Section 2:

A FRAMEWORK FOR CITY-LEVEL POLICIES AND STRATEGIES FOR DISTRICT ENERGY

Tokyo is maximizing efficiency in its district energy systems through the use of waste incineration, waste heat from buildings and metro stations, heat pumps connected to local water sources and solar thermal. Land-use planning policies require developers of new areas to assess the opportunities for cost-effective modern district energy or to identify a cheaper next-available sustainable heat or cooling option.
KEY FINDINGS

- **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.

- **OF THE 45 CHAMPION CITIES** for district energy, 43 are using their ability to influence planning policy and local regulations to promote and accelerate district energy deployment. Over half of the cities started with broad energy targets (e.g., energy efficiency, renewable energy, greenhouse gas emissions, etc.), which led to district energy-specific targets.

- **WHEN LOCAL GOVERNMENTS** do not have regulatory powers in the energy sector, a stake in a local utility, or the resources to undertake feasibility studies, they can incorporate energy supply or efficiency requirements into planning and land-use policies, as has been done in Amsterdam, London, Seoul and Tokyo.

- **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 systems, and to apply tailored policies or financial incentives. Of the 45 champion cities, 55 per cent used spatial heat maps to bring together stakeholders for business development and to share opportunities, inform policy and optimize network design.

- **ACROSS THE 45 CHAMPION CITIES**, local governments were ranked as the “most important” actor in catalyzing investment in district energy systems. Several cities — including Dubai, Munich, Tokyo, Paris, and Warsaw — attracted more than US$150 million of investment in their respective district energy systems between 2009 and 2014.

- **ALMOST ALL 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. To reduce risk and project cost, smaller systems can be interconnected over time, as has occurred in Copenhagen and Dubai.

- **FINANCIAL AND FISCAL INCENTIVES** 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 champion cities use demonstration projects to raise awareness and technical understanding of district energy applications, and to showcase their commercial viability.

- **OPTIMIZING DISTRICT ENERGY SYSTEMS** to ensure efficient resource use and to realize the 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 other utilities (water, waste management, transport) and incorporating these synergies into a mutually beneficial business case.

- **MANY CITIES** are looking to integrate publicly or privately owned waste heat through heat tariffs that reflect the cost of connection and the ability to guarantee supply. This is similar to the development of feed-in tariffs for renewable power.

- **ADDITIONAL BEST PRACTICES INCLUDE**: CHP access to the retail electricity market; net metering policies and incentives for feed-in of distributed generation; customer protection policies, including tariff regulation; technical standards to integrate multiple networks; and cooperation with neighbouring municipalities for joint development or use of networks.

- **INTEGRATING ENERGY INTO URBAN PLANNING** leads to the most efficient use of energy and to the optimization of local resources by encouraging mixed-use zoning and compact land use — two of the most important planning tools for encouraging district energy and reducing carbon emissions.
Local governments worldwide are using a wide range of policies and activities to promote district energy, demonstrating the significant and diverse roles that cities can play in deploying such systems. These policies and activities can be grouped into four main categories, reflecting the varying roles of local governments as 1) planner and regulator, 2) facilitator, 3) provider and consumer and 4) coordinator and advocate, as described in sections 2.2 to 2.5.

The involvement of local government is important to ensure that district energy serves broader policy objectives, including energy security, economic development, community acceptability and higher environmental performance (e.g., low greenhouse gas emissions, good local air quality). Many successful private district energy systems have included some degree of local government involvement, whether in the form of passive policy frameworks or franchise agreements; more-proactive vision, regulation and in-kind support; financial involvement such as grants, tax considerations or partial investment; or other support such as coordination of diverse stakeholder interests, awareness-building, public education and capacity-building.

Heizkraftwerk West CHP plant in Frankfurt, Germany.
2.2 LOCAL GOVERNMENT AS PLANNER AND REGULATOR

Local governments can effectively catalyze district energy deployment first and foremost in their role as planner and regulator. Local governments have an integral role in planning community-based energy solutions that can help meet specific targets and objectives. By adapting the local regulatory framework, governments can encourage the development of district energy through vision and target setting, integrated energy planning and mapping, policies that encourage connection, and waste-to-energy mandates. Table 2.1 summarizes the policy activities that local governments are undertaking in their role as planner and regulator.

2.2.1 ENERGY POLICY OBJECTIVES, STRATEGY AND TARGETS

"The role of target setting cannot be under-estimated. Next to the clear guidance for investors, an official target for renewable energy in a certain region can also help in overcoming conflicting interests of different departments – from environment, transport, economy, buildings, etc."

Stefan Schurig, World Future Council, 2014

<table>
<thead>
<tr>
<th>POLICY INTERVENTION AREA</th>
<th>DESCRIPTION OF POLICY ACTIVITY</th>
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| ENERGY POLICY OBJECTIVES, STRATEGY AND TARGETS (section 2.2.1) | - Energy strategy linking the benefits of district energy and broad policy targets, such as targets related to CO₂ and greenhouse gas emissions, energy intensity, fossil fuel consumption, energy efficiency and renewable energy
- District energy-related target or goals, whether for the future share of district heat/cooling/power, the share of district energy in specific buildings (e.g., public buildings) or the share or absolute numbers of buildings connected
|
| ENERGY MAPPING AND HOLISTIC ENERGY PLANNING (sections 2.2.2 and 2.2.3) | - Energy mapping, such as of a city’s local heat or cooling demand, in order to understand energy use, infrastructure, emissions and available resources
- Holistic energy planning that integrates district energy into land-use and infrastructure planning, provides guidelines for urban development plans to contain the energy vision, and requires energy assessments for new developments
|
| CONNECTION POLICIES (section 2.2.4) | - Connection policies that encourage connection where it is economically and technically feasible and minimizes load risk
- Zoning bylaws that allow, encourage or require district energy developments
|

Source: Adapted from Martinot, 2011, and Sims, 2009
DEVELOPING AN ENERGY STRATEGY: To develop an energy strategy, a city needs to undertake a holistic study of municipal energy use and needs, from which it can identify goals and pathways for realizing specific socio-economic benefits, both now and into the future. A key requirement of such a study is a local heat and cooling assessment that identifies potential energy technology pathways that can be pursued to achieve city goals.

In many cases, customers and political decision makers may underestimate or simply not know the energy demand for cooling from air conditioning and electric chillers, as these data may be hidden in a building’s total electricity bill and the cooling energy delivered is not measured (Persson et al., 2012). This leads policymakers to underestimate the potential role of cooling in achieving objectives such as energy access, affordability or reliability, and to overlook the need to regulate, research or support it. Additionally, because chiller plants in individual buildings often have 50–70 per cent more installed capacity than is required, this can result in overestimation of demand and potential overstating of cooling revenue.

A heat and cooling assessment is key to understanding this demand, and can provide important data that can aid in strategy development at both the city and national levels (see section 4.1). For cities in hot climates, understanding local electricity consumption for cooling can enable governments to address issues of electricity demand locally rather than having to rely exclusively on improvement and development of the national electricity network. For cities in cool climates that have high heat demand, understanding the relative benefits of district heating versus energy efficiency measures in buildings can lead to greater impact or alleviate cost barriers. Retrofitting old or historical buildings to a passive-house standard can be expensive and may lead to efficiency improvements that could have been achieved more cheaply with a district energy connection, or that could be addressed with new financing tools through a combined approach with a district energy utility (see section 1.3.3, figure 1.5 and the case study online detailing Seattle’s energy efficiency ESCO model).

For many cities, a technology pathway that includes district energy will be the cheapest solution with the highest impact. As such, district energy can become a key component of a city’s energy strategy, as seen across the 45 champion cities. An important means of articulating the role of district energy in relation to energy consumption and its impact on wider policy objectives is through development of a district energy goal or target.

* Note that a heat and cooling assessment is different from energy mapping, which combines the assessment data with a GIS exercise/spatial mapping of heating/cooling resources and nodes of consumption.

Air-conditioning units on a house in Singapore, 2013.
DEVELOPING A TARGET OR GOAL FOR DISTRICT ENERGY: Cities should develop their targets and goals for district energy alongside the tangible benefits and objectives to be achieved, which they can use to measure their actions and progress. Once these goals have been identified, they can then be followed by elaboration of specific policies and activities (see section 2.2.3).

Most cities that are active in district energy started with broader targets, such as targets for CO₂ and greenhouse gas emissions, energy intensity, fossil fuel consumption, energy efficiency (either for the city overall or for individual sectors, such as buildings) and renewable energy (see table 2.2). Over time and with learning, these broad targets can then lead to targets that are specific to district energy. An early demonstration project can provide concrete data and experience and ultimately legitimize a city-wide energy plan focused on scaling up district energy (see case studies 3.1 on Vancouver and 3.12 on Port Louis). Nearly all of the 45 local governments surveyed have established some type of district energy goal, and the majority have developed a district energy-specific target that typically extends to the 2020–50 period and is based on a broader target (see figure 2.1).

France’s targets of, by 2020, 20 per cent renewable energy, 20 per cent energy efficiency improvement and 20 per cent reduction in CO₂ emissions (from a 2008 base) provided the incentive for Brest to develop a district heating system with a high share of renewables. These renewables provide cheaper heat than gas boilers and have benefited the city through a national grant and tax reductions on district heating.

DISTRICT ENERGY TARGETS MOST OFTEN ARE SEEN IN CONSOLIDATED OR REFURBISHMENT CITIES AND CAN INCLUDE THE FOLLOWING: (see table 2.2 for more detailed examples)

- **Expansion of the district energy system** by the total amount of homes (or unit equivalent) connected to the system, or by development type (e.g., Anshan, Helsinki)
- **Target to interconnect segregated district energy networks** through transmission pipes (e.g., Frankfurt, Anshan)
- **Share of total greenhouse gas reduction target** to be met by district energy (e.g., Vancouver)
- **Share of electricity/heating/cooling capacity or consumption** provided by district energy systems (e.g., Dubai, Helsinki)
- **Share of local government’s energy usage** from buildings or operations that should come from district energy systems (e.g., Amsterdam)
- **Share of renewable or waste heat to be used** in a district energy system (e.g., Paris, Copenhagen)
- **Per cent increase in energy performance of buildings** due to district energy (e.g., Hong Kong)
- **Sector targets** for waste management or waste heat recovery (e.g., Bergen)
- **Targets for replacing existing building heating or cooling systems** (e.g., Copenhagen, Łódź)

Łódź, Poland has a vast district heating network, which in 2011 supplied approximately 60 per cent of the city’s heating demand (top).

A portion of Milan’s district heating network, connected to the Canavese CHP plant. Milan’s segregated networks are undergoing interconnection and expansion to form three large heat networks by 2016, which will then be interconnected via a ring around the city.
Amsterdam thus has a total of 390,000 + (8 million m²/100) = 470,000 REU.  

A residential equivalent unit (REU) is used to compare the heating consumption of homes and apartments to that of commercial or industrial buildings (offices and corporate buildings). One REU is equivalent to a single home or apartment, or 100 m² of commercial or industrial floor space.

** For more on local renewable energy targets, see the local policies section of REN21, 2014.

### TABLE 2.2

<table>
<thead>
<tr>
<th>CITY</th>
<th>CO₂ EMISSIONS REDUCTION TARGET</th>
<th>RENEWABLE ENERGY AND/OR ENERGY EFFICIENCY TARGET</th>
<th>DISTRICT ENERGY-RELATED GOALS</th>
<th>FEATURES</th>
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| AMSTERDAM   | 40% by 2025; 75% by 2040 (from 1990 base) | All new building development climate-neutral by 2015  
25% of power demand met locally by 2025  
50% of power demand met locally by 2040 | 100,000 residential equivalent unit** connections by 2020 (up from 55,000 today); 200,000 by 2040  
Fuel switch from electricity and gas in heating and cooling to higher use of waste heat  
Target to interconnect multiple systems using a ring transmission network | The city’s 90% ownership of land city-wide is being used to encourage district energy development  
Looking to capture waste heat from data centres  
Multi-stakeholder partnerships for planning and implementation |
| BERGEN      | 50% by 2030 (from 1991 base) | 95% renewable energy supply  
Replace oil-based heating (14% of greenhouse gas emissions) | Use district heating in all new buildings and major renovations within the concession area for district heating  
Waste incinerators must utilize 80% of energy (higher than national target of 50%) | Network developed based on waste incinerator energy efficiency target |
| COPENHAGEN | 20% by 2015 (from 2005 base)  
Carbon-neutral by 2025 | By 2025: 100% renewable energy supply, 20% reduction in heat demand, 20% reduction in power consumption in commercial/service companies | By 2025, 100% share of renewable energy and waste incineration heat in the district heating system (up from 35% today)  
By 2016, ban oil-fired installations in existing buildings where district heating (or gas) is available | Carbon-neutral target  
District heating systems/CHP as cornerstone of energy policy to integrate renewables  
District heating currently meets 98% of city’s heat demand |
| DUBAI       | 20% reduction from buildings by 2030 | 30% reduction in energy demand by 2030  
5% renewable electricity by 2030 | Meet 40% of cooling capacity through district cooling (up from 20% in 2011) by 2030  
Use district cooling in all new developments by 2030  
Incorporate thermal energy storage into all new district cooling plants, representing at least 20% of the design capacity of the plant by 2030 | Use of treated sewage effluent water instead of fresh water  
Reduced investment in power infrastructure |
| FRANKFURT   | 50% by 2020  
95% by 2050 (from 1990 base) | 100% renewable energy supply by 2050, while reducing demand | Connect waste heat from incinerator and industry; interconnect three district heat grids into a closed-loop system; integrate renewable energy such as biomass and biogas in CHP | 100% renewable energy target  
Fuel switching using biomass, biogas and synthetic methane |
| HELSINKI    | 30% by 2020 (from 1990 base)  
Carbon-neutral by 2050 | 20% share of renewables in energy production in 2020 (up from 7% in 2013) | By 2015, cooling capacity of over 200 MW  
By 2020, expand cooling to new residential areas | Captures heat from district cooling return water, for zero-waste  
Tri-generation  
Utility-set target |
| HONG KONG   | Reduce carbon intensity 50–60% by 2020 (from 2005 base) | By 2020, reduce coal to less than 10% of the electricity generation mix  
By 2030, phase out existing coal and reduce energy intensity by at least 25% (from 2005 base) | Expand use of district cooling so that by 2020, up to 20% of commercial buildings will be up to 50% better in refrigeration performance compared with buildings using regular air conditioners | Reduced consumption of coal and power for cooling |

* For more on local renewable energy targets, see the local policies section of REN21, 2014.

** A residential equivalent unit (REU) is used to compare the heating consumption of homes and apartments to that of commercial or industrial buildings (offices and corporate buildings). One REU is equivalent to a single home or apartment, or 100 m² of commercial or industrial floor space. Amsterdam thus has a total of 390,000 + (8 million m²/100) = 470,000 REU.
To identify opportunities for targeting resources and policies to meet district energy goals, municipalities often need more detailed information on the current and future geographical distribution of energy use at the neighbourhood and building levels, as well as on local heat and energy assets and distribution structures. This can be achieved through an energy mapping process that analyses the local conditions, such as sources of excess heat, renewable heat assets (geothermal and solar), and concentrations of heat or cooling demand – often using GIS-based spatial information (Connolly et al., 2013; Persson et al., 2012). Further data and layers of analysis can be added over time, depending on the policy objectives and goals.

Energy maps for district energy can contain, among other variables, data on:

- Existing and projected energy consumption by sector, fuel source or neighbourhood; the resulting emissions and pollution; and an understanding of the load profile
- Present and future building density and use type (residential, commercial, etc.)
- Sources of surplus or industrial heat supply
- Large energy consumers and buildings with potential excess heating or cooling capacity (e.g., buildings for events such as a stadium or arena)
- Current networks and potential network routes (see figure 2.3)
- Potential anchor loads and their energy consumption (see figure 2.4)
- Barriers and opportunities particular to the location related to local energy sources, distribution, transport, land use, development density and character
- Socio-economic indicators to identify fuel-poor areas that could benefit.

Energy mapping can help cities identify specific district energy projects that could be developed, how they can best be expanded and connected in the future, and how this expansion ties into other infrastructure development. Energy maps also can identify how a city can best apply its land-use authority (see section 2.2.3) to encourage district energy and to develop tailored incentives in different zones to reduce load risk (see section 2.2.4).

In addition, cities can use mapping to facilitate stakeholder engagement. Amsterdam, for example, uses mapping as a tool to build public-private partnerships, which helps the city share the task of data collection, scenario analysis and the development of new business models (see case study 2.1). Energy mapping also helps raise public awareness by creating an effective visualization tool for communication (Persson et al., 2012; Connolly et al., 2013).

For some cities, a city-wide energy mapping exercise may not be initially realistic due to financial and other constraints. The idea of energy mapping is that the tool is constantly evolving. As such, a city could identify high-potential areas in the energy strategy and focus on a detailed mapping exercise of these areas (e.g., the Central Business District (CBD), airports, social housing, large retail areas). Obvious anchor loads and heat/cooling sources near these areas should still be accounted for.

"A combination of energy modelling and mapping of the local conditions using a high geographical resolution is crucial for district heating analysis, since the potential for expansion is dependent on local heat resources and demands." 

*Heat Roadmap Europe 2050, 2012*
To create incentives for district energy projects, the City of Amsterdam is focusing on tools that facilitate the involvement of both end-users and private sector stakeholders in developing urban energy plans. According to the city, scaling up district energy is about finding the right combinations of stakeholders to create new, scalable business models, with potential clients being part of the development. The city, housing authorities or energy companies also need to encourage buy-in from residents and tenants, as these end-users are regularly involved in the decision to switch from natural gas to district heating. In Amsterdam, 70 per cent of occupants must agree to this changeover, which can represent an obstacle for the expansion of a district energy system.

The City of Amsterdam has developed an Energy Atlas to inform the local energy strategy, implement the right combination of measures and technologies, and build the business case for supplying district energy to households and companies. The city collects the data and presents it via the city website, using an "open data" philosophy that enables full access to the information collected. In a second step, the data is analysed together with the different stakeholders to identify opportunity areas or zones for district heating, cooling and power. The aim is to develop "what if" scenarios for adding or changing infrastructure such as transformers or data centres, or retrofitting the existing building stock, and to optimize urban plans for energy efficiency.

Amsterdam produced its Energy Atlas in collaboration with local stakeholders, including businesses and property owners, to ensure a bottom-up process. Currently, the interactive atlas shows:

- thermal and electricity production and consumption data in each district
- existing and proposed sustainable energy projects
- opportunities to connect to existing sources or networks
- data on building stock (size, construction date, density) in areas
- social indicators such as ownership of property, disposable incomes and consumption patterns, willingness to invest or launch initiatives, and modes of transport
- potential for energy saving and local/renewable energy generation
- an opportunity map for storage of heat and cooling in the city centre.

Amsterdam has used the Energy Atlas to provide a decision-support tool for planning; to generate enthusiasm for district energy (and other) projects; and to "create space" and provide matchmaking services by bringing together different stakeholders interested in business case development. Using the Energy Atlas has enabled the city to transform Zuidoost, an existing 300 hectare mixed-use area, and to establish cooperation among various industrial partners on the exchange of energy and the use of excess waste heat from data centres. The maps provided these stakeholders with insight into the thermal management in the area and allowed them to identify different functions that could contribute to heat demand. Their calculations produced a balanced business case for the use of excess heat in Zuidoost and resulted in a new area plan on the use of waste heat.

Mapping the energy flows and actively approaching potential partners would not have been possible without the use of current data visualization. Amsterdam aims to use the Energy Atlas to replicate this end-user-driven urban development model in Zuidoost in order to advance district energy opportunities in other communities.
Over half of the cities surveyed had started to embark on an energy or heat mapping exercise in connection with their urban energy plans. London, for example, has developed an extensive heat map as part of the London Development Authority’s Decentralised Energy Master Planning programme, a partnership with Arup, the Greater London Authority, London Councils, Capital Ambitions and leading city boroughs. The London Heat Map showcases potential heat supply, demand and network opportunities for district energy across the city (see figures 2.2 and 2.3). To act on these opportunities, each of London’s 29 boroughs has developed an implementation plan that includes barriers and possibilities, actions to be taken by the council, key dates and personnel responsible. As a result of this programme, London envisions leveraging £8 billion (US$12.9 billion) of investment in district energy by 2030 (see case study 4.1 for more on the commercialization phase of the programme).

Figure 2.2 shows London’s heat density in combination with current networks (yellow lines), current CHP plants (yellow diamonds) and potential networks (red lines). The existing network at the top of the image is the Olympic Park and Stratford City development project (discussed in detail in case study 3.8). Figure 2.3 highlights the city’s existing Westminster and Pimlico heat networks (yellow) and the proposed interconnection (red). The grey circles show potential central government anchor loads, and the red cross shows a potential anchor load of St. Thomas’s Hospital, which consumes 59 GWh of fuel per year (see section 3.2).
2.2.3 HOLISTIC ENERGY PLANS: INTEGRATING ENERGY IN INFRASTRUCTURE AND LAND-USE PLANNING

"You often have land-use folks saying let's put the buildings here, and transport planners saying how do we get people moving around – and then almost as an afterthought, folks say, well, how do we provide energy to the neighbourhood? In Vancouver, we pioneered the integration of these various issues into our community building and urban planning."

Sadhu Johnston, City of Vancouver, 2014

An energy plan is a road map of project developments and policy interventions to help a city realize the articulated goals of its energy strategy. Energy plans that aim to realize district energy-related goals must be developed in a holistic and integrated way, assessing and coordinating the various stakeholders necessary for implementation. To identify synergies and opportunities for cost-effective district energy, such plans need to analyse the impact of (and interaction between) energy, land use and infrastructure – including waste, water, buildings and transport (see case studies 2.2 on Bergen and St. Paul, and 2.3 on Tokyo). Mixed-use zoning and the encouragement of high energy density areas (through compact land use) is "strongly correlated with lower greenhouse gas emissions" by reducing transport and energy consumption (Seto et al., 2014). District energy relies on such mixed-use zoning and high energy density to be economical, as described in section 1.5. The importance of mixed-use zoning and compact urban form for district energy is discussed further below.

Synergies between energy, land use and infrastructure are vital to realizing the district energy developments or objectives defined in the energy plan. Collaboration with city-owned or private wastewater or transport utilities may help to reduce costs in project development and construction. Additionally, other utilities either may already be providing heat and cooling to the city (such as electricity or gas utilities) or could in the future (such as wastewater treatment and water purification utilities). To ensure the most cost-effective district energy system, these utilities and city departments need to integrate energy planning within all city developments (see section 2.4.1 for a discussion of a city’s role as provider of services and how this can benefit district energy).

Holistic energy planning also can allow a city to promote and/or designate areas or zones that have favourable conditions for district energy development or expansion, and to apply tailored policies or financial incentives on a case-by-case basis (see section 2.2.4 on connection policies). These zones can be selected based on the mapping exercise. Some cities designate franchise zones for district energy companies, effectively giving them exclusive license to operate in this zone. This zoning also can enable the local authority to negotiate or regulate end-user tariffs in exchange for the operator licence, thereby ensuring that district energy is the most cost-effective option for providing heat and cooling (see case study 4.2 on Norway). In addition to customer protection, this is particularly important to building owners who may be implicated by mandatory connections.
CASE STUDY 2.2

BERGEN and ST. PAUL

Bergen’s municipal master plan, which closely links energy, urban development and transport, has made it easier to identify expansion pathways for the city’s district energy network. For example, the city has identified a new light-rail project – which encourages compact urban design in developments along its route as an area for a district heat network. Developing this network along the light-rail corridor will minimize disruption and direct network expansion towards the high-growth, dense areas that the light rail is encouraging.

A group of companies and agencies named the Digging Club – whose members include the district heating network owner, water and sewage departments, waste management company and local electricity distribution operator – is coordinating Bergen’s district energy planning efforts, in order to reduce the inconvenience for residents, businesses and road users when improving infrastructure works.

St. Paul, through integrated energy planning, similarly used the construction of a light-rail line to extend the city’s district energy infrastructure several kilometres to a major industrial customer.

Combining the development of infrastructure with district energy development can lead to significant cost savings. At least 60 per cent of the network costs of district energy (i.e., excluding heat/cool production) is from the installation costs of pipes, as roads need to be dug up to install the infrastructure, causing costly disruption and the need to replace parts of the road surface. If such disruption and earthworks could occur at the same time as other infrastructure, costs can be reduced dramatically (Swedish District Heating Agency, 2007).

To encourage district energy, the energy plan can use policy interventions and adapt the planning framework to improve the business case of district heating or cooling. Such interventions can include:

- encouraging mixed-use zoning (see box 2.1)
- planning for compact land use in new developments (e.g., Frankfurt)
- requiring water-based heating or cooling systems in new developments (e.g., Dubai)
- developing local energy plans for new developments (e.g., Tokyo)
- using energy criteria in planning documents (e.g., London)
- identifying future sites for energy infrastructure to meet anticipated growth
- allocating franchise licences to give district energy operators exclusive delivery in set areas (e.g., Vancouver, Oslo; see also case study 4.2 on Norway)
- considering district energy in new infrastructure, waste management or public works (hospitals, leisure centres, etc.) projects (e.g., Hong Kong)
- establishing connection policies (see section 2.2.4)

Successful integrated planning requires collaboration among the diverse local government organizations that are affected by land-use planning – such as energy, waste, buildings, transport, etc. (see the discussion of coordination committees in section 2.5). Most of the 45 champion cities have established an administrative structure to coordinate these various bodies, for example through an interdepartmental committee, multi-stakeholder partnership or designated agency. Early collaboration helps to ensure that the energy plan is incorporated effectively into other planning documents and reduces the risks that can arise from permitting, rights of way, and lack of public awareness and support.

Denmark provides leading examples of the benefits of integrated heat planning. The presence of stable, integrated plans for heating has reduced the real and perceived risks to customers, heat suppliers, local authorities and owners of district energy systems – helping to develop long-term confidence in these systems. As a result, Denmark’s 400 district heating companies enjoy an average connection rate of 82 per cent (Chittum and Østergaard, 2014).
District energy systems are most viable in high-density and mixed-use areas. This can be at any scale of development, from villages and small towns to large urban neighbourhoods or entire cities. In mixed-use areas, many types of energy consumers (commercial, residential, public buildings) are located in close proximity. When connected via a district energy network, areas that are zoned as mixed-use create smoother and less-profiled energy demand than if the buildings are zoned separately (see figure 2.4).

Targeting areas that have mixed use is important for district energy system development. Mixed-use zoning has huge potential for greenhouse gas emission reduction in cities (Seto et al., 2014), and encouragement of mixed-use zoning is one of the most important planning tools that local governments have for emissions reduction. The significant benefits that mixed-use zoning has on the economics of district energy should make this planning tool even more of a priority to local authorities.

Having a smoother, less-profiled energy demand lowers the unit costs related to district energy infrastructure per square metre of building. A smoother profile reduces the need for less-desirable generation capacity, such as boilers and chillers, and allows for maximization of more-profitable and efficient capacity, such as CHP (which runs best as baseload power, enabling it to recover its capital costs faster). With fossil fuel heat generation, a smoother load is more efficient because plants do not need to start up and shut down (i.e., cycle) as frequently.

The establishment of anchor loads (hospitals, data or leisure centres, hotels, government buildings, etc.) in a certain zone is extremely useful, as these can help to secure the initial build-up of a district energy system and are often controlled by public authorities who would be encouraging such build-up. Anchor loads generally have high energy demands that are not as profiled as other users.

For district energy development, compact land use is just as important as mixed-use zoning because the closer together that buildings (and hence energy demand) are, the less pipe is needed to connect them, greatly decreasing costs and losses (King and Parks, 2012).

Figure 1.10 demonstrates the range of network costs that can occur as linear cool density increases: a 278 GWh cooling demand spread over a 100 km network (linear cool density: 10 GJ/metre/year) has network costs over two times greater than a similar demand across 33 km of network (linear cool density: 30 GJ/metre/year). Such a difference can determine whether district energy is competitive with decentralized, carbon-intensive technologies such as domestic air conditioning. To maximize the potential of district energy, city planners must consider the benefits of compact land use on district energy potential, which in turn will enable dramatic reductions in carbon emissions.

*FIGURE 2.4* Energy demand profile in a mixed-use neighbourhood

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Source: Data contribution from Dalkia
2.2.4 CONNECTION POLICIES

Because district energy projects require significant investment of capital prior to connecting customer buildings, one of the greatest risks in system deployment is load uncertainty. To aggregate, provide or guarantee a certain level of demand, local governments are promoting a variety of connection policies, with the aim of creating a minimum level of absolute load certainty through the use of anchor loads and consumer variety. Once load connection is made, additional risks may include customer retention (which can be managed by providing cost-competitive and reliable energy services) and ensuring that customers are actually using the district energy.

In theory, connecting existing buildings would be a good starting point for a district energy network because these structures have known heating/cooling load levels that are likely to continue, making them lower risk. However, it can be difficult for local governments to influence existing buildings, because often the only leverage that governments have is through planning control, meaning that there is no guarantee that existing buildings would connect to the network. In addition, connecting existing buildings can be more difficult if they are in a difficult area to develop.

As such, existing development is often not the best starting point for new district energy systems. Rather, new construction developments can act as a catalyst to establish a new network, which can then be extended to existing development. Alternatively, initial load certainty can be obtained by connecting large commercial buildings and local government assets (such as hospitals, social housing, etc.; see section 2.4.3). Large buildings with intermittent heating and cooling loads, such as arenas, convention centres or stadiums, can be effective anchor loads and sources of capacity.

Local governments’ connection policies can include: mandatory connection, land-lease models, density bonuses, credit towards green building requirements, and removing barriers to voluntary connection. These are described as follows.

CITY-WIDE MANDATORY CONNECTION POLICIES are often used to enforce connection to district energy schemes. These policies typically target new developments but can also target commercial and public buildings. To ensure that end-users who are mandated to connect are not disadvantaged, profits to district energy companies are capped (as in Copenhagen), or tariffs are regulated to be lower than those for similar technologies (as in Singapore and Oslo), or both (as in Rotterdam). Cities can enforce mandatory connections in their capacity as an urban planner (if regulation allows) or, if they are large landowners, in their ability to lease land with conditions (land-lease model).

In Dubai, all public sector buildings and all new developments are required to connect to the district cooling system. In Oslo, all public buildings where possible must connect to the district heating network. In Łódź, a new building permit mandates that all new building developments connect to the district heating network. Not all cities are able to utilize a mandatory connection policy for all buildings, however, and may need to explore other policy options.

ZONAL MANDATORY CONNECTION POLICIES are similar to city-wide policies but focus only on specific areas or zones within a city. A city may use a “service-area bylaw” that effectively applies a mandatory connection policy to a limited area. This bylaw then can be extended as the system grows. In Hong Kong, all non-domestic buildings in the Kai Tak development must connect to the district cooling system, including hotels, hospitals, shopping centres, government offices and the planned multi-purpose stadium. Vancouver used a service-area bylaw to mandate connections within the Southeast False Creek Official Development Plan area, and the service area has since been extended to accommodate growth. In Rotterdam, building codes in the two concession areas for district heating require that buildings connect to the network, a stipulation that was core to the business case for the concessions. German municipalities can also use building codes to oblige buildings to connect to district heat networks (Schönberger, 2013).
The Greater London Authority’s (GLA’s) energy planning started with a focus on climate change, but it now also takes into account the city’s rapid growth and ageing infrastructure, including the electricity grid. London uses its land-use planning authority to promote district energy development. Current GLA planning policies require all new developments to include energy assessments that detail efforts to minimize the associated CO₂ emissions. The supply of energy efficiently is part of these assessments, and, as such, major development proposals must develop along a heat hierarchy of:

1) connect to existing heating and cooling networks,
2) install a CHP network on the development site and
3) use communal heating and cooling.

Two thirds of the planning policies’ overall CO₂ reductions since 2010 can be attributed to CHP development. Specialist advisors evaluate each energy assessment to ensure that the energy policies are met. Where they are not met, the developer makes a cash-in-lieu contribution to account for the shortfall in CO₂ emission reductions. In 2012, this planning policy resulted in significant commitments to new district heating systems, including:

- £20 million (US$32 million) of investment in a new, high-efficiency CHP plant able to produce 29 MW of electricity and a similar amount of heat. From 2010 to 2012, a total of 74 MWₑ of CHP electrical capacity – roughly the amount required to supply 150,000 homes – was secured through the planning process.
- £133 million (US$213 million) of investment in heat network infrastructure for approximately 53,000 communally heated dwellings.
- Commitment to 10 very large (more than 1,000 dwellings each) mixed-use developments implementing site heat networks, each of which is key to the development of an area-wide network.

**CASE STUDY 2.3**

**THE GREATER LONDON AUTHORITY: ENCOURAGING CONNECTION THROUGH PLANNING**

The Greater London Authority’s (GLA’s) energy planning started with a focus on climate change, but it now also takes into account the city’s rapid growth and ageing infrastructure, including the electricity grid. London uses its land-use planning authority to promote district energy development. Current GLA planning policies require all new developments to include energy assessments that detail efforts to minimize the associated CO₂ emissions. The supply of energy efficiently is part of these assessments, and, as such, major development proposals must develop along a heat hierarchy of:

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- £133 million (US$213 million) of investment in heat network infrastructure for approximately 53,000 communally heated dwellings.
- Commitment to 10 very large (more than 1,000 dwellings each) mixed-use developments implementing site heat networks, each of which is key to the development of an area-wide network.

**Bunhill CHP plant in Islington, London. The tower is a large heat storage unit that reduces the need to provide heat from the district heating system’s backup gas boilers.**

**Mandatory Connection (Unless) Policies** add flexibility to the planning process by requiring developers to connect to and use the district energy supply unless it is proven that this is not economically or technically feasible against specific “viability criteria.” Or, cities may allow buildings to use alternative energy sources if this can be shown to be environmentally preferable to district energy (Bergen allows this in mandatory connection areas). In Velenje, new facilities must connect to the district heating network except in exceptional circumstances where connection would be irrational, in which case heating is permissible by electricity and renewable technologies. Other cities that have “connect...unless” policies include Amsterdam, London and Tokyo (see case study 2.3). Such policies also help the city mitigate the cost of feasibility studies by placing the onus on the developer.

**Mandatory District Energy Development Through Zoning Policies** may, for example, require district energy systems in new development areas that are over a certain size and that cannot connect into other networks, and/or if district heating is the best available technology to provide sustainable heat services. In London, “major developments” must consider creating a CHP network if they cannot connect to a district energy network (see case study 2.3). Similarly, in Tokyo, if a new development area will be over 50,000 m², it has to develop a district energy system if it cannot connect to a network, unless this is not technically feasible or the next-available sustainable heat or cooling option is more economic (see case study 2.4). In Vancouver, as part of Parklane’s River District development, rezoning conditions required connecting to a district energy utility if available, which incentivized Parklane (as the landowner and master planner) to create its own private district energy utility with a mix of individual developers in the neighbourhood.
POLICIES TO ENCOURAGE CONNECTIONS

Aside from making it mandatory for buildings to connect to district energy, to consider connection if it is cost effective, or to develop district energy systems, other types of incentives can be used to encourage connection and reduce investor risk. Such policies may not be as effective as mandatory connections in alleviating load risk, but they are often easier for a local authority to enact. These policies include:

- Density bonus, whereby a city may grant extra development space (such as an extra story on a commercial office block) in return for the developer agreeing to connect to the district energy system.

- Access to rights-of-way, whereby the city simplifies the development process by waiving or reducing some fees associated with obtaining rights-of-way permits, soil displacement and other discretionary expenses consistent with treatment of infrastructure improvements.

- Take or pay, whereby a local government could guarantee load or pay for any missing load if it is confident in customer connections based on the value proposition of the district energy system. This would apply to a concession model (see section 3.3.2) where the private utility may need guaranteed load.

- Banning undesirable alternatives, such as the use of specific carbon- or energy-intensive technologies for heating. Starting in 2016, Copenhagen will not allow oil-fired installations to be installed in areas with district heating or natural gas networks. The city also has banned electric heating in all new buildings. Norwegian national policy also bans some technologies as a direct incentive for district energy connections (see section 4.1).

- Regulated and transparent tariffs that are competitive with next-available technologies, which may make it more likely for building owners and developers to connect voluntarily to district energy. For example, Vancouver’s SEFC NEU has transparent heat tariffs and connection costs, which encourage connections (see case study 3.1).

- Streamlined rezoning or permitting processes that, for example, give preference to developers that design buildings to be district energy-ready (as in Oslo).

- Building compatibility requirements, whereby all new buildings must be compatible or district energy-ready across the city or certain areas. Vancouver is considering bringing this compatibility into green building standards.

- Clear credit towards green building requirements, whereby local green building standards account for district energy in their certification schemes, thus encouraging building owners to connect (e.g., Frankfurt, Sonderborg).

- Provide financial assistance to new connections, by partially paying the cost to connect (e.g., Brest) or paying the full cost (e.g., the private operator in Seattle paying for profitable connections).

FIGURE 2.5 Connection policies by type in the 45 champion cities

<table>
<thead>
<tr>
<th>Policy Description</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory connection enforced in SERVICE/FRANCHISE AREAS</td>
<td>23%</td>
</tr>
<tr>
<td>Mandatory connection enforced for COMMERCIAL/PUBLIC BUILDINGS</td>
<td>10%</td>
</tr>
<tr>
<td>Mandatory connection enforced for NEW DEVELOPMENTS*</td>
<td>13%</td>
</tr>
<tr>
<td>Mandatory connection or mandatory connection (unless enforced) IN ALL CITY AREAS</td>
<td>27%</td>
</tr>
<tr>
<td>No mandatory connection**</td>
<td>27%</td>
</tr>
</tbody>
</table>

* Vancouver and Tokyo have this policy, but only for new developments over a certain size, and were not counted for this.

** Cities that are still developing their first district energy network are not included here because their connection policy is undecided.
**CASE STUDY 2.4  TOKYO: INTEGRATING LAND USE, BUILDINGS AND DISTRICT ENERGY**

"The Tokyo Metropolitan Government introduced its District Energy Planning System for Effective Utilization in 2009. The policy for this programme is based on the principle that 1) district-wide energy planning and 2) energy consideration in the early stages of planning are necessary to further promote the design of energy-efficient buildings and to introduce renewable energy."  Yuko Nishida, City of Tokyo, 2014

Under its District Energy Planning System for Effective Energy Utilization, the city of Tokyo implemented several policies to promote district energy. For example, new developments above 50,000 m² of floor area are required to provide an Energy Plan for Effective Utilization in order to obtain a building permit. The Plan submission requires setting targets for energy-saving performance in newly constructed buildings, as well as studying the introduction of unused energy, renewable energy, and district heating and cooling.

For buildings that exceed 10,000 m² or residential developments that exceed 20,000 m² in total floor area, developers also are required to submit documentation evidencing an economic and technical assessment of district energy and consultation with district energy suppliers. Where the barrier is economic, the city will consider on a case-by-case basis if it can address this with remedial policies. A similar approach is taken in Seattle and Vancouver.
Municipal governments have played a central role in addressing the risks (actual and perceived) and costs associated with investing in district energy systems. Local governments are enabling and easing access to low-cost finance in order to stimulate private investment and industry activity. This relationship is supported by evidence from the 45 champion cities—such as Dubai, London, Munich and Paris—with many cities attracting over US$150 million of investment in their respective district energy systems between 2009 and 2013. Local governments ranked the public sector as the “most important” actor to catalyze investment in district energy, particularly in new schemes. The private sector was ranked as “very important” in catalyzing investment, primarily through the provision of technical and operational support.

This section examines the role of local government as a facilitator of district energy through its ability to leverage finance. It focuses on three main policy intervention areas, as described in table 2.3.

### 2.3.1 Financing and Fiscal Incentives

City authorities have an important role to play in financially supporting the development of district energy, particularly in cities where it is a new technology or requires significant retrofitting. District energy is cost-competitive with other energy technologies. National policies may provide some financial (and fiscal) support by reducing project risk through subsidies (such as feed-in tariffs or renewable energy certificates), grants, funds, environmental

### TABLE 2.3 Policy activities that local governments are undertaking in their role as facilitator

<table>
<thead>
<tr>
<th>POLICY INTERVENTION AREA</th>
<th>DESCRIPTION OF POLICY ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financing and Fiscal Incentives</strong></td>
<td>• Debt provision and bond financing, loan guarantees and underwriting, city-financed revolving funds</td>
</tr>
<tr>
<td>(section 2.3.1)</td>
<td>• Grants, low-cost financing/loans, rebates, subsidies</td>
</tr>
<tr>
<td></td>
<td>• Tax credits and exemptions within tax systems; for example, sales, property taxes, permitting fees and carbon taxes</td>
</tr>
<tr>
<td><strong>City Assets</strong></td>
<td>• Use of local government land/property/buildings for district energy installations or connections, or for anchor loads (leasing/selling/permitting)</td>
</tr>
<tr>
<td>(section 2.3.2)</td>
<td></td>
</tr>
<tr>
<td><strong>Demonstration Projects</strong></td>
<td>• Piloting and testing emerging (often hybrid) technologies, such as low-grade waste-heat recovery from sewage or metro, and renewable energy integration and storage</td>
</tr>
<tr>
<td>(section 2.3.3)</td>
<td>• Piloting new policies for district energy systems</td>
</tr>
</tbody>
</table>

Source: Adapted from Martinot, 2011, and Sims, 2009

* The economic barriers to district energy systems result from the capital costs associated with the construction of plant, network and connections. As such, the cost of capital (or the required return) is a core driver of the cost competitiveness of any scheme and is determined by the risk of investing in the project. Economic barriers can be categorized as those that affect project risk (actual or perceived) and project cost.
taxes (such as polluter taxes and carbon pricing) and value-added tax reductions, among others (see section 4 for further discussion of the national government’s role).

Cities can accelerate district energy through a variety of financial and fiscal incentives (described below) that can significantly improve the viability of district energy projects, and that provide an alternative to direct public ownership of the project (a model that is discussed in section 3). Where cities have limited capacity to provide such incentives, they can still drive district energy forward by creating favourable urban planning, energy regulations and local policies, as described in section 2.2.

**DEBT PROVISION AND BOND FINANCING:**
Cities can provide low-cost loans to projects by passing on their ability to raise low-cost recourse capital. Similarly, cities can issue general obligation bonds to provide debt to a project. Revenue bonds can also be issued to effectively provide this debt at a higher interest rate. Using non-recourse loans and revenue bonds in project financing will have a high due-diligence cost and is best suited to mature markets or in combination with connection guarantees.

In St. Paul, long-term revenue bonds were issued to develop both the heating and cooling networks, and the city was able to avoid having to guarantee debt repayments. This was made possible by the signing of long-term contracts with initial customers. Toronto, meanwhile, used revenue and general obligation bonds in tandem to raise the necessary capital for its deep-water lake cooling system. To secure the financing for the project, the city required future customers to sign contracts or letters of intent. A city’s issuance of bonds can be an important factor for decisions by federal, state and private investors, who look to municipal support as a key indicator of city priority and capacity for fostering district energy.

**LOAN GUARANTEES AND UNDERWRITING:**
Loan guarantees from cities allow access to low-interest debt for projects, which can greatly reduce the total project cost. Creditors may require some form of loan guarantee from municipalities, obliging the city to repay the loan if the project defaults. In the U.K., the Aberdeen City Council underwrites (via a loan guarantee) the non-profit district heating company, allowing it to obtain commercial debt financing at attractive rates. In Denmark, district energy companies similarly may request that their municipality act as guarantor for the needed loans. This “kommune-garanti” reduces lenders’ risk and thus lowers interest rates. KommuneKredit, a credit union for Danish cities, lends out more than DKK1 billion (US$176 million) annually to district energy companies that hold the kommune-garanti. Since the early 1990s, there has been no instance of a municipal government being called upon to cover the losses of such loans (Chittum and Østergaard, 2014).

**GRANTS:**
Cities may provide capital grants or annual payments to specific projects to enable their initial development or to help direct them to social or environmental objectives. The City of London has provided development grants for early-stage feasibility assessments and investment-grade audits. The first phase of the Bunhill Heat and Power project in the city’s Islington borough, which aims to provide cheap heat to social housing, benefited from £4.2 million (US$6.7 million) in grants from the London Development Agency (now dissolved) and the Homes and Community Agency (see case study 3.2).

**INTERNATIONAL OR NATIONAL GRANTS OR LOANS:**
Significant international and national funds are being directed to district energy networks in cities, both for initial development and for rehabilitation. Cities can lobby for such funds to be made available to projects. Velenje was able to secure a €729,000 (US$911,000) long-term loan from Slovenia’s Eco Fund for its district cooling system that is based on absorption chillers using waste heat. Across Europe, EU Structural Funds play a key role in helping local and national governments modernize dilapidated district heating infrastructure (see case study 2.5 on Botosani) (Sharabaroff, 2014).

* Provision of guarantees (as well as of recourse debt/general obligation bonds) is risky for municipalities and can affect their borrowing capacity; thus, guarantees normally would be provided for socially, economically or environmentally critical projects. Some municipalities are wary of setting a precedent that could lead lenders to demand loan guarantees for all large infrastructure projects, making them less inclined to use recourse debt, general obligation bonds and loan guarantees.
In the north-eastern Romanian town of Botosani (population 115,000), space heating and hot water services are provided by the municipally owned district heating utility, Modern Calor. The district heating system was built in the 1960s, following the typical socialist-era design concept of “low CAPEX, high OPEX”.

During the 1990s and early 2000s, Romania’s district heating sector experienced tremendous difficulties, as the lack of investments led to dramatic reductions in operational efficiency and reliability of heat supply. Combined with the rising cost of natural gas, this led to serious affordability constraints for end-users, resulting in disconnections from the network, which further reduced operational efficiencies. By the mid-2000s, Modern Calor’s annual heat losses topped 50 per cent. The poor financial state of the district heating sector resulted in a scarcity of long-term commercial financing needed to modernize these utilities.

EU Regional Operational Programs (part of EU Structural Funds) provided a greatly needed CAPEX incentive to upgrade dilapidated district heating systems throughout the country. However, several municipalities, including Botosani, experienced difficulties in securing their share of co-financing, as access to commercial financing was scarce. The International Finance Corporation’s (IFC’s) Subnational Finance group assessed the project and provided a long-term debt to Botosani to help secure the municipality’s co-financing requirement.

As a result of the project, a state-of-the-art 8 MW_e CHP plant and two 52 MW th heat-only boilers were installed, replacing an oversized and inefficient heat capacity of 560 MW th prior to the project; in addition, 6.5 km (dual-pipe) of transmission and 14.3 km of distribution in the district heating network were replaced. The second phase of the project financed replacement of an additional 3.7 km of distribution, as well as an energy efficiency improvement programme for residential buildings.

The total project cost was €45.7 million (US$57.1 million), with the IFC providing a loan of some €8 million (US$10 million). In addition to financial support, the IFC provided advisory services to Modern Calor to identify cost-reduction opportunities through technical measures (largely changes in operational modes) and cost-structure review. In total, the project is projected to abate 684,100 tons of CO_2-equivalent, and 21 large-scale district heating consumers that had formally disconnected from the system re-connected following project completion.

Source: Sharabaroff, 2014

**CASE STUDY 2.5**

**BOTOSANI: LEVERAGING INTERNATIONAL FINANCE FOR MODERN DISTRICT ENERGY**

**The new CHP plant and boiler system in Botosani, Romania.**
The City of Oslo established a Climate and Energy Fund in 1982. While the fund was originally built up through a surcharge on electricity, activities are now paid for from the interest on the existing fund. The fund provides subsidies to projects that reduce greenhouse gas emissions and local air pollution from buildings and construction and that result in reduced and/or more effective use of energy. It has supported projects resulting in total energy savings of 1.3 terawatt-hours (TWh) per year, or about 10 per cent of what the city as a whole uses. In 2012, the fund supported 2,592 climate and energy efficiency projects, with half of the funding directed to new renewable energy, such as heat pumps, district heating, bioenergy and solar power.

Toronto established the non-profit Toronto Atmospheric Fund (TAF) in 1991 with CAD$23 million (US$20.2 million) from the sale of a city-owned property. The fund’s mission is to accelerate reductions in local greenhouse gas emissions by testing and scaling up solutions in renewable energy, energy efficiency and reduced fossil fuel consumption. TAF originally provided only grants, but a key barrier to scaling solutions lay in leveraging capital. Today, TAF provides grants and loans, undertakes special projects and creates partnerships.

TAF’s assets generate around CAD$1.5 million (US$1.3 million) in revenue annually for grants and special projects. Total project funding since inception has been about CAD$30 million (US$26.3 million). TAF provided CAD$80,000 (US$70,000) in 2002 for a feasibility study and subsequently loaned CAD$1 million (US$0.87 million) to help finance a tri-generational system that combines electricity generation, heating and cooling produced by a highly efficient system servicing three large buildings.
REVOLVING FUND: Some local governments are establishing investment funds or green funds to provide subsidies, grants and zero- or low-cost financing, particularly at early stages, for developments that are in the public interest. These endowments can stem from the sale of a city asset (such as city land, shares in a utility, etc.), a surcharge on utility energy bills or innovative sources such as avoided subsidy costs. The funds are designed to be self-sustaining and to grow through returns on investment, interest rates on debt and other revenues (see case study 2.6 on Odense).

A revolving fund allows for public support of strategic investments without necessitating direct city ownership, and it caps the city’s overall involvement in district energy. Often, the fund provides deferral on principal repayment for the first 3–5 years while the system is being constructed and customer revenue has not yet commenced. A revolving fund can support specific district energy starter schemes, designed both to illustrate the feasibility of installing a major heat network (see case study 2.7 on Toronto) and to provide the catalyst for the cost reductions and development of a local supply chain. Capital can be repaid and redeployed in other projects.

CITY-LEVEL SUBSIDIES: Although many countries provide national subsidies for low-carbon or energy-efficient heating or cooling, subsidies developed at a city level are less prominent. In Botosani, municipal heat networks historically were heavily subsidized by municipalities to account for inefficiencies in the network and to protect the population from high heat prices (Sharabaroff, 2014). Some cities exploring modern district energy systems have been advancing mechanisms – such as feed-in tariffs, net metering and heat incentives – that internalize the public benefits of these systems, in association with a public utility. Seoul has a city-level feed-in tariff for CHP, and Tokyo initiated a cogeneration subsidy to encourage increased electricity generation in response to the power outages from the 2011 earthquake (see section 2.4.1 for more on tariff setting).

DEVELOPMENT-BASED LAND-VALUE CAPTURE STRATEGIES: Converting rural to urban land can increase the land value by approximately 400 per cent in Latin America (Smolka, 2014), and this increase can be even higher for high-density urban land. Because such windfalls to the landowner can be captured for public use, land-value capture is described as a “no-brainer,” particularly as the value added to the land can be higher than the infrastructure cost needed to develop it. This concept has a long precedent in many countries, based on the “principle of unjustified enrichment” – or the idea that citizens should not accumulate wealth that does not result from their own efforts.

Following the conclusions of the China Urbanization Study (World Bank and DRC, 2014), China’s State Council is shifting to a new strategy for urban development and will prioritize urban (re)development in transit station districts (1 km² in size). Within the next decade, China will have 6,000 new transit stations, 15 per cent of which (i.e., 900 districts) will have high development potential. These 1 km² districts around transit stations are very high-potential urban areas, where Development-Based Land-Value Capture (DB–LVC) strategies will be implemented to finance infrastructure investment and energy efficiency.

Rural land requisition allows for the development of new urban zones, increasing the value of the land. Future and continuing revenues from selling or leasing land in distinct zones, and capturing taxes from new landowners, provides the finance for infrastructure. This is an excellent demonstration of an integrated approach to district energy. By incorporating urban planning (mixed-use zoning, compact land use and high connectivity) with transport and district energy planning, financing of optimal and well-planned district energy projects can be achieved (World Bank and DRC, 2014).
SECTION 2

2.3.2 CITY ASSETS

Unless private property owners are willing to host generation within their buildings, cities will need to allot land for district energy generation. Publicly owned parcels can be used in-kind or can generate rents for the city, depending on the ownership model of the system (see case study 3.8 on London’s Olympic Park). As real estate is phased in, more generators can be added and connected within the network, and space should be allotted for future system growth. Since 2012, Seoul has supported the construction of fuel cell-CHP power plants — some on city-owned land — and the municipal government is targeting an additional total installed capacity of 290 MW (see section 2.4.4 on the city as a consumer for more examples).

Some cities may need to finance refurbishments to modernize their district heating systems. Selling a portion of the district heating system can inject the capital needed for such improvements. Warsaw has the largest district heating system in the EU, supplying 136 km² of floor space and meeting 76 per cent of the city’s heating requirements. In 2011, Warsaw sold 85 per cent of its publicly owned district heating company, SPEC, to Veolia Polska S.A. (until recently Dalkia Warszawa S.A.) for PLN4 billion (US$446 million). Veolia Polska S.A., which now operates the system, has pledged to invest PLN1 billion (US$310 billion) during 2012–2018 to finance essential upgrades, including the modernization and expansion of the district heating networks.

2.3.3 DEMONSTRATION PROJECTS

Regulated district energy systems provide a stable, low-risk level of return to investors with long-time horizons. However, the private sector often has insufficient incentives to undertake more-risky or unfamiliar initial investments. Once the pipes are in the ground, it is much easier to leverage private sector finance to expand the network. Local governments are supporting demonstration projects to:

- illustrate the feasibility and commercial viability of modern district energy systems and showcase socio-economic benefits to citizens, private building owners, developers and investors (see case study 2.8 on Amsterdam);
- pilot new policies for uptake by the city council or national government; and
- build local and institutional capacity and confidence.

Local governments commonly use demonstration projects to facilitate market development, raise awareness of potential investors and accelerate private sector engagement. Cities need to develop well-documented demonstration projects to prove the potential benefits and payback periods of district energy systems — thus supporting the business case and facilitating access to more traditional financing sources — as well as to generate both public and local government support. In Vancouver, the use of a demonstration project made it easier to gain the confidence of institutional and private condominium developers, who traditionally are not interested in taking on unfamiliar technologies, assuming project development risk or losing control of critical construction schedules (see case study 3.1).

CASE STUDY 2.8

AMSTERDAM'S SMART CITY INITIATIVE AND TAX-FREE ZONE FOR DEMONSTRATION PROJECTS

The city of Amsterdam initiated the "Amsterdam Smart City" (ASC) initiative – together with the Amsterdam Economic Board, Liander, the grid operator and KPN – to bring together diverse stakeholders and to pilot local projects and policies focused on the energy transition. The designated areas are also tax-free zones to incentivize companies to pilot new technologies. The overall goal is to help the city achieve its CO₂ emission targets and to support economic development in the Amsterdam Metropolitan Area, in order to improve residents’ quality of life.

The initiative involves more than 70 partners – including local companies, housing corporations and residents – in a variety of pilot projects focused on the energy transition, including district energy. The most effective initiatives are then implemented on a larger scale (see, for example, case study 2.1 on Amsterdam, which included cooperation among various industrial partners on the exchange of energy and the use of excess waste heat from data centres). All of the acquired knowledge and experience is shared via the ASC platform, helping to accelerate the city’s climate and energy programmes.
CASE STUDY 2.9

Gujarat International Finance Tec-City (GIFT City) is developing India’s first district cooling network as part of an effort to attract financial services companies to the country. This development is significant given the large potential for district cooling in India (see section 1.1). A demonstration project that is scalable not only showcases the technology, but it provides local capacity building on how to develop a project, which could then be transferred nationally. It also builds investor confidence in district cooling technology and in the ability of local governments to deliver it.

The city has set up GIFT District Cooling Systems Limited, a Special Purpose Vehicle limited by shares, to deliver the proposed district cooling network through a public-private partnership model. The city opted to use district cooling due to its higher efficiency, lower operation and maintenance cost, and its ability to significantly cut carbon emissions. The system will reduce electricity consumption 65–80 per cent through the use of industrial-scale electric chillers, which have a far higher coefficient of performance and energy efficiency ratio.

The system initially will represent 10,000 refrigeration tons (35 MW), combined with 10,000 refrigeration ton-hours of storage (35 MWh), and will later add to this as buildings are developed and connected. Developing the initial phase will reduce risk in future phases, lowering the cost of the project.

District cooling in the city will demonstrate the benefits of having a diversified load, as the system will connect different types of buildings (residential, commercial, retail and convention centres). The system also will use a refrigerant that has a lower global warming potential (GWP) than the decentralized chillers that otherwise would have been installed. Carbon reductions from the use of an environmentally friendly refrigerant as well as from the higher system efficiency are expected to count towards green building ratings in the city.
"There was not one financial company that would say we are ready to invest in the transmission line, not until there is enough demand and supply connected. But in the beginning, it's about risk taking. We invested in the transmission line in order to get things done – we think it is workable and we have different rules about investment, and a different view on return on investment rates, as transmission delivers other benefits."

City of Rotterdam representative, 2014

As a provider of infrastructure and services (energy, transport, housing, wastewater treatment, etc.), a city can shape the low-carbon pathways of these services, capture synergies across the different business segments, and direct the local district energy strategy towards social and economic objectives. As a consumer of heating and cooling (in public buildings, social housing, hospitals, leisure centres, etc.), the city is ideally placed to demand the energy services that it deems optimal and has the ability to facilitate a project’s conception through the provision of anchor load and connection certainty. Table 2.4 summarizes the roles and leverage that a city has as both a provider and consumer of services.

### 2.4.1 MUNICIPAL UTILITY TARGETS AND PROMOTION POLICIES

Local governments that have stakes in a municipal utility can prescribe the use of recovered or renewable heat in district energy networks in order to achieve public policy objectives. Anshan, Copenhagen, Frankfurt, Oslo, Paris and Växjö are just a few examples of cities that have mandated the use of waste or renewable heat or cooling (see section 2.2.1 on targets). Local authorities can also direct municipal utilities to focus on specific demand groups, such as social housing (see case study 2.10 on Paris).

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**TABLE 2.4**  
Policy activities that local governments are undertaking in their role as provider and consumer

<table>
<thead>
<tr>
<th>POLICY INTERVENTION AREA</th>
<th>DESCRIPTION OF POLICY ACTIVITY</th>
</tr>
</thead>
</table>
| CITY-OWNED OR OPERATED UTILITIES AND WASTE-HEAT TARIFF REGULATION (including local utilities, distribution companies, energy service companies (ESCOs) (sections 2.4.1–2.4.3) | ■ Utility mandates and incentives  
■ Interconnection policies and incentives  
■ Waste-heat tariff regulation and customer protection policies  
■ Investment in, or partnership with, other utilities |
| PROCUREMENT, PURCHASING, INVESTMENT (sections 2.4.4) | ■ Investment in district energy for government buildings, schools, public transport; purchase or joint purchase of district heating/cooling or power (cogeneration) with other cities; green public procurement |

Source: Adapted from Martinot, 2011, and Sims, 2009
Historically, district energy has played an important role in Paris and has been developed mostly on its financial credentials and ability to provide security of supply. In 1927, the city created a concession for developing a network to deliver steam for heating national and public buildings. The goal was twofold: 1) to reduce the city’s coal and wood use in order to minimize fire risk and improve air quality, and 2) to reduce the need for thousands of people to deliver coal or wood to the streets of Paris (see section 1.6 on catalysts for district energy). After World War II, the city of Paris became a 33 per cent shareholder in the Paris Urban Heating Company (CPCU), which, 90 years later, still operates (under concession) the Paris district heating network.

The network started by delivering heat to a factory in Paris while also pre-heating passenger trains prior to departure, and quickly expanded as neighbouring buildings wished to benefit from heating that was cheap, safe and reliable. Today, the network continues to flourish using the underground tunnels and pipelines that already serve the Paris metro system. CPCU’s 475 km network connects the equivalent of 500,000 households (including all of the city’s hospitals, half of all social housing units, and half of all public buildings) and interconnects 13 towns (including Paris). Heat is produced at eight facilities – including two cogeneration facilities and three waste-to-energy plants – that have a combined total of 4 GW of generating capacity and produce 5.5 TWh of heat and 1 TWh of electricity per year. The waste-to-energy plants avoid the emission of 800,000 tons of CO₂ annually.

Because the city has a large stake in CPCU, it is able to control the production mix of heat and to influence the company’s policy objectives. As the network’s role has developed, it now aims not only to provide affordable, reliable heat, but also to reduce the city’s carbon emissions by lowering primary energy use and enabling a greater share of renewable heat. CPCU’s target is to achieve 50 per cent renewable or recovered energy in heat production by 2015, and 60 per cent by 2020, in line with the Paris Climate Action Plan. This transition will include developing biomass and geothermal; heat recovery from sewers; and co-firing coal and wood. If the 50 per cent target is met, a national value-added tax (VAT) incentive will save CPCU customers some €35 million (US$43.7 million) a year by reducing the VAT on heat to 5.5 per cent. Once CPCU reaches a 50 per cent renewable share, the city will investigate the establishment of mandatory connection zones to encourage connection (see section 2.2.4).

Paris has a relatively large amount of social housing, with 1 in 5 people living in social housing units and a higher proportion in some suburbs. Through the city’s stake in CPCU, the district heating network is being developed to incorporate new social housing. The concession contract sets a maximum price for the heat delivered, indexed against the share of renewable heat generated. The city of Paris also can enforce a special low price for those in social housing.
2.4.2 MUNICIPAL UTILITY INTERCONNECTING RESOURCES AND NETWORKS

For cities that are beginning to develop district energy networks, development often happens in a nodal manner: systems develop in segregated “blocks” that are not interconnected. The city-wide systems in Anshan, Copenhagen, Milan, Oslo, Paris, Rotterdam and Sonderborg all started with a small plant serving a large anchor load or several small buildings. As nodal networks expand, they may be interconnected to create greater economies of scale through transmission backbones (see figure 2.6).

Local governments can direct the expansion and integration of district energy networks through municipal utilities, enabling technical and economic efficiency improvements. Many consolidated cities have network interconnection plans that rely on municipal ownership of utilities to progress. In the absence of such ownership, it is difficult for the private sector to deliver the business model for interconnection.

In Copenhagen, local municipalities own many of the local heat distribution networks. Over time, transmission infrastructure spanning individual networks was developed to share energy and access larger supply sources. In many cases, the transmission systems evolved as partnerships among municipal distribution companies. Such systems have been crucial in enabling Copenhagen to meet over 98% of its heat demand with district heating. Figure 2.7 shows the city’s current heat networks and highlights the importance of transmission lines in connecting the networks.

Cities worldwide are emulating Copenhagen’s model of nodal development leading to the interconnection of municipal utility’s transmission because of its demonstrable efficiencies and its ability to connect larger heat sources to the network. The key role of municipal ownership in developing transmission lines to connect nodal networks is a recommended best practice to help cities expand their systems into fully interconnected city-wide networks.

Anshan, with the help of Danish companies, is doing just this (see figure 2.8). The local authority’s ownership of a district heating company made it possible to invest directly in a transmission network that will connect the city’s 42 district heating companies, pooling demand and generation capacity and enabling the connection of 1 GW of waste heat from a steel plant (see case study 3.7).

In Milan, A2A will expand the currently segregated networks into three large heat networks by 2016, and these will then be interconnected via a ring around the city. This is to meet a larger proportion of the city’s heat demand which, by 2020 will be 50% per cent higher than the 590 GWh of heat supplied in 2014. This will enable Milan to exploit the most efficient plants in its system, such as three large CHP plants, a waste incinerator and groundwater heat pumps. A2A is planning the district heating network development in coherence with the urban planning instruments (i.e., an urban master plan and district plans).

Sonderborg’s ZERO Carbon Roadmap considers transmission pipelines to connect the area’s islanded district heating networks, as a way to green its network sources and create cost efficiency. The main heating network draws heat from multiple complementary renewable sources, including a waste incineration facility, a geothermal facility, straw- and wood chip-burning boilers, heat-driven heat pumps and solar heat facilities. Although just 36% of the area’s buildings currently are connected to district heating, the ambition is to grow this number to around 55% per cent by switching existing buildings that burn natural gas for space heating to district heating.

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**FIGURE 2.6** Nodal development of district energy systems in a city

1. Nodal networks develop around anchor loads, often linked to new development, served by a small heat source.
2. Networks expand and larger heat sources start to emerge to meet growing demand.
3. Networks begin to link in order to share excess heat capacity. Original heat sources are replaced as they reach the end of their life, potentially with waste heat from a power station. A transition main will carry large volumes of heat over long distances.

Source: King and Parks, 2012
The ZERO Carbon Roadmap was developed by ProjectZero, a public-private partnership that is enabling Sonderborg to realize its zero carbon visions – including the city’s plans for district energy (see case study 2.14).

London has identified city-wide district energy as crucial to meeting its target of 25 per cent decentralized energy by 2025. It is not clear, however, whether such a network would be municipally owned, due in part to the highly liberalized and privatized nature of the U.K. energy system. It is possible that the municipality’s role could be in establishing concession contracts or tenders for the build-out of transmission pipes. Development of the network will be made easier by interconnection standards currently under consideration. In some cities, the development of transmission lines is key to connecting heat sources that are located far from demand. Bergen (see case study 3.3) and Oslo both have long transmission lines leading to waste incinerators. Rotterdam has developed a 27 km transmission system to connect waste heat in the harbour (see case study 2.11). And in Velenje, waste heat from the 779 MW Šoštanj Thermal Power Plant supplies most of the heat to the city’s extensive district energy network (97 per cent of residential demand), helping to keep the city’s heat price extremely low. The plant, located in a neighbouring municipality, is connected by a transmission line that was only possible because of the 83 per cent share that Velenje has in the public utility that owns the plant.
In Rotterdam, the city partially owns the two utilities, Warmtebedrijf Rotterdam and Eneco*. Warmtebedrijf Rotterdam transports waste heat from the harbour area to the city, and Eneco distributes heat in the city’s north. Rotterdam has one of the largest industrial harbours in Europe, with significant potential for waste heat recovery. Initially, the city solicited private sector actors to invest in developing a heat transmission connection between the harbour and the city’s district heat networks, but these actors were not ready to invest in the line until sufficient demand and supply was connected (Hawkey and Webb, 2012).

In 2010, the city decided to invest €38 million (US$50.9 million) to establish a municipal district heating company (Warmtebedrijf Rotterdam) to develop a 26 km heat transmission connection. The line would initially connect Rotterdam’s Rozenburg (AVR) waste incinerator, located in the harbour, to the Nuon heat network in Rotterdam-South and the Eneco network in Rotterdam-North.

To create sufficient economies of scale on the demand side for the two distribution companies (Eneco and Nuon) to expand the district heating network, the city sought and obtained support from several large housing cooperatives, building developers and energy companies to meet the target of connecting the equivalent of 150,000 households to the network. In addition, a local ordinance was introduced making it mandatory to connect new buildings to the network in order to reduce the risk for the district energy companies in the north and south.

In 2013, Warmtebedrijf Rotterdam finalized the connection between the Rozenburg incinerator and the city of Rotterdam, and in 2014 Eneco finalized the connection between the incinerator and the city’s north. The network enables the transmission of significant amounts of waste heat from the harbour. With both utilities connected, Rotterdam now has its own “heat roundabout,” which ensures a reliable heat supply to the city (boosting resilience), makes possible the transition to more sustainable energy sources and supports growth of the district energy network in both the city and the region.

In its capacity as a shareholder of Warmtebedrijf Rotterdam, the City of Rotterdam provided equity that enabled the utility to fund its investment in the heat transmission system. This municipal contribution was critical because of the severe disruption to financial markets during the development period. By providing equity to Warmtebedrijf Rotterdam, the City emphasized the utility’s role as a public utility. The city’s stake in Warmtebedrijf and in the Nuon and Eneco concessions was a key factor in the network’s success and makes it possible for the city to also support future expansion. Among the public sector objectives achieved from the network connection project are reduced carbon intensity, improved local air quality, greater cost efficiency and the utilization of waste heat.

* Eneco is owned by Dutch municipalities. Rotterdam is the largest shareholder, with a 32 per cent stake. Warmtebedrijf Rotterdam comprises two public companies with limited liability. Rotterdam holds 88 per cent of shares in Warmtebedrijf Infra N.V. and 50 per cent of shares in Warmtebedrijf Exploitatie N.V.
The development of new waste-to-energy facilities, sewage treatment plants and landfills can drive the creation of a district energy system, particularly when the local government wants to leverage this opportunity and not let a resource be wasted. District energy networks also can utilize waste heat from industry and data centres, and waste cooling from liquefied natural gas (LNG) terminals (see table 1.1 for examples of these technology uses and their benefits). Waste heat sources, which tend to be more plentiful than waste cooling sources, can be combined with an absorption chiller to provide cooling. Yet numerous cities have faced difficulties in pricing waste energy accurately.

Policy recommendations for tariff setting will differ depending on the city’s heat mix, the maturity of the market and who is deciding on the tariffs. Generally, having a public utility can enable a city to set a framework for pricing heat that can encourage more sources to connect. The tariff for heat should account for:

- the cost of connection to waste energy and any running costs (e.g., electricity running a heat pump; the cost of avoided electricity generation),
- the cost to the utility of required redundancy in the network (e.g., gas boilers or electric chillers) to reflect the fact that waste heat may not be able to guarantee supply, and
- any incentives needed to encourage the waste heat provider to connect to the network (and shift away from its core business practice).

**Connection Costs:** Connecting waste heat to a district energy system can require capital-intensive equipment and adaptation of the waste heat supplier’s infrastructure. Equipment to divert waste heat from its normal outlet is required, as well as heat exchangers. Heat pumps are required if the heat produced is too low for direct input to the heat network. Such a fixed rate should be reflected in a heat tariff or in agreed upon off-take levels that will effectively pay off the fixed costs of the connection. Such a fixed return for the connection is particularly important where useful heat production is a significant diversion from normal business practices and risk of the connection may have to be removed from the provider as much as possible.

**Waste Incinerators and CHP Plants:** Waste incinerators and CHP plants may have the price of their waste heat valued at the opportunity cost of the electricity that could have been produced instead of the heat (by providing heat to a district network, the electrical efficiency can decrease). For example, if the decrease in electrical efficiency is 14 per cent (i.e., 45 per cent electrical efficiency is reduced to 39 per cent), then the opportunity cost will be 14 per cent of the electricity price at that point, and this is how much the heat produced should cost. For a CHP plant, this could be the wholesale cost of electricity at any given moment. For a waste incinerator, the power purchase price may be fixed and low to reflect the fact that the incinerator’s core business is combustion of waste and not electricity generation.

Such a methodology for calculating the waste heat price of CHP or a waste incinerator assumes that the heat supplier is focused on electricity production. This is often not the case, and the heat supply is integral to delivering heat to a network. In such a case, an opportunity cost approach may not be appropriate and the heat should be priced such that the heat supply has a positive net present value. This requires analysis of the typical running patterns of the CHP plant or waste incinerator (i.e., the heat load profile), which may mean that the CHP plant receives an average price that is higher than the average wholesale price (as the wholesale price is higher when it is cold and heat demand is higher).

**No Guarantees:** Some providers of waste heat are unable to guarantee heat, particularly in the long term. This is a reflection of heat supply being a waste product of the provider’s core business, with the core business being more profitable and dependent on external factors such as product demand and weather. Providers of waste energy are able to predict the amount of heat they will be able to deliver, but the lack of guarantee means that redundancy will be required in the network.

For example, extraction of heat from sewage has no guarantee of heat delivery, as sewage is received at a given temperature over which the wastewater treatment company has no control. Similarly, industrial waste heat, such as from a steel plant, may not be able to provide long-term guarantees, as a steel plant is unlikely to adapt operation significantly to ensure sufficient heating for the district heat network. Waste incinerators whose principle activity is combustion may be more flexible in their maximum provision of heat and more willing to enter contracts to guarantee supply.

This is why, after several years of negotiation with industry in the harbour area, Rotterdam has so far managed to connect waste heat only from an incinerator. By having a heat transport network, however, it will be easier to get more suppliers in the future. With that, the long-term guarantees can drop, because there are alternatives. The connection to the waste incinerator is considered to be the first step. The lack of guarantee of heat provision from waste heat means that the heat typically will have a low purchase price because the network will have to make additional expenditures in heat production elsewhere in the system to alleviate the risk of loss of waste heat.
**SECTION 2**

**NEXT-COST TECHNOLOGY:** Although waste heat sources are flexible in providing heat up to a maximum level of supply, they frequently will be producing heat at the maximum rate possible so as to provide as much baseload heat into a system as possible. This is due to the high-CAPEX, low-OPEX nature of connecting waste heat and its avoidance of using additional fossil fuels. This provision at baseload will normally mean that there is a slightly more expensive technology not producing at full capacity. The heat price of this more expensive technology can provide a good metric against which to base a waste heat price; however, considerations on redundancy should still be made (see case study 2.12 on Gothenburg).

District energy networks often are designed to ensure that baseload heat can be running as often as possible. To meet system demand peaks, they will use a more flexible plant that is often more carbon- and fossil fuel-intensive, in combination with thermal storage. For example, the SEFC NEU energy centre in Vancouver utilizes waste heat from the wastewater system using a 3.2 MW heat pump that is designed to meet 30 per cent of peak heat capacity, but that over the whole year supplies 70 per cent of the system’s heat demand (see case study 3.1). The waste heat is provided for free, although connection and running costs are paid for by SEFC NEU. The heat is free, as Metro Vancouver (a public entity) decided that this would maximize utility of the resource.

**INTEGRATION WITH OTHER UTILITIES:** 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 – such as providers of water, waste management or transport – and incorporating these synergies into a mutually beneficial business case (see case study 2.13 on the EU’s Project CELSIUS). Bergen’s urban densification policies, for example, promote district energy in coordination with the city’s new light-rail network (see section 2.1).

Such collaboration can go further than just joint planning of infrastructure, and can mean the participation of multiple utilities in developing the business case. Rotterdam, which historically has enjoyed plentiful natural gas supplies and has an extensive gas network, is expanding district energy as a means to reduce domestic gas production, meet carbon-reduction targets and improve air quality. The city hopes to develop a business model that can identify synergies between district energy systems and gas distribution networks, and that incorporates the value of offsetting investments in gas piping. Although it is not clear how this will work in practice, it is an innovative step towards trying to capture the external benefits of district energy.

Toronto’s district energy company, Enwave, was able to develop its deep-water cooling system because the project was mutually beneficial for the local water utility, Toronto Water, which needed new pipes to extract water from Lake Ontario. Enwave pays to co-locate its network with Toronto Water’s drinking water systems and pays for pumping costs, allowing the company to dump heat into the drinking water system (see case study 3.5).

Historically, waste incineration was solely a means to reduce the flow of waste to landfills. But today, as a result of municipal waste management plans (as in Tokyo) or national laws (as in Norway), many incinerators are required to utilize waste heat, making these facilities critical to district heating systems. Incorporating waste incineration into the business model involves providing sufficient revenues to cover connection costs and any other deviation from the core business model of waste incineration. Connecting waste and heating/cooling utilities can result in cost savings for both parties, reducing the costs of waste management and energy provision in a city.

Wastewater utilities are increasingly involved in district energy as well, because of the thermal energy contained in sewage. Metro Vancouver, which operates the city’s sewage system, is looking to work with district energy companies to utilize this resource, and is even willing to do so for free as long as it does not affect the core business (Carmichael, 2014). Oslo, Seattle and Tokyo are also installing sewage-capture systems.

Local electricity utilities can benefit from the distributed cogeneration that district energy often provides. In Bergen, electricity companies, facing capacity concerns and network strains, supported the development of district heating because it reduced reinforcement costs and provided additional revenues. The local district heating industry association was created mostly by electricity suppliers. London, Seattle and Tokyo also are investigating the incorporation of electricity suppliers into district energy networks, utilizing waste heat from substations and transit lines. Seattle is working to overcome electricity suppliers’ concerns about locating pressurized water close to electricity lines.

London is looking to overcome the challenge of not receiving retail rates for CHP-produced power by using this electricity to run more of the city’s low-voltage metro system (see case study 4.4 on London’s Licence Lite). In Tokyo, if CHP developers are approved as “Specified Electricity Utilities” under the Electricity Business Act, they can provide power to a specified area, such as the district heating and cooling area they supply, and can sell the electricity at retail prices. Both Tokyo and London also are investigating the use of waste heat from their metro systems in district heating.
In the 1970s, there were discussions about how to value the excess heat from refineries in Gothenburg. The parties had a hard time agreeing on a price for this waste heat, as they had very different perspectives on its value. From the city's perspective, the heat would not be utilized otherwise and so should be priced at a low level. From the refinery's perspective, the heat could be used to grow tomatoes and therefore should be valued at the world market price for tomatoes. After tough negotiations, the national government stepped in and supported the parties financially so that they could conclude a deal.

In Gothenburg today, the price for waste heat is set via individual heat purchase agreements, linked to the marginal alternative price. The city uses two main principles to set the price for waste heat: 1) The heat should be valued in relation to the alternative for district heat production (so if the alternative is cogeneration from natural gas, then the waste heat should be valued in relation to this production heat price, whereas if the alternative is a heat pump or a natural gas boiler, it should be valued in relation to that), and 2) the excess heat should be valued in relation to how much it costs for Göteborg Energi to produce its own heat (i.e., using next-cost technology pricing).

Waste heat prices can thus fluctuate to a large extent, which is why there can be a minimum and a maximum price. In wintertime, Göteborg Energi monitors the price of producing heat on an hourly basis in order to settle the price for waste heat. In summertime, when the company’s own production is not running at all, the prices are fixed at a lower rate. Although this method of setting the price was developed by Göteborg Energi and the Gothenburg refineries, it is now used in many other cities in Sweden as well.
EU PROJECT CELSIUS: THE ROLE OF GRANTS IN BUILDING CAPACITY FOR NEW BUSINESS MODELS

Through its Project CELSIUS grant programme, the EU is pioneering innovative business models and technologies across Europe in cities such as Gothenburg (lead partner), Cologne, Genoa, London and Rotterdam. The programme’s overall aim is to save energy by utilizing more waste heat in Europe. Business models incorporate a range of actors for whom district energy is not a core part of their business.

Cities at the forefront of these efforts include Gothenburg, which is basing 60 per cent of its district heating on waste/recycled heat including from industries, waste incineration and waste water treatment; even ships are connected to district heating networks. Rotterdam is taking advantage of free cooling from river water and has also created a “heat hub”, incorporating smart storage into the heat network rather than at the source of waste heat. And in London, waste heat from an electricity substation and the subway are connected into the city’s Bunhill energy centre.

Source: Celsius, 2014

In Christchurch, where there is no pre-existing district energy network, public facilities will be the anchor customers of the city centre’s new district energy system, as part of the earthquake rebuild. Public sector organizations have been the key to identifying this development opportunity, undertaking feasibility studies and procuring preferred partner companies to develop the new system.

The Greater London Authority’s district energy strategy assumes a strong public sector role in preparing the district energy market for eventual private sector takeover. The city targets the London borough authorities to lead and coordinate district schemes based on two key factors: 1) although most of the land in London is privatized, the boroughs have access to more housing land, estates and office buildings, all of which can act as anchor loads delivering a base-heat demand and revenue; and 2) the boroughs can take cheaper loans and take a longer-term risk for public benefit than the private sector. The focus on borough and public sector buildings provides the most-secure and lowest-risk opportunities for longer-term heat contracts and network expansion.

In the United States, some private entities have used long-term customer service contracts from a municipality (20-year off-take agreements) as security collateral on debt. This demonstrates the importance of load uncertainty, as highlighted in section 2.2.4.

2.4.4 CITY AS CONSUMER
Perhaps the most important factor in developing financially viable district energy projects is the ability to find an initial customer base with a large and steady demand load. Consequently, new district energy schemes often involve the use of public buildings such as schools, hospitals, leisure centres and municipal housing buildings. Many publicly owned or regulated buildings are used 24 hours a day and/or have fairly large and steady loads (also referred to as anchor loads). Often these buildings also have space available where energy centres could be placed, making them ideal cornerstones for developing heat networks.

The city, as a consumer of energy, can set district energy targets for its buildings and operations (see table 2.2 for examples). Also important are formal and informal networks and contacts between, for example, municipal employees or officials and municipal housing companies and cooperative housing associations (Summerton, 1992).

* Demand load is the amount and flow rate of energy that consumers require to maintain desired comfort levels in a building or development. Demand is equal to a volume of energy consumed over time, normally a one-hour period, and frequently is defined by a seasonal peak period such as the middle of winter for heating and middle of summer for cooling. At the household level, demand load is not evenly distributed throughout the day or year and varies depending on the activities of occupants. Public buildings and commercial office space often have larger and steadier demand loads driven by schedules and advanced energy management control systems.
"A key question when it comes to energy planning and the municipal approach to energy is, where does it start? It doesn’t start with energy, it starts with the community."

Fernando Canu, City of Toronto, 2014

As shown in sections 2.1 to 2.3, implementing district energy demands a new level of planning and coordination capacity as well as significant time, expertise and resources from local governments. Developing a district energy system requires a strong champion or series of advocates committed to coordinating agencies and processes; developing a customer base; securing permits, approvals, and regulatory requirements; and driving the overall process. In some cities, the local public utility may be instrumental in steering district energy systems towards city objectives (as seen in section 2.3). In others, the driver may be an institutional structure created to help develop and implement the district energy vision. Regardless of the form, local governments have a vital role to play in advocacy and coordination.

Table 2.5 provides an overview of the city’s role as an advocate. Capacity-building is crucial to raising public and investor awareness, thereby lowering perceived risk, improving the bankability of projects and facilitating effective policy implementation.

Velenje, Slovenia has established an energy agency, KSSENA, to facilitate the implementation of its energy concept, including modern district energy.

### TABLE 2.5 Policy activities that local governments are undertaking in their role as coordinator and advocate

<table>
<thead>
<tr>
<th>POLICY INTERVENTION AREA</th>
<th>DESCRIPTION OF POLICY ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARKET FACILITATION AND CAPACITY-BUILDING (section 2.5.1)</td>
<td>■ Dedicated city unit or coordination mechanism to facilitate the development of bankable projects through capacity-building, trainings, project structuring, multi-stakeholder engagement</td>
</tr>
<tr>
<td>AWARENESS-RAISING AND OUTREACH (section 2.5.2)</td>
<td>■ Outreach through public media and education campaigns; awards; community events; website; publications; geospatial energy, infrastructure and emissions mapping; information centres</td>
</tr>
<tr>
<td>ADVOCATING FOR DISTRICT ENERGY AT OTHER LEVELS OF GOVERNMENT (section 2.5.3)</td>
<td>■ Promotion of district energy systems in state- and federal-level policy and regulatory processes, including in utility operations in the city ■ Lobbying of higher levels of government for supporting policies and funding commitments, including grants and taxation policies</td>
</tr>
</tbody>
</table>

Source: Adapted from Martinot, 2011, and Sims, 2009
2.5.1 Market Facilitation and Capacity-Building

Coordination and capacity-building is required at different stages in the development of district energy, from planning to implementation. Planned systems often serve many different property owners, and unless there is one large developer of the system, the economic benefits of a citywide, multi-stakeholder district energy system are too widespread to motivate any single stakeholder to commit the resources required to drive this facilitation process. Having a dedicated city unit or coordination mechanism to facilitate the development of bankable projects through capacity-building, trainings, project structuring and multi-stakeholder engagement is a key best practice in developing and implementing a district energy strategy.

A dedicated district energy champion is essential to coordinate within the city council and across stakeholders, and to scan the horizon for project and financing opportunities. Several cities have a champion in the form of a public utility, government agency or specific councilors. Such champions may have a regulatory function, or they may be “market facilitators” that provide information, training, finance, stakeholder convening, etc. Often, government departments or agencies tasked with promoting district energy take on both these roles. The key contribution of such agencies is outlined below.

2.5.2 Awareness-Raising and Outreach

Within the current energy dialogue, there is a multi-disciplinary need to involve professional stakeholders as well as citizens, in order to promote sustainable urban development and alternative energy generation. Yet such discussions need to go beyond the energy sector. A broader understanding of district energy systems can be fostered by making use of tools such as public media and education campaigns; awards; community events; websites; publications; spatial energy, infrastructure and emissions mapping; heat mapping; and information centres. Making the process of developing and executing a district energy project as transparent as possible can result in greater acceptance by potential heat customers as well as broad political consensus for project implementation.

Raising awareness of the working principles and benefits of district energy is often a largely “invisible” solution among society at large, and is especially important in countries where the district heating market is undeveloped and where knowledge about the technology is likely to be limited. Civic partnerships, professional networks and community organizations are essential groups with whom to cooperate to catalyze discussions of district energy systems and to advocate for their incorporation into city strategies. Milan, for example, has created municipality-run Energy Help Desks that promote fuel switching, provide technical and financial information on energy efficiency and renewables, and strongly promote district heating to consumers (see case study 2.16).

Continued communication and dialogue with a wide range of stakeholders — including customers; the wider public; national, regional and local policymakers; investors; universities; architects and builders; and others — is a vital element for the successful expansion and implementation of district energy strategies. The aim is to mainstream actions to foster the transition to such systems and to sustainable urban development.
To transition Sonderborg to a zero-carbon community by 2029, local stakeholders established ProjectZero as a public-private partnership in 2007. For the city, this was a means to secure a strong partnership among key stakeholders, with contributions from the regional utility company, Syd Energi; the Danish national energy company, DONG Energy; the Danfoss fund; the Nordea Fund and Sonderborg Municipality.

The ProjectZero Company supports the city in coordinating, developing and implementing the energy strategy together with multiple stakeholders. It initiates energy efficiency improvement programmes, supports the transformation of current energy infrastructure to green renewable sources and monitors progress based on energy consumption and production data. In 2009, ProjectZero and the city launched a joint master plan for achieving the city’s ambitious goals. The plan shows how energy-efficient solutions and community engagement will reduce energy consumption by some 40 per cent by 2029, in part by switching to carbon-neutral district heating sources.

One of the first steps in the initiative has been to “green” the existing district heating system by replacing natural gas with renewable energy sources, combined with energy retrofitting of existing buildings. To achieve this goal, the ProjectZero Company has developed several successful programmes to encourage stakeholder participation. It offers training programmes and also allows companies to promote themselves as ZERO companies if they adopt strategies to reduce their emissions by a minimum of 10 per cent within the first year.

LINAK, a global producer of electric linear actuator systems, is a participating local company that has used energy efficiency initiatives to reduce its energy consumption for heating by 30 per cent and for power by 20 per cent. Large solar PV systems, together with green district heating and wind power from local turbines, will ultimately make the company CO₂-neutral.

ProjectZero has also demonstrated on a large scale that a field energy advisor can motivate citizens to energy retrofit their homes. Such advisors have visited some 1,200 Sonderborg-area homes, and 65 per cent of the homes took investment actions following the visit. The retrofits, together with other ProjectZero initiatives, have resulted in the creation of 700 new local jobs.

"We already notice remarkable CO₂ reductions created by the transition to green district heating. A unanimous City Council is committed to Sonderborg’s climate vision, and thanks to our ProjectZero project we succeed in involving the citizens—in their private homes, in business and education. It is with great satisfaction that, at the same time, we create growth and green jobs."  
Erik Lauritzen, Mayor of Sonderborg, 2014
CASE STUDY 2.15
FRANKFURT’S ENERGY AGENCY AND THE EXPANSION OF CHP

“We set up a new structure in 1990 to deliver these policy targets. Municipal energy policy was a new concept. We made it happen.”

Frankfurt has created an Energy Agency that acts as an arms-length, independent consultancy service able to: carry out a systematic search on potential customers and suitable sites for CHP and district energy; promote regular exchange with the local utilities and other key stakeholders; develop case studies on energy supply alternatives for new urban development schemes; offer free consulting services; and provide after “sales” customer service. Together, these activities are seen to have led to the success of the district energy component of the city’s climate protection policy (Fay, 2012).

For example, the feasibility studies often have resulted in new CHP plants or in connections to existing district heating areas. The city of Frankfurt recognized that, due to the efficiency of CHP, this approach holds enormous potential for reducing greenhouse gas emissions. Because there was political consensus on the matter, there has been no change in policy related to district energy, despite changes in government over the past three decades.

2.5.3 ADVOCATING FOR DISTRICT ENERGY AT OTHER LEVELS OF GOVERNMENT
Cities can become involved in broader policies to push forward district energy, whether at higher levels of government, with other municipalities, or with utilities or various regulatory agencies. Although national policies and regulations can help foster a market for district energy (see section 4), the city’s role in lobbying for, demonstrating and providing input on policies is very important. Such policies can include:

- benchmarking and disclosure requirements of building energy performance
- interconnection measures/standards that enable district energy
- incentives for the electricity produced in district energy systems (e.g., CHP) to reflect the benefits of local, decentralized power generation
- clear, consistent rules for connecting CHP to the electricity network
- guaranteed purchase of CHP electricity (i.e., priority in exporting to the grid)
- licensing exemption (operators can generate without a generator licence, which helps to keep costs down)
- enabling of decentralized generators such as allowing net metering of heating/cooling
- feed-in tariffs (or equivalent) for heating/cooling.

In both Amsterdam and Rotterdam, the liberalization and enlargement of energy companies has reduced the influence of local authorities over energy issues. As a result, lobbying on a national level and cooperating with energy providers and network companies in the city itself has been necessary to influence national policy changes that can facilitate the energy transition. By doing so, Amsterdam successfully advanced a net metering policy that allows decentralized generators to provide heat to the district energy network. Oslo is currently advocating for a national policy on zero fossil fuel consumption in buildings to move forward the city’s progressive green agenda and support expansion of the district energy network.
In Milan, many existing buildings already have a centralized heating system. In these cases, besides substituting the existing boiler with a heat exchanger and connecting to the network, no other significant infrastructural work is needed in the shift to district heating. When the existing system has a diesel oil boiler, this shift is cost-effective and has a short payback time (4–5 years). The region previously provided subsidies to promote the switch from diesel oil, but today it is cost-effective enough not to need any financial support.

Energy suppliers offer retrofitting through energy service contracts. However, communication is key to obtaining these agreements, and building owners need to be educated on the benefits of being a customer of a district energy system. The municipality strongly promotes this awareness-raising through its Energy Help Desks, as switching away from diesel oil boilers in order to improve local air quality is a municipal priority.

Energy Help Desks are run by the municipality and provide an information service on energy issues to end-users and residents. Energy experts are available according to a fixed schedule in the institutional offices of the city’s districts, to address any questions and to provide information on potential interventions, available incentives and financing instruments for district heating, energy efficiency and renewable energy. A new central office, opened in September 2014, promotes district heating through information campaigns that elaborate its environmental benefits.

Vilnius, Lithuania, has developed a modernization programme that could cut heat tariffs by 22 per cent and achieve the lowest price for heat in the country at 18.4 Lithuanian cents (0.61 U.S. cents) per kWh, saving the city LTL 150 million (US$50 million) per year (The Baltic Course, 2014).