EXECUTIVE SUMMARY

UNEP

DISTRICT ENERGY IN CITIES

Unlocking the Potential of Energy Efficiency and Renewable Energy

United Nations Environment Programme

UNEP in collaboration with

COPENHAGEN CENTRE ON ENERGY EFFICIENCY
SE4ALL EE HUB

ICLEI
Local Governments for Sustainability

UN-HABITAT
FOR A BETTER URBAN FUTURE

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URBAN LEDS
URBAN LOW EMISSION DEVELOPMENT STRATEGIES

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In 2013, UNEP initiated research on and surveyed low-carbon cities worldwide to identify the key factors underlying their success in scaling up energy efficiency and renewable energy, as well as in attaining targets for zero or low greenhouse gas emissions. District energy systems emerged as a best practice approach for providing a local, affordable and low-carbon energy supply. District energy represents a significant opportunity for cities to move towards climate-resilient, resource-efficient and low-carbon pathways.

Among the core components of the transition to a sustainable energy future are the integration of energy efficiency and renewable energy technologies, and the need to use "systems thinking" when addressing challenges in the energy, transport, buildings and industry sectors. Tackling the energy transition will require the intelligent use of synergies, flexibility in demand, and both short- and long-term energy storage solutions across different economic sectors, along with new approaches to governance. The UNEP publication, *District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy*, provides a glimpse into what integration and systems thinking look like in practice for heating and cooling networks, and showcases the central role of cities in the energy transition.

The development of modern (i.e., energy-efficient and climate-resilient) and affordable district energy systems in cities is one of the least-cost and most-efficient solutions for reducing greenhouse gas emissions and primary energy demand. A transition to such systems, combined with energy efficiency measures, could contribute as much as 58 per cent of the carbon dioxide (CO_2) emission reductions required in the energy sector by 2050 to keep global temperature rise to within 2–3 degrees Celsius.

District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy is among the first publications to provide concrete policy, finance and technology best practice guidance on addressing the heating and cooling sectors in cities through energy efficiency improvements and the integration of renewables. The recommendations have been developed in collaboration with 45 "champion" cities, all of which use modern district energy, and 11 of which have set targets for either carbon neutrality or a 100 per cent renewable energy supply. The report is also the first to consolidate data on the multiple benefits that cities, countries and regions have achieved through the use of modern district energy, in an effort to support evidence-based policy recommendations and to raise awareness of the significance of the heating and cooling sectors, which have been insufficiently addressed in the climate and energy debate.

District energy is a proven energy solution that has been deployed for many years in a growing number of cities worldwide. In several European cities, such as Copenhagen, Helsinki and Vilnius, nearly all of the required heating and cooling is supplied via district networks. The largest district cooling capacity is in the United States, at 16 gigawatts-thermal (GW_{th}), followed by the United Arab Emirates (10 GW_{th}) and Japan (4 GW_{th}).

Modern district energy systems supply heating and cooling services using technologies and approaches such as combined heat and power (CHP), thermal storage, heat pumps and decentralized energy. District energy creates synergies between the production and supply of heat, cooling, domestic hot water and electricity and can be integrated with municipal systems such as power, sanitation, sewage treatment, transport and waste. This report provides an overview of the various district energy technologies and their specific applications and costs, in order to help local governments and actors identify the most cost-competitive and appropriate options in their regions. It also highlights the need for dialogue between national and subnational governments and for the development of mutually reinforcing policies.

REAPING THE MULTIPLE BENEFITS OF DISTRICT ENERGY SYSTEMS

Through the development of district energy, the 45 champion cities were achieving or pursuing the following key benefits or policy objectives:

GREENHOUSE GAS EMISSIONS REDUCTIONS

District energy allows for a transition away from fossil fuel use and can result in a 30–50 per cent reduction in primary energy consumption. Denmark has seen a 20 per cent reduction in national CO_2 emissions since 1990 due to district heating, and many cities are turning to district energy as key components of climate action plans. District energy is a core strategy in putting Paris on the pathway to a 75 per cent reduction in CO_2 emissions by 2050; the city's waste-to-energy plants alone avoid the emission of 800,000 tons of CO_2 annually. In Copenhagen, recycling waste heat results in 655,000 tons of CO_2 emission reductions while also displacing 1.4 million barrels of oil annually. And Tokyo's district heating and cooling systems use 44 per cent less primary energy and emit 50 per cent less CO_2 compared to individual heating and cooling systems.

AIR POLLUTION REDUCTIONS

By reducing fossil fuel use, district energy systems can lead to reductions in indoor and outdoor air pollution and the associated health impacts. In Gothenburg, Sweden, district heating production doubled between 1973 and 2010, while CO_2 emissions fell by half and the city's nitrogen oxide (NO_x) and sulphur dioxide (SO_2) emissions declined even more sharply. As the share of oil used in Sweden's district heating networks dropped from 90 per cent in 1980 to less than 10 per cent in 2014, the country's carbon intensity similarly declined. In China, the city of Anshan will reduce its use of heavily polluting coal by a projected 1.2 million tons annually through the pooling of separate networks and the capture of 1 gigawatt (GW) of waste heat from a steel plant in the city.

ENERGY EFFICIENCY IMPROVEMENTS

Linking the heat and electricity sectors through district energy infrastructure and utilizing low-grade energy sources, such as waste heat or free cooling, can greatly improve the operational efficiency of new or existing buildings. All buildings require basic efficiency measures; however, as the efficiency in a building improves, connecting to a district energy system can be more cost-effective than a full retrofit, as Frankfurt, Germany, discovered when evaluating its 12,000 buildings with historic façades. Experience in Rotterdam, the Netherlands, has similarly shown that above a certain threshold for energy efficiency labelling, district energy is more cost-effective than retrofits. Helsinki's CHP plants often operate at very high levels of primary energy efficiency, utilizing up to 93 per cent of the energy in their fuel source to produce electricity and heat. In Japan, the high efficiencies of CHP plants make it possible to reduce imports of natural gas relative to business as usual. And in many cities – such as Dubai in the United Arab Emirates – district cooling can result in 50 per cent reductions in electricity use compared to other forms of cooling.

USE OF LOCAL AND RENEWABLE RESOURCES

Through economies of scale and the use of thermal storage, district energy systems are one of the most effective means for integrating renewable energy sources into the heating and cooling sectors. District energy also enables higher shares of renewable power production through balancing. Several countries with high shares of wind and solar power – such as China, Denmark and Germany – have begun using district heat systems to utilize excess renewable electricity during periods of oversupply. In China's Inner Mongolia region, the city of Hohhot is piloting the use of curtailed wind to provide district heating in order to meet rising heat demand. In Germany, a key reason that the national *Energiewende* ("Energy Transition") policy promotes CHP is because it allows for the integration of higher levels of solar photovoltaics into the electricity grid.

RESILIENCE AND ENERGY ACCESS

District energy systems can boost resilience and energy access through their ability to improve the management of electricity demand, reduce the risk of brownouts and adapt to pressures such as fuel price shocks (for example, through cost-effective decarbonization, centralized fuel-switching and affordable energy services). In Kuwait City, where air conditioning accounts for 70 per cent of peak power demand and for more than half of annual energy consumption, district cooling could reduce peak demand by 46 per cent and annual electricity consumption by 44 per cent compared to conventional air-cooled systems. Botosani, Romania, was able to reconnect 21 large-scale district heating consumers by modernizing its district energy infrastructure to provide more-affordable heat. And Yerevan, Armenia, was able to provide heat below the price of residential gas boilers by opting for gas-fired CHP instead of gas boilers for its district heating network.

GREEN ECONOMY

District energy systems can contribute to the transition to a green economy through cost savings from avoided or deferred investment in power generation infrastructure and peak capacity; wealth creation through reduced fossil fuel expenditure and generation of local tax revenue; and employment from jobs created in system design, construction, equipment manufacturing, and operation and maintenance. In Bergen, Norway, electricity companies supported district heating because it reduced reinforcement costs and provided additional revenues. St. Paul, USA, uses district energy fuelled by municipal wood waste to displace 275,000 tons of coal annually and to keep US$12 million in energy expenses circulating in the local economy. In Toronto, Canada, the extraction of lake water for district cooling reduces electricity use for cooling by 90 per cent, and the city earned US$89 million from selling a 43 per cent share in its district energy systems, which it could use to fund other sustainable infrastructure development. Oslo, Norway's, employment benefits from district energy are estimated at 1,375 full-time jobs.

CITIES WORLDWIDE HAVE FOUND INNOVATIVE WAYS TO OVERCOME KEY BARRIERS TO DISTRICT ENERGY DEPLOYMENT

The ability of district energy systems to combine energy efficiency improvements with renewable energy integration has brought new relevance to these technologies. However, market barriers to greater deployment remain, including a lack of awareness about technology applications and their multiple benefits and savings, a lack of integrated infrastructure and land-use planning, and a lack of knowledge and capacity in structuring projects to attract investments. Data and accounting challenges include a lack of sufficient data on municipal heating and cooling, the lack of an agreed methodology to recognize energy savings and environmental benefits, and the lack of agreed accounting methods to develop efficiency ratings, labels and standards for buildings. Additional barriers include interconnection regulations and grid access limitations, high upfront capital costs, and energy pricing regimes or market structures that disadvantage district energy systems relative to other technologies.

Despite these challenges, cities and countries worldwide have successfully developed targeted measures and policies to support district energy systems, fostering significant industry growth. The 45 champion cities collectively have installed more than 36 GW of district heating capacity (equivalent to some 3.6 million households), 6 GW of district cooling capacity (equivalent to some 600,000 households) and 12,000 km of district energy networks. Over the next 10 years, all 45 cities will increase their district energy capacity, with many of them finishing initial or planned projects, including Christchurch (New Zealand), GIFT City (India), Guelph (Canada), Hong Kong (China) and Port Louis (Mauritius).

HONG KONG

CHRISTCHURCH

PORT LOUIS

LOCAL GOVERNMENTS CAN PLAY MANY DIVERSE ROLES IN ADVANCING DISTRICT ENERGY SYSTEMS

Local governments are uniquely positioned to advance district energy systems in their various capacities as planners and regulators, as facilitators of finance, as role models and advocates, and as large consumers of energy and providers of infrastructure and services (e.g., energy, transport, housing, waste collection and wastewater treatment). The policy options available to cities often are influenced by national frameworks and the extent of devolved authority. This publication outlines the policy best practices that local governments can use within these four broad capacities, accounting for diverse national frameworks.

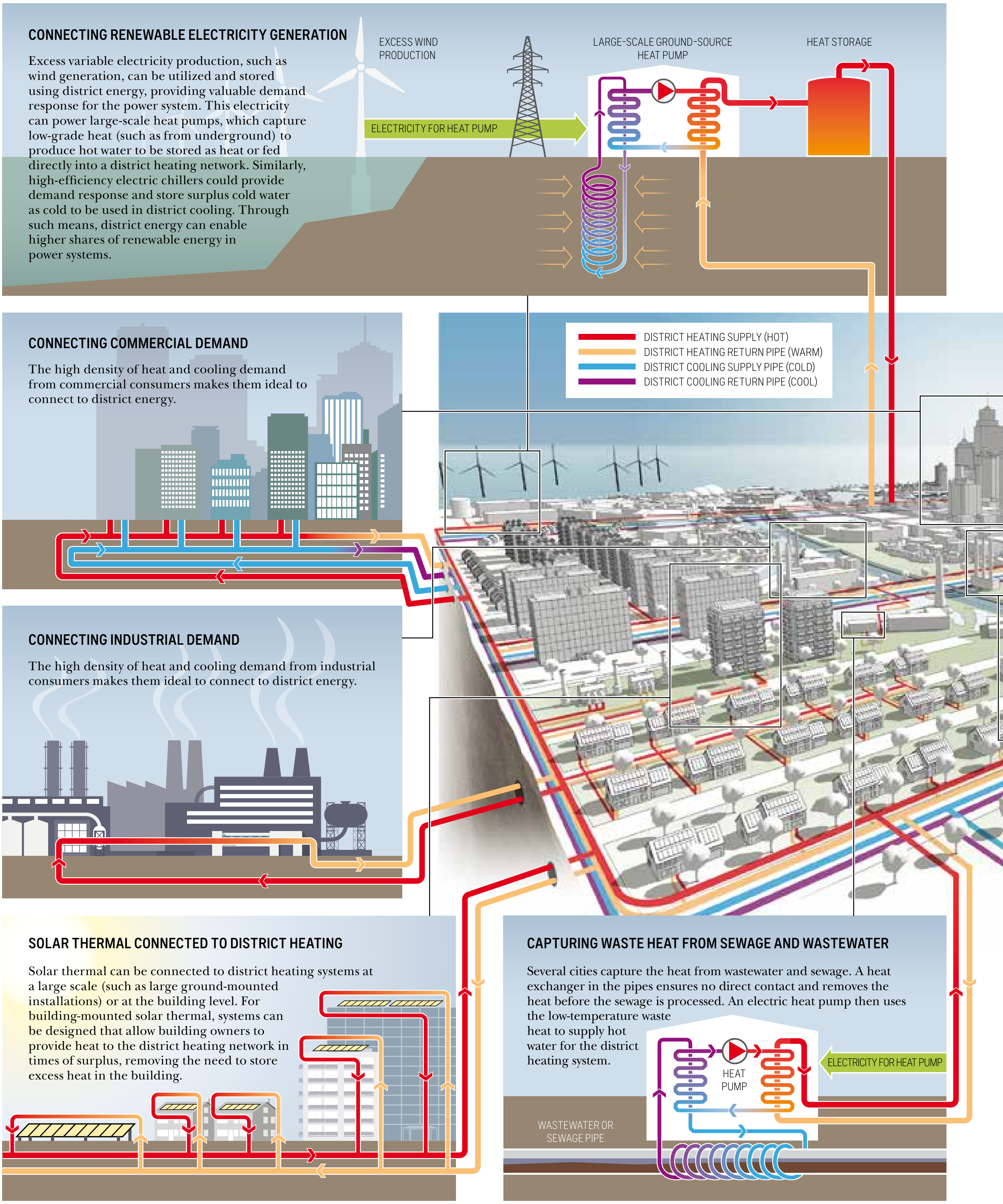
Of the 45 champion cities, 43 are using their ability to influence planning policy and local regulations to promote and accelerate district energy deployment through vision and target setting; integrated energy, land-use and infrastructure planning and mapping; connection policies; and waste-to-energy mandates. Over half of the 45 cities have district energy-specific targets, which either resulted from or are linked to broader energy targets (e.g., energy efficiency, greenhouse gas emissions, fossil fuel consumption, energy intensity).

Integrated energy planning and mapping, supported by a designated coordination unit or a public-private partnership, is a best practice to identify synergies and opportunities for cost-effective district energy and to apply tailored policies or financial incentives within different areas of a city. Through such policies, the Greater London Authority envisions leveraging £8 billion (US$12.9 billion) of investment in district energy by 2030. In 2012 alone, the city's integrated energy and land-use planning policy resulted in £133 million (US$213 million) of investment in heat network infrastructure.

Across the 45 champion cities, local governments were ranked as the "most important" actor in catalyzing investment in district energy systems, playing a central role in addressing the associated risks and costs. Several cities – including Dubai (UAE), Munich (Germany), Tokyo (Japan), Paris (France) and Warsaw (Poland) – attracted more than US$150 million of investment in their respective district energy systems between 2009 and 2014.

Almost all of the 45 champion cities have leveraged city assets, such as land and public buildings, for district energy installations or connections, including by providing anchor loads to alleviate load risk and facilitate investment. Other financial and fiscal incentives that local governments use to support district energy include: debt provision and bond financing, loan guarantees and underwriting, access to senior-level grants and loans, revolving funds, city-level subsidies and development-based land-value capture strategies. All 45 of the cities use demonstration projects as a tool to raise awareness and technical understanding of district energy applications and their multiple benefits, as well as to showcase their commercial viability. Vancouver, Canada, has developed a demonstration project capturing waste heat from the wastewater system, which has spurred private sector investment in other networks.

WHOLE DISTRICT ENERGY SYSTEM SHOWING VARIOUS END-USERS AND THE FEEDING IN OF HEAT AND COOLING SOURCES (INCLUDING RENEWABLES)



CONNECTING RENEWABLE ELECTRICITY GENERATION

Excess variable electricity production, such as wind generation, can be utilized and stored using district energy, providing valuable demand response for the power system. This electricity can power large-scale heat pumps, which capture low-grade heat (such as from underground) to produce hot water to be stored as heat or fed directly into a district heating network. Similarly, high-efficiency electric chillers could provide demand response and store surplus cold water as cold to be used in district cooling. Through such means, district energy can enable higher shares of renewable energy in power systems.

CONNECTING COMMERCIAL DEMAND

The high density of heat and cooling demand from commercial consumers makes them ideal to connect to district energy.

CONNECTING INDUSTRIAL DEMAND

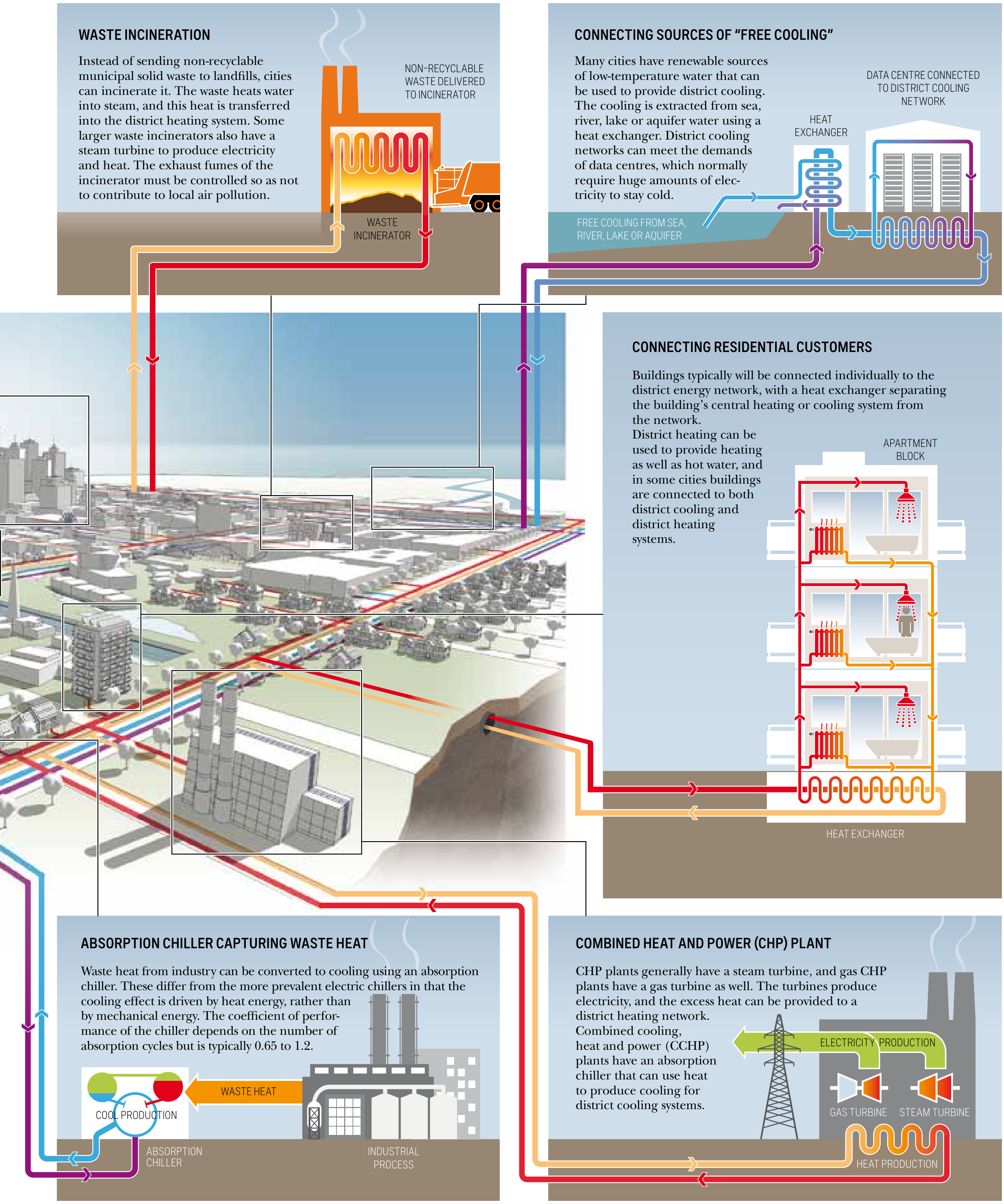
The high density of heat and cooling demand from industrial consumers makes them ideal to connect to district energy.

SOLAR THERMAL CONNECTED TO DISTRICT HEATING

Solar thermal can be connected to district heating systems at a large scale (such as large ground-mounted installations) or at the building level. For building-mounted solar thermal, systems can be designed that allow building owners to provide heat to the district heating network in times of surplus, removing the need to store excess heat in the building.

CAPTURING WASTE HEAT FROM SEWAGE AND WASTEWATER

Several cities capture the heat from wastewater and sewage. A heat exchanger in the pipes ensures no direct contact and removes the heat before the sewage is processed. An electric heat pump then uses the low-temperature waste heat to supply hot water for the district heating system.



WASTE INCINERATION

Instead of sending non-recyclable municipal solid waste to landfills, cities can incinerate it. The waste heats water into steam, and this heat is transferred into the district heating system. Some larger waste incinerators also have a steam turbine to produce electricity and heat. The exhaust fumes of the incinerator must be controlled so as not to contribute to local air pollution.

CONNECTING SOURCES OF "FREE COOLING"

Many cities have renewable sources of low-temperature water that can be used to provide district cooling. The cooling is extracted from sea, river, lake or aquifer water using a heat exchanger. District cooling networks can meet the demands of data centres, which normally require huge amounts of electricity to stay cold.

CONNECTING RESIDENTIAL CUSTOMERS

Buildings typically will be connected individually to the district energy network, with a heat exchanger separating the building's central heating or cooling system from the network.

District heating can be used to provide heating as well as hot water, and in some cities buildings are connected to both district cooling and district heating systems.

ABSORPTION CHILLER CAPTURING WASTE HEAT

Waste heat from industry can be converted to cooling using an absorption chiller. These differ from the more prevalent electric chillers in that the cooling effect is driven by heat energy, rather than by mechanical energy. The coefficient of performance of the chiller depends on the number of absorption cycles but is typically 0.65 to 1.2.

COMBINED HEAT AND POWER (CHP) PLANT

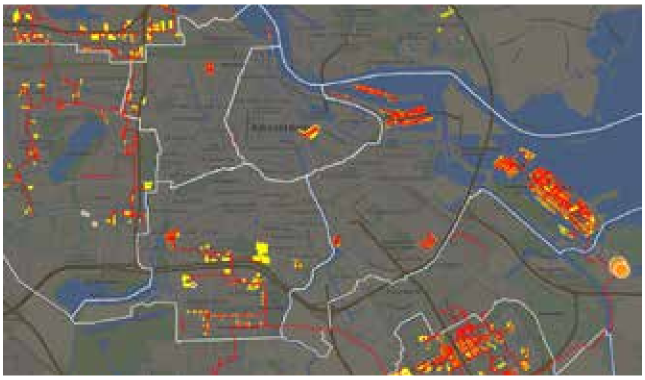
CHP plants generally have a steam turbine, and gas CHP plants have a gas turbine as well. The turbines produce electricity, and the excess heat can be provided to a district heating network.

Combined cooling, heat and power (CCHP) plants have an absorption chiller that can use heat to produce cooling for district cooling systems.

As providers of infrastructure and services, local governments can shape the low-carbon pathways of district energy systems, capture synergies across the different business segments and direct the district energy strategy towards broader social and economic objectives. Optimizing district energy systems to ensure efficient resource use and to realize their diverse benefits requires working with actors outside of the standard heating/cooling utility and end-user model. Cities pursuing district energy have benefited from identifying synergies with non-energy utilities and incorporating these synergies into a mutually beneficial business case. In Bergen, Norway, the city's urban densification policies promote district energy in coordination with the new light-rail network. Such collaboration can go further than just joint planning of infrastructure, and can mean investment in, or partnership with, other utilities.

Additional best practices include: waste-heat tariffs that reflect the cost of connection and the ability to guarantee supply; CHP access to the retail electricity market; net metering policies and incentives for feed-in of distributed generation; customer protection policies, including tariff regulation; nodal development; technical standards to integrate multiple networks; cooperation with neighboring municipalities for joint development or use of district energy networks; and a range of policies that encourage connection, such as zoning bylaws, density bonuses and building codes.

The opening up of heat or cooling markets to multiple sources is a key component of the transition to modern district energy. Creating a market for heat or cool means that multiple companies and stakeholders are included in the business model, and this can drive competition, potentially lowering end-user tariffs. However, the opening up of heat or cooling markets may not be appropriate for all types of district energy systems, and cities should also consider the impacts of such changes on various consumer groups. Waste heat is an important source in a modern district energy system, and open markets for heat and cooling can accelerate its inclusion. However, many cities have faced difficulties in pricing waste heat accurately. Waste heat can be likened to variable renewable electricity production in electricity markets which have low operating costs, multiple benefits that are unaccounted for, as well as difficulty in guaranteeing supply. As such, the tariffs waste heat receives can be modelled in a similar way to renewables incentives, such as the feed-in tariff. Pricing of waste heat is discussed in detail in section 2 of the full report.



City of Amsterdam, Interactive Maps, 'Energy from waste incineration and waste heat'. Map showing the existing district heat network in Amsterdam (red) with connected load (yellow) and sources of waste heat (orange).

Map data: © 2015 Google. www.amsterdamsmartcity.com

CITIES CAN CHOOSE FROM A VARIETY OF BUSINESS MODELS FOR DISTRICT ENERGY, DEPENDING ON THEIR SPECIFIC SITUATIONS

Cities worldwide are utilizing diverse business models for district energy, depending on the specific local context. The business model should ensure that all of the players involved – including investors, owners, operators, utilities/suppliers, end-consumers and municipalities – can achieve financial returns, in addition to any wider economic benefits that they seek. By evaluating the innovative business approaches being used elsewhere, planners can make better-informed decisions for developing and financially structuring systems in their own cities. The majority of business models for district energy involve the public sector; they range from fully publicly owned systems, to cooperative models and public-private partnerships, to privately owned and developed systems. In 18 of the 45 champion cities, public ownership is the most dominant model, while in 22 of the cities, hybrid business models are the most dominant, ranging from a privately operated concession to a public-private joint venture.

Since 1927, the Paris Urban Heating Company (CPCU), a utility that is 33 per cent owned by the City of Paris, has developed district heating under a concession contract. The combination of city ownership and the use of a concession model has allowed Paris to maintain a high degree of control over district heating development, while also benefiting from the efficiency improvements and capital investment contributed by the private sector. The concession contract sets a maximum price for the heat delivered, indexed against the share of renewable heat generated. The City also can enforce a special low price for those in social housing. In addition to providing cheaper, more renewable heat, the CPCU provides Paris with an annual dividend of €2 million (US$2.6 million) and an annual concession fee of €7 million (US$9.1 million). The CPCU expects to achieve its 2020 target of 60 per cent renewable or recovered energy in the district heating network, which would lead to a net reduction in greenhouse gas emissions of some 350,000 tons of CO_2-equivalent.

Incorporating national utilities into the business model – such as through full or partial ownership – is key to realizing the national benefits of district cooling. In Dubai, where air conditioning represents over 70 per cent of electricity consumption, the city aims to meet 40 per cent of its cooling needs through district cooling by 2030, using 50 per cent less electricity than standard air conditioning. By integrating the publicly owned electricity utility into the business model, Dubai's district cooling is being developed with full recognition of the national benefits.

NATIONAL-LEVEL SUPPORT FOR DISTRICT ENERGY CAN SIGNIFICANTLY STRENGTHEN INITIATIVES AT THE SUBNATIONAL OR LOCAL LEVEL

Although many of the specific decisions and measures associated with a district energy system must be made at a local level, national policies are key to achieving optimal results. Based on the 45 champion cities, the four national policies with the greatest impact are: incentives for CHP and renewables, national regulation on tariffs, incorporation of district energy into building efficiency standards and labels, and tax regimes, alongside clear planning guidance and regulations that provide local governments with a mandate to act. For example, European Union legislation on energy efficiency requires that regional and local authorities develop plans for heating and cooling infrastructure that utilize all available renewable energy sources and CHP in their region. In Norway, the national licensing framework supports local implementation of district heat by requiring aspiring providers to develop detailed development plans that include evidence of the socio-economic and environmental benefits of district heating relative to other options.

The use of polluter taxes is a key best practice in Nordic countries such as Denmark, Finland and Sweden in achieving high levels of district energy. Taxes and other penalties also have played an important role in driving the modernization of district energy systems in China, where a national-level regulation empowers provincial authorities to fine cities for high levels of air pollutants. Anshan's investment in a transmission line to integrate the city's isolated boilers and to capture surplus waste heat is projected to have a payback period of only three years due to the avoided penalties on pollution and the reductions in coal purchase. Where taxes are not in place, national governments may offer grants and subsidies to indicate their support for district energy and to create a level playing field. Rotterdam, for example, secured a €27 million (US$33.8 million) grant from the Dutch government to reflect the equivalent avoided social costs of CO_2 and NO_X emissions.

To encourage effective policy integration and implementation between the national and local levels, cities are increasingly involved in the design and development of "vertically integrated" state and national policies. Climate finance through Vertically Integrated Nationally Appropriate Mitigation Actions (V-NAMAs) represents a promising means of promoting low-carbon district energy systems.

DECIDING NEXT STEPS TO ACCELERATE DISTRICT ENERGY

UNEP has developed a policy and investment road map comprising 10 key steps to accelerate the development, modernization and scale-up of district energy in cities. A decision tree, developed as an outcome of the *District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy* publication and of the exchanges with the 45 champion cities, will guide cities through these various stages and highlight tools and best practices that could be available to local governments in their roles as planner and regulator, facilitator, provider and consumer, coordinator and advocate. Twinning between cities – matching champion ones with learning ones – will be a key component of UNEP's new district energy initiative.

THE DECISION TREE IS SPLIT INTO FOUR BROAD AREAS:

- **WHY?** Why district energy, what is the energy demand and what are the next-available technology costs for district energy deployment?
- **WHEN?** When should district energy be developed, and what are the catalysts that take district energy from vision to reality?
- **WHAT?** What steps need to be taken to begin development of a district energy strategy in the city?
- **HOW?** How can the city foster and develop district energy? How can incentives, policy frameworks, business models and tariff structures best serve district energy in the city?

photo: GIZ, Zeller

Multi-stakeholder discussion on V-NAMAs in Durban, South Africa.

"It is an honor for Sonderborg, with our ProjectZero transition project, to be featured as a district heating champion city in the UNEP publication. Green district heating is the backbone for our ZEROcarbon goal, and we are grateful to inspire other cities. This publication is a great tool for every city that wants to meet ambitious carbon targets, and they are all welcome to visit Sonderborg – as seeing is believing."

Mayor of Sonderborg, Mr. Erik Lauritzen

INSIGHT INTO TARIFF REGULATION

An extract from section 4 of ***District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy***

Tariff regulation is an important aspect of district energy that can ensure consumer protection in a naturally monopolistic market. Tariff regulation is particularly important in ensuring consumer protection if mandatory connection policies are enacted. Tariffs can be regulated in numerous ways: some are regulated so that district energy is priced at the alternative technology costs, and some are effectively indirectly regulated by controlling the profits of district energy companies or the costs that they can pass on to consumers. Often, where connection is voluntary, countries will rely on competition from other sources of heat or cooling to ensure fair prices.

Furthermore, tariffs can be applied at the same rate to groups of consumers (e.g., all residential customers pay the same tariff), or costs can be levied at specific customers, relating to the cost of network expansion to connect them. Levying specific costs at individual consumers can be important to insulate uninvolved consumers from costs, in order to serve a particular geographical region or consumer type; however, it could leave individual consumers with unfairly high heat tariffs.

TARIFF REGULATED AT ALTERNATIVE TECHNOLOGY COST. Some countries control tariffs through national policies requiring that heat or cooling be priced at the cost of the next-alternative technology. The main benefit is that consumers will always get a better deal than if the district energy network were not there. For mandatory connection policies, this is important, as consumers may not have a choice in whether they connect. However, this pricing model will not necessarily mean cheaper and less-volatile prices for consumers, often a key benefit of district energy. Countries where the next-alternative technology (such as domestic gas boilers) has high or volatile prices may consider a tariff regulated at the next-alternative cost to not be passing on the significant benefits of district energy.

Furthermore, district energy operators may not be able to pass on costs, which could mean unviable business models.

One potential issue with such regulation is that it does not necessarily require district energy companies to innovate and reduce costs, particularly if the fuel for the next-available technology is the same fuel used for district energy. For example, pricing district heating against the residential gas price may mean that the business model for district energy makes the most sense if it is mostly gas CHP producing the heat. Or, pricing district cooling against the residential electricity price may mean that electric chillers make the most sense, potentially ruling out other, lower-carbon technologies, such as absorption chillers. Such issues will be very country dependent, and each country must weigh the benefits of a regulated price based on alternative technologies against the negatives of such a price structure.

In Norway, tariffs for district energy are regulated to be below the next-available technology, which is electric heating. In return for such regulation, district energy companies are given a monopoly over a licence area, which helps to ensure that costs are low enough for the regulated tariff. In Singapore, under the 2011 District Cooling Act, all commercial buildings in the Marina Bay district cooling zone are mandated to connect, and tariff controls prevent tariffs from exceeding the equivalent costs of chilled water produced by building-scale plants. The district cooling operator in Singapore is allowed to earn a baseline return based on its invested assets; however, once start-up losses have been recovered and the system achieves a critical mass of load for economic efficient operation, any financial gain above the baseline return must be shared equally between the operator and its customers. Therefore, customers are assured of long-term savings, while the start-up demand risks associated with a greenfield project are mitigated. Yerevan, Armenia, is successfully attracting consumers back to district heating by implementing multi-tariff structures that are priced to be similar to individual natural gas boilers and that also encourage energy conservation by having a significant variable charge.

TARIFF REGULATED INDIRECTLY THROUGH CAPPED PROFITS AND PASS-THROUGH COSTS. One benefit of this model of tariff regulation is that, when district energy is cheaper than the alternative technology cost, customers experience savings in energy expenditure. However, if in certain years district energy is more expensive (for example, due to falling gas prices), the consumer could potentially pay more than the next-alternative technology.

In Denmark, the national government determines which costs can be recovered in district heating prices, and these can then be levied on consumers. If a consumer is singularly responsible for a cost, such as the cost to connect a new home, the district heating company must ensure that this consumer pays the fixed cost. Although this is perhaps a fair model for connection, it can increase the proportion of fixed costs versus variable costs in the tariff, which can reduce the incentive for energy conservation. National oversight ensures that district heating companies charge fair tariffs and do not pass on costs that should not be incurred by the consumer. Furthermore, consumers are able to evaluate their tariff against other tariffs nationally, as district heating companies must publicly report the breakdown of fixed and variable costs each year.

The tariff regulation of passing costs on to consumers (as opposed to setting the price at the next-available technology cost) has meant that consumers in Denmark have enjoyed low prices for heat relative to other technologies, with 94.4 per cent of the heat sold by Danish district heating companies being cheaper to customers than an alternative individual heating solution. Denmark also has profit controls on district heating companies, capping the profits that they can make and requiring excess profits to be used to reduce heat tariffs. Japan has taken a similar approach to heat pricing, where the Heat Supply Business Act fixes the tariff to include all initial costs, and the price is approved by the national government, leading to inflexible pricing.

In the Canadian province of British Columbia, district energy utilities are regulated by the British Columbia Utilities Commission, which enforces a capital structure and allowable return on equity, essentially limiting the profits of the utilities. This translates explicitly to the charging of an allowable average tariff. In Vancouver, public ownership also means that the tariff structure is extremely transparent, further encouraging connections.

- **TARIFF NOT REGULATED.** In the absence of regulatory authority from the national level, local authorities can still influence tariffs through active participation in and ownership of district energy in their cities. This could be through concessions given out with requirements on tariff levels, or public ownership reducing costs and eliminating profits to reduce tariffs. For some markets, competition between heat sources will be deemed sufficient to keep prices low. However, consumers will need to be protected due to the effect of long-term contracts, which could be five years. After all, district energy could be set slightly cheaper than individual heating/cooling solutions, but consumers will never own the connection to their property, whereas they would own, and have paid for, a boiler or air conditioner after 10 years, and such ownership should be accounted for in pricing formulas. Industry standards of contracts to consumers should be developed, as well as services that can advise consumers on the best heating option.

The *District Heating Manual for London* recommends setting district heating prices against the cost of the next-alternative technology, which in the U.K. is normally natural gas boilers (the manual recommends the same for district cooling prices). Such tariffs are unlikely to be regulated heavily in the future, and individual district heating companies could use varying tariff structures. Such a model is likely to work well, particularly because mandatory connection is unlikely in London and because district heat networks will be developed, with many heat sources being from gas CHP. As London decarbonizes heat further in the future, different pricing structures are likely to emerge, particularly if district heat costs diverge from gas prices.

For countries where energy is subsidized at the consumer level (for example, for electricity or natural gas), such subsidies should be considered by the relevant authority and also be allowed to pass through district energy prices. For example, in a country with district cooling, if electricity prices to residential customers are subsidized to be flat throughout the day and low, then 1) such low prices should be allowed to pass through district cooling prices to keep district cooling competitive, and 2) flat-priced electricity tariffs should be passed to the district cooling operators, or subsidies somehow should be redirected to storage at the district cooling level, stimulating more-efficient and timely electricity use.

THE DISTRICT ENERGY IN CITIES INITIATIVE IN SE4ALL

To facilitate the transition to district energy systems, UNEP and a group of partners have launched a new initiative on District Energy in Cities, as the implementing mechanism for the Sustainable Energy for All (SE4ALL) District Energy accelerator (see figure).

The UNEP publication, ***District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy***, prepared in collaboration with the Copenhagen Centre on Energy Efficiency (C2E2), ICLEI – Local Governments for Sustainability and UN-Habitat, is the first of a series of guidance documents and tools within the new District Energy in Cities Initiative.

The publication offers an in-depth review of 45 cities around the world, providing a platform for further global expansion of district energy approaches across cities worldwide. It will serve as guidance for accelerated implementation and expansion of district energy systems through a "cities-for-cities" thematic twinning process.

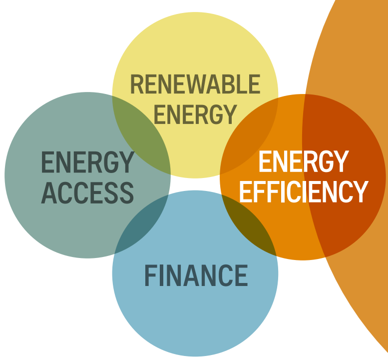
The publication highlights why and how cities are deploying district energy systems, including by demonstrating key policy best practices, new business models and emerging innovations.

SUSTAINABLE ENERGY FOR ALL

SE4ALL is a global multi-stakeholder partnership, led by the UN Secretary-General and the President of the World Bank, which has three interlinked objectives for 2030:

- Ensure universal access to modern energy services
- Double the global rate of improvement in energy efficiency
- Double the share of renewable energy in the global energy mix

Sustainable Energy for All (SE4ALL) Sub-Committees



CO-CHAIRS:

- UNEP Executive Director
- CEO Accenture
- Minister for Trade and Development Cooperation, Denmark

Global Energy Efficiency Accelerator Platform: to scale up efficiency gains and investments at the national, subnational and city levels through technical assistance, support and public-private sector collaboration. Individual accelerators focus on specific energy efficiency sectors:

- Buildings
- Transport
- DISTRICT ENERGY
- Lighting
- Appliances & Equipment

DISTRICT ENERGY IN CITIES

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"District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy *highlights key technology options available to communities to provide heating and cooling services in a cost-effective manner and with low environmental impacts. The findings of this report should be studied carefully by all policymakers and private developers who are endeavouring to achieve a more sustainable future."*

Ralph Sims, Professor at Massey University, New Zealand and member of the Scientific and Technical Advisory Panel of the Global Environment Facility

"District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy *provides a critical set of information to cities as they develop action plans to meet sustainability, energy and climate goals. By providing thoughtful analysis of both key barriers and successful best practices, this handbook helps decision makers quickly identify important issues and successful tactics from peer cities as they move forward with district energy."*

Katrina Pielli, Senior Policy Advisor, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy

"District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy *is a timely, comprehensive and useful knowledge tool. This publication provides a pragmatic, high-level analysis of major issues – including technological solutions, costs, business models, and the roles and capacities of the public and private sectors – and offers the way forward. It includes an extremely useful set of nearly 40 specific, practical examples of best practices from around the world. Overall, the District Energy in Cities initiative offers a great platform for cooperation among cities, the private sector and multilateral development institutions."*

Alexander Sharabaroff, Operations Officer (Energy), International Finance Corporation

"With the publication of District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy, *UNEP has made a hugely valuable contribution to the climate and energy debate. Not only does it rightly identify the specific challenge of supplying low-carbon heat to the urban environment as a necessary element of the general energy transition, it provides highly practical advice and analysis for policymakers on how this can be achieved. An elegant demonstration of the value of thinking globally while acting locally, UNEP's effort to drive the emergence of district energy as a solution for cities is the right initiative at the right moment!"*

Paul Voss, Managing Director, Euroheat & Power

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