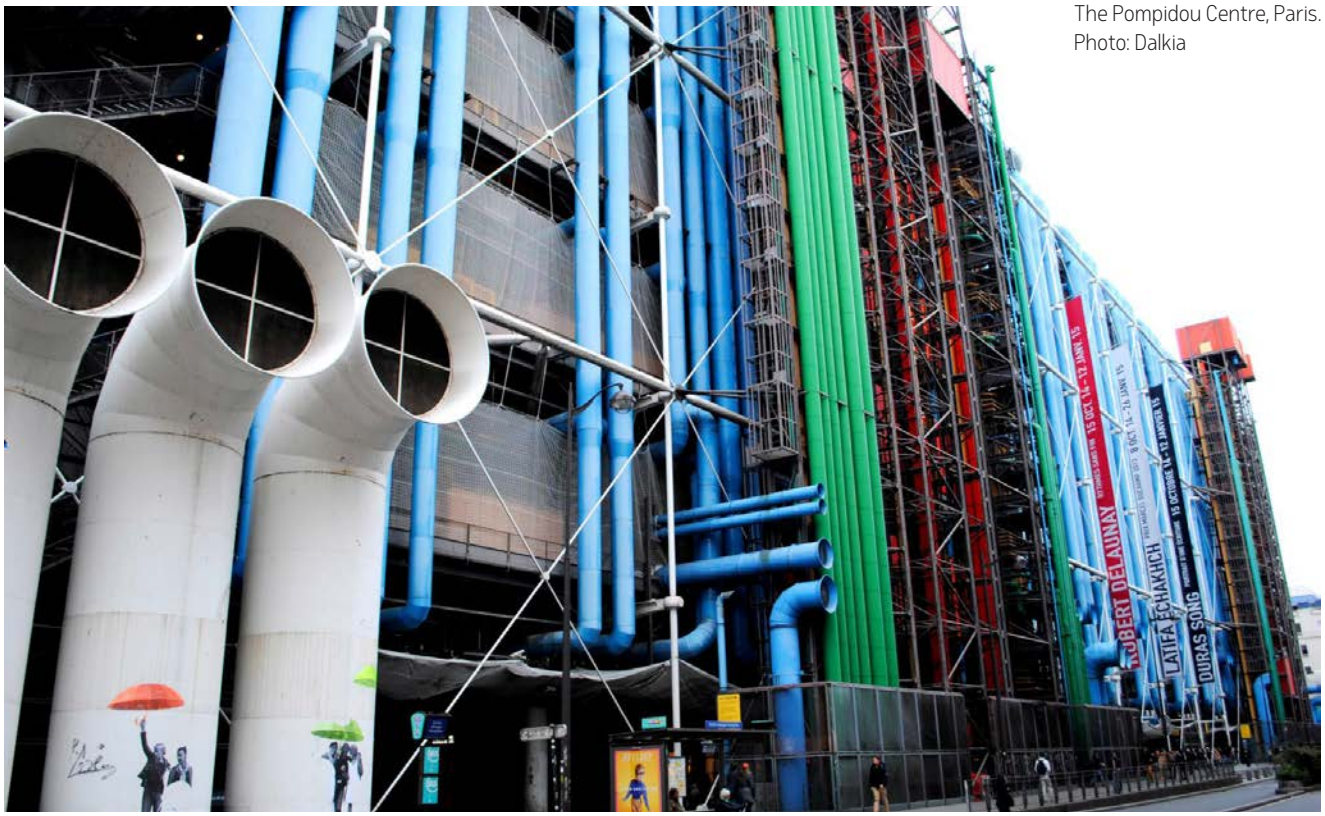


Source: Mairie de Paris, 2012

In 2010 the city of Paris launched a government-subsidised housing programme (OPATB) to improve the thermal performance of buildings. The first goal of this programme was to retrofit poorly insulated buildings by installing new insulations (building façades, roofs), removing oil boilers, and installing double glazed window. Where possible the programme also sought to switch heat from electricity or natural gas to district heating. The city of Paris paid 100% of the thermal diagnosis and provided double the national incentives for these renovations. Initially the programme focused on very energy intensive buildings in the 13th arrondisement (i.e. buildings built between 1940 and 1981). These buildings already had a high proportion of collective heating (56%) and the programme catalysed the creation of co-owners' associations to seek to reduce the energy demand on such collective heating systems, which sometimes involved connecting collective heating to the district heat network. Within two and a half years of the programme, 151 co-owned properties had carried out an energy audit, 38 co-owned properties had undertaken a works project and 28 (2,236 housing units) had already voted to approve work for a 8 GWh/year saving under the OPATB. This programme, piloted in one area of the city, has proved extremely successful and is now being deployed throughout Paris.

It is extremely important that as well as assessing district heating, cities improve the efficiency of buildings. By improving efficiency through building design and district heating, cities can reduce energy consumption at least cost. The Pompidou centre in Paris is a strong example of how building efficiency and district energy can compliment each other.

THE POMPIDOU CENTRE RENOVATION AND EFFICIENCY PROJECT



The Pompidou Centre, Paris.
Photo: Dalkia

The Pompidou Centre is Europe's largest modern art gallery with close to 4 million visitors per year. Built in 1977 the building has been undergoing a modernisation process of its heating and cooling facilities of the Pompidou Centre's 100,000 square-metres. Dalkia have been a partner from the early construction phase of the Pompidou Centre and have since been in charge of the operation and maintenance of the whole building air conditioning systems (temperature and humidity controls) with heat being provided by the CPCU district heating network and cold being produced by the Pompidou Centre's chillers.

Through the modernisation process, the Pompidou Centre needed to replace 13 roof mounted air units that ejected heat from the building. Rather than simply replacing these, Dalkia developed an energy efficient alternative of 13 air-to-air roof mounted heat pump units that optimise the Pompidou Centre's heat and cool consumption and reduce the in house chillers' operation and production. In winter, or when it is necessary to raise the temperature to 21°C in the Pompidou Centre, the air-to-air heat pumps provide heat by removing heat from the outside air. In summer or when the temperature of the rooms should be lowered to 23°C, the heat pumps work in reverse to remove heat from inside the building. The modernisation process was phased over a 41 month period to prevent damage risk to the exhibitions' artefacts and maintain full public access and work was completed in April 2015. The full installation being now completed, monitoring of the delivered savings will be conducted over the coming months.

New air-to-air
heat pumps on the roof of Centre Pompidou.
Photo: Dalkia

The operation of the new equipment is projected to reduce by 25% the energy demand for heating and cooling in the Pompidou Centre including a 28% reduction in heat demand from CPCU and a 34% reduction in electricity consumption by the electric chillers.

This significant reduction in energy consumption as well as other environmental benefits during development, such as the reduction of chemicals in water treatment and legionella prevention and the reduction of water effluents. are contributing to the building achieving the required HEQ (Haute Qualité Environnementale) building standards.

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