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How to decarbonise your city's heating and cooling systems

Buildings and Construction | Clean Energy

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Heating and cooling homes and workplaces uses a vast amount of energy. When this energy is sourced from fossil fuels, it is responsible for a major portion of a city's greenhouse gas emissions.

This article describes the three primary strategies cities can take to tackle heating and cooling-related emissions:

- Convert heating and cooling of individual buildings to renewable technologies.
- Promote clean district heating and cooling networks powered by renewable energy.
- Improve building energy efficiency to reduce energy demand.

Convert heating and cooling of individual buildings to renewable technologies

Take steps to convert fossil-fuel based heating systems in buildings (such as gas-powered domestic boilers) to technologies that are directly or indirectly powered by renewable sources. The main clean technologies are air source heat pumps, ground source heat pumps, solar thermal systems, and wood pellet furnaces. Emissions from natural gas grids can also be reduced by shifting to gas from renewable sources. Renewable heating and cooling projects should be implemented in tandem with building energy efficiency measures, to make more cost-effective use of these capital-intensive technologies.

The main clean technologies:

- **Air source and ground source heat pumps.** These are efficient and cheap technologies that use electricity to transfer heat from the surrounding air or ground to the interior of a building, and vice versa for cooling. Heat pumps are more efficient than traditional boilers, so switching usually results in immediate energy cost and emissions savings. Coupled with a clean electricity grid, they deliver zero emission heating and cooling. Air source heat pumps are suitable for most buildings, but ground source heat pumps require access to an outdoor space, about twice the floor area of the building in question, which can be excavated to lay pipes containing the heating fluid. Sometimes these pipes can also be installed in vertical drilled boreholes, which require less space.

- **Solar thermal hot water systems.** These use the sun's energy to heat collector fluid in rooftop panels, which is then used to heat water for use in the building. This technology is best suited to properties with high and relatively stable demand for hot water, roofs oriented toward the sun and ample space for solar thermal collectors. The use of solar thermal is growing, with at least 471 solar district heating or central hot water systems operating worldwide by the end of 2020, totalling 1.8 GWth (gigawatts thermal) of capacity.[1]

- **Wood-pellet furnaces.** These are an efficient and clean source of heat, and are sustainable if the pellets (or woodchips) are sourced responsibly.

- **Renewable natural gas.** This is bio-methane produced from the anaerobic digestion of organic waste or gasification of wood waste. It is also possible to use surplus electricity from wind or solar projects during off-peak demand times to produce hydrogen for use in heating networks. Avoid fossil-fuel-based natural gas, which is not renewable and causes significant emissions.

To take the lead on clean heating and cooling cities should:

- **Raise awareness of alternative technology options and provide incentives.** To combat low consumer awareness of alternative heating options, provide clear information to building owners about their options and emphasise the personal cost savings. Consider providing financial incentives – such as rebates, subsidised loans or tax incentives – to help households cover the upfront costs of conversion. In addition, help to connect households to any existing incentive programmes at the national or regional level.

- **Take the lead by converting heating systems in city-owned buildings.** Raise awareness and build public support for conversion to cleaner heating and cooling technologies through a high-profile project in municipal buildings. Assess the heating systems in all municipal properties and identify which buildings are best suited for conversion.

- **Adjust building codes to require renewable heating.** If possible, adjust the building code to require renewable heating in new or retrofitted buildings, or lobby the authority with control over the

building code to do so. For example, Barcelona approved a solar thermal ordinance in 1999 that required new buildings using more than 0.8MWh per day for hot water production, and those undergoing major renovations, to source at least 60% of their hot water from solar thermal collectors. The policy has since been strengthened to cover buildings of all sizes, and has been extremely successful: the total surface area of solar thermal systems in Barcelona grew from 1,650 square metres in 2000 to 87,600 square metres in 2010.[2]

Improve building energy efficiency to reduce heating and cooling demand. More efficient buildings require less energy to maintain a comfortable internal temperature. Therefore, improving building energy efficiency is critical for reducing heating and cooling-related greenhouse gas emissions, as well as to save residents money and increase comfort. You can find dedicated resources on building energy efficiency here.

Promote clean district heating and cooling

In district heating systems, a central power plant generates hot water or steam that is pumped around a network of pipes to heat connected buildings. Many cities already have district heating networks in some areas. In a district cooling system, the central plant powers an electric chiller that produces cold water for cooling, although to date this is used on a large scale in only a few countries.[3]

Where the density of energy demand is high enough to make it viable, district heating and cooling (DHC) is far more efficient than heating and cooling buildings individually and therefore results in lower emissions – especially where a combined heat and power (CHP) plant is used to generate electricity, heat and hot water for connected buildings in one facility. In combined cooling, heat and power plants (CCHP), also known as 'tri-generation' facilities, the central plant also provides cooling and is an ideal solution when buildings' cooling requirements are high.

Most existing DHC networks are powered by fossil fuels but they are well suited for the integration of renewable technologies, as well as low cost energy storage solutions that can reduce emissions and improve system efficiency. Clean district heating is typically powered by solar thermal systems, waste-to-energy plants or biofuels, geothermal, and waste heat recovery from sewage or industry. Waste incineration should be avoided in most circumstances. Renewable-powered district cooling usually uses cool bodies of water nearby.

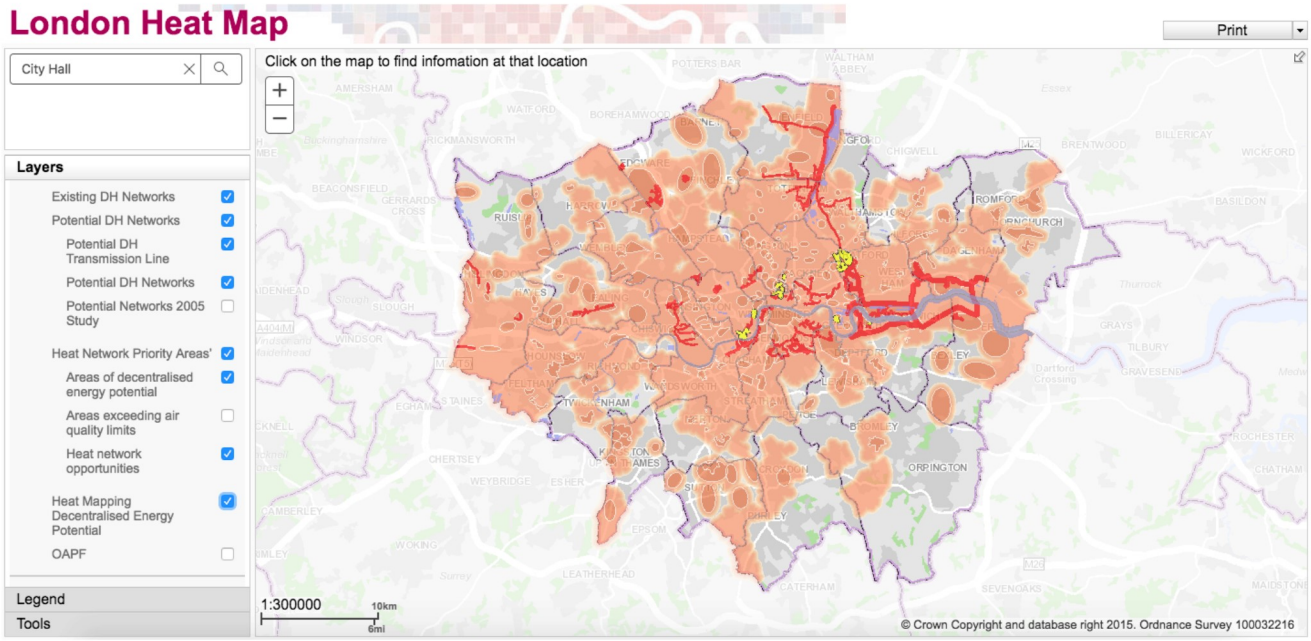
Examples include Hong Kong's plans to use seawater to supply centralised cooling to everything from schools to shopping centres, and the use of heat from London's underground metro network, Paris's data centres and Næstved's glass recycling plant.[4, 5, 6, 7]

To support the expansion of clean DHC, cities should:

- **Target high energy demand areas, informed by a city-wide energy map.** To be financially viable, DHC requires high energy demand to be concentrated in a small area. It requires urban planning to promote dense and mixed-use neighbourhoods that have more balanced energy demand profiles throughout the day than single-use residential or commercial districts. Start by developing a city-wide energy map of existing network locations, such as London's Heat Map (see box), and assess current and future energy demand to guide decision-making on the locations for network expansion or creation. Build this into a strategy for dense, mixed-use, transit-oriented development.

The London Heat Map

District heating is an important part of London's strategy for meeting its goal to generate 25% of its energy supply from decentralised sources by 2030. As a first step, the Greater London Authority (GLA) developed the London Heat Map, shown below,[8] which shows the location of district heating networks and how energy demand varies across the city. The GLA uses the online map to determine where market-competitive heat networks could be located, and the tool is publicly available for use by local authorities, developers and community advocates.



- **Introduce clean DHC through incremental network upgrading.** Start by expanding or upgrading existing DHC systems, where they exist. This is the cheapest and fastest way to introduce renewable DHC because the system does not need to be created from scratch. Renewable technologies can be integrated as the existing fossil-fuel powered network is extended or upgraded.

- **Develop supportive policies and enabling tools.** District heating requires a robust policy framework to address risks and promote financial and physical viability. The main tools and policy options for

encouraging connections, dependent on the strength of the city's regulatory powers.[9]

- Make connection to a district heating network mandatory in certain areas, for certain types of buildings, and/or for all new developments. In Heidelberg, Germany the city made connection mandatory in 'development areas' where they were seeking to expand the district heat grid (see box).
- Introduce a 'connect unless' policy, where developers are required to connect new buildings to DHC networks unless they can demonstrate that this is unfeasible against specific viability criteria.
- Introduce density bonuses that allow developers to build more densely, coupled with district energy connection requirements. This 'up-zoning' is also vital for implementing transit-oriented development, which is an important long-term strategy for reducing transport emissions.
- Guarantee a specified high-level of demand or compensatory payments to a private district energy utility.
- Ban energy- or carbon-intensive heating technologies.
- Regulated, transparent and competitive tariffs to encourage voluntary connection.
- Subsidies to fully or partially cover connection costs.

Read IRENA's *Renewable Energy in District Heating and Cooling* and UNEP's *District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy* for more guidance.

District heat expansion in Heidelberg

The district heating system in Heidelberg, Germany satisfies 47% of the city's heating demand. The heat was originally produced by coal plants and was responsible for 40% of Heidelberg's energy-related greenhouse gas emissions. However, under the city's plan to reduce emissions by 95% by 2050, these have been phased out and replaced with CHP plants running on renewable fuels. A woodchip-fired CHP plant opened in 2014 using regionally-sourced sustainable wood chips. In addition, six gas-fired CHP plants have been introduced, four of which operate on biomethane sourced from agricultural bi-products, allowing the system to reach 20% renewables very quickly. The city plans to integrate solar thermal power and build a storage tank to convert surplus renewable electricity from the grid to be stored as hot water.

Copenhagen is heated mostly by clean district heating[10]

Copenhagen, Denmark has one of the largest, oldest and most successful district heating systems in the world. It supplies 98% of the city with clean, reliable and affordable heating. Set up in 1984 to improve energy security after the oil crisis in the 1970s,[11] the system captures waste heat from electricity production – which would otherwise be released into the sea – and channels it back through pipes into peoples' homes. The

system saves households 1,400 EUR annually in energy costs, and has saved Copenhagen district 665,000 tonnes of CO_2 every year.

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