

Section 3:

BUSINESS MODELS FOR DISTRICT ENERGY: A CONTINUUM FROM PUBLIC TO PRIVATE



The City of Vancouver, for the 2010 Winter Olympics, developed a publicly owned district heating utility that captures waste heat from sewage.

The financial structuring of the project proved the commercial viability of district heating in Vancouver and has encouraged private sector development of district heating elsewhere in the city.

03

KEY FINDINGS

- **THE MAJORITY OF BUSINESS MODELS** for district energy involve the public sector to some degree, and in many cases the public sector has partial or full ownership of the project. The degree to which the public sector is involved is determined in part by how much it may wish to steer a district energy project towards a variety of local objectives.
- **BUSINESS MODELS THAT ARE REPLICABLE AND SCALABLE** both technically and financially at the neighbourhood, city and national levels are key to the acceleration of district energy.
- **THE “WHOLLY PUBLIC” BUSINESS MODEL** is the most common globally. The public sector, in its role as local authority or public utility, has full ownership of the system, which allows it to have complete control of the project and makes it possible to deliver broader social objectives, such as environmental outcomes and the alleviation of fuel poverty through tariff control. Of the 45 champion cities, 18 have or are developing “wholly public” models as the majority district energy model.
- **“HYBRID PUBLIC AND PRIVATE” BUSINESS MODELS** have a rate of return that will attract the private sector, but the public sector is still willing to invest in the project and retain some control. Of the 45 champion cities, 22 have or are developing “hybrid public and private” models as the majority district energy model. These business models can include:
 - a public and private joint venture where investment is provided by both parties that are creating a district energy company, or where the public and private sector finance different assets in the district energy system (e.g., production of heat/cooling versus transmission and distribution);
 - a concession contract where the public sector is involved in the design and development of a project, which is then developed, financed and operated by the private sector, and the city usually has the option to buy back the project in the future; and
 - a community-owned not-for-profit or cooperative business model where a municipality can establish a district energy system as a mutual, community-owned not-for-profit or cooperative. In this model, the local authority takes on a lot of risk initially in development and if it underwrites any finance to the project.
- **“PRIVATE” BUSINESS MODELS** are pursued where there is a high rate of return for the private sector, and require limited public sector support. They are developed as a wholly privately owned Special Purpose Vehicle but may benefit from guaranteed demand from the public sector or a subsidy or local incentives. Of the 45 champion cities, 5 have or are developing “private” models as the majority district energy model. However, many cities also had small private sector projects.
- **BUSINESS MODELS FOR DEVELOPING COUNTRIES** that are beginning to develop district energy typically have strong public sector ownership, as energy markets often are not liberalized and market mechanisms for reflecting the municipal/regional/national benefits are not present. For example, the benefits of reduced peak and total electricity consumption due to district cooling may mean that the publicly owned electricity utility should have a strong presence in the business model.

THIS SECTION LOOKS AT

- 3.1 Introduction
- 3.2 The “wholly public” business model
- 3.3 The “hybrid public and private” business model
- 3.4 The “private” business model
- 3.5 Expanding the business model via additional innovative practices

3.1 INTRODUCTION

The business model for a district energy system is very project-specific. It needs to ensure that all of the players involved – including investors, owners, operators, utilities/suppliers, end-consumers and municipalities – can achieve financial returns, in addition to any wider economic benefits that they seek.



Laying district cooling pipes in Dubai, UAE.

This section provides insight into potential business models and financial structures for project developers in a variety of investment environments. Showcasing innovative approaches from cities around the world can help planners make better-informed decisions on how to develop and financially structure a district energy system. Categorization of such approaches can help planners identify similarities that may apply to their own cities and specific circumstances. This section outlines the business models used in individual projects as well as some city-wide business models (for discussion of the business models of each of the 45 champion cities, see the full case studies available online).

The section builds on the revenues and costs described in section 1.5 and on the role of the city as a provider of energy services, as described in section 2.4.1.

● 3.1.1 CATEGORIZING BUSINESS MODELS

When designing a business model for a new district energy system, it is important to consider site-specific circumstances, including the type of project finance that is available. The majority of business models for district energy involve the public sector to some degree, whether as a local policymaker, planner, regulator or consumer, or more directly through partial or full ownership of projects (see section 2). Public sector involvement can be critical in coordinating multiple, diverse projects around a broader city-wide vision. Even projects with a high degree of private sector control are often still facilitated or supported in some way by the public sector.

Although the business models and ownership structures described here vary significantly, they can be grouped along a continuum from public to private. The relative involvement of the public or private sector depends broadly on two factors: 1) the return on investment for project investors, and 2) the degree of control and risk appetite of the public sector.

RETURN ON INVESTMENT (ROI) FOR PROJECT INVESTORS

The ROI is a financial metric that is dependent on both a project's Internal Rate of Return (IRR) and its Weighted Average Cost of Capital (WACC). The IRR is extremely site-specific and is developed initially by the project sponsor, which could be a private district energy company or private utility, or a public body such as a local authority or public utility. The IRR will depend on the costs and incomes of the project. The WACC depends on the project's risk profile and its current and future sponsors, as well as on the debt-to-equity ratio of its financial structuring. Typically, while private sector investors will focus primarily on the financial IRR of a given project, the public sector, either as a local authority or a public utility, will also account for additional socio-economic costs and benefits that are external to standard project finance.

Table 3.1 categorizes the various business models highlighted in this publication according to the financial ROI and the degree of control and risk appetite of the public sector.

In assembling the project finance for a district energy project, two further considerations need to be made:

- The project needs to be built before it can begin to deliver revenues. This is referred to as the investment/revenue time lag. To reduce this lag, the network should be built from the generation plant outwards, placing priority on any anchor loads.
- The project will likely be developed in stages, requiring waves of capital investment. Taken together with the investment/revenue time lag, enough headroom needs to be built into the model to cope with these fluctuations in investment and to avoid cash-flow problems. This headroom also must account for debt repayments relative to operating income to ensure that the project meets debt service requirements.

DEGREE OF CONTROL AND RISK APPETITE OF THE PUBLIC SECTOR

The public sector may wish to steer a district energy project towards a variety of local objectives (see section 1.2), including: cheaper local energy for public, private and/or residential customers (e.g., the alleviation of fuel poverty); local job creation; local wealth retention; low-carbon power generation; and/or local air pollution reduction. By quantifying these objectives through economic modelling, it is possible to realize additional ROI outside of the standard financial modelling.

The degree of public sector control over a project can vary widely, ranging from full development, ownership and operation (see section 2.4) to a role focused mainly on project coordination, local planning and policy (see section 2.2). The public sector also may wish to showcase the business case for district energy projects in the city by developing demonstration projects (see section 2.3.3). Some cities and countries are more inclined to have energy services provided by public utilities, while others are more open to private sector participation. The degree to which private sector involvement in energy provision is the norm will influence the business model.

The public sector is extremely important in project development because of:

- its ability to leverage finance for projects, such as through access to senior levels of grant funding and better access to capital (see section 2.3),
- its ability to be a large, stable consumer and to provide off-take agreements (see section 2.4) and
- its longer-term planning focus, greater interest in meeting social and environmental objectives and ability to coordinate the multiple stakeholders involved in district energy.

TABLE 3.1 Categorization of business models for district energy systems

FINANCIAL RETURN ON INVESTMENT	DEGREE OF CONTROL AND RISK APPETITE OF PUBLIC SECTOR	TYPE OF BUSINESS MODEL	EXAMPLES
● LOW	↑ High	Wholly public	<ul style="list-style-type: none"> ■ District energy to meet social objectives related to housing or fuel poverty
● MEDIUM / LOW	↑ High	Wholly public	<ul style="list-style-type: none"> ■ Public sector demonstrating the business case of district energy systems ■ Public sector looking to create projects that will improve its cash flow ■ Public sector lowering the IRR by allowing cheaper energy tariffs than the private sector would
● MEDIUM / HIGH	→ Medium	Public/private hybrid	<ul style="list-style-type: none"> ■ Public/private joint venture ■ Concession contract ■ Community-owned not-for-profit or cooperative
● HIGH	↘ Medium / Low	Private (with public facilitation)	<ul style="list-style-type: none"> ■ Privately owned project with some local authority support, perhaps through a strategic partnership

3.2 THE “WHOLLY PUBLIC” BUSINESS MODEL

Of the various ownership models for district energy systems, the “wholly public” business model is the most common globally. Here, the public sector, in its role as local authority or public utility, has full ownership of the system, which gives it complete control of the project and makes it possible to deliver broader social objectives, such as environmental outcomes and the alleviation of fuel poverty through tariff control. The public sector can achieve these objectives by assessing a potential project based on its economic returns.

“Wholly public” projects typically are developed either by a subsidiary of the local authority (such as a pre-existing or newly created public utility), or within a department of the local authority, where they are funded using the authority’s balance sheet. Existing, city-wide public utilities can play an important role in developing district energy and are often kept as separate utilities to identify a difference in their core business practice. In Oslo and Bergen (see case study 3.3), the waste incinerators are publicly owned but are separated from the district energy company, and in Vancouver (see case study 3.1), the wastewater utility is separate from the district energy company. Such separation is important if the system is to be later sold to the private sector. “Wholly public” projects are common in both consolidated and refurbishment cities, and their existence reflects the city’s desired degree of control over the provision of thermal energy.

This section focuses on the project-level investments that these existing utilities make, as well as on the creation of new public utilities in expansion cities (15–50 per cent market share of district energy) or new cities (0–15 per cent market share of district energy). The “wholly public” ownership model also can be used to demonstrate the business case for district energy systems within a city (see case study 3.1 on Vancouver).

RISK AND GOVERNANCE: In the “wholly public” business model, the city takes on most of the risk associated with the investment. In expansion or new cities, if a project has a low IRR, typically in the range of 2–6 per cent, an internal department of the local authority can develop and operate the project to reduce administrative costs (see case study 3.2 on London). Consolidated cities develop such projects via the public utility, and the low return is spread across other projects that have higher IRRs.

Projects with a higher IRR in expansion or new cities are being developed by creating a “Special Purpose Vehicle” (SPV) or subsidiary (such as a new public utility) to reduce the administrative burden on the local authority, with governance typically overseen by a board of directors that represents the local authority. Shifting to a subsidiary can provide additional benefits, including limiting the city’s financial liability in the event of project failure, increasing the flexibility and speed of decisions, and offering greater transparency and a more commercial operation. The local authority can outsource the technical design and construction (and sometimes operation) of the project to reduce risk related to the delivery cost and time frame.

In some cities, such as Bergen (see case study 3.3), multiple neighbouring municipalities have ownership over the utilities that provide district heating. This reflects the ability of district energy to supply multiple cities through interconnection.

Because a city typically has a high degree of control over the demand groups targeted for district energy – particularly any anchor loads that are connected – energy demand is typically lower risk (see section 2.4.2). Moreover, customers are connected that may not be prioritized under a private scheme, such as customers with a low connection capacity or those in social housing (e.g., Brest). The local authority may take a utility approach to tariffs by applying a standard charge for a specific customer group, such as residential consumers, allowing for more equitable billing (rather than, say, basing the connection charges and tariffs on a building’s location within the network). This also encourages expansion of the system: because network costs are borne by all users equally, more connections will lower the overall cost.

SOURCES OF FINANCE: A district energy project with a low IRR will compete for financing with other projects that the local authority is considering. To the extent that a district energy system contributes to a city’s strategic objectives – such as reducing carbon, improving resilience or energy security, or providing affordable heat supply – projects often leverage the city’s cash reserves and/or public debt raised based on the balance sheet of the local authority. The lower interest rate of public debt is why many proponents of district energy systems argue that cities can (and should) be investing in this way (see section 2.3), and why several district energy models are locally led.

For example, the £3.5 million (US\$5.6 million) connection between London’s publicly owned Westminster and Pimlico heat networks (see figure 2.4)

VANCOUVER

CASE STUDY 3.1

SEFC NEU IN VANCOUVER:
A “WHOLLY PUBLIC” MODEL

The City of Vancouver created and fully owns the South East False Creek Neighbourhood Energy Utility (SEFC NEU), which developed, owns and operates a district heating network based on various renewable sources. The network currently captures waste heat from a relocated and expanded sewer pump station that is co-located with the NEU Energy Centre; however, it has been designed to accept heat energy from future new connections of waste heat and renewable energy sources.

The city opted to develop the district heating system for several reasons. A tight development schedule (in time for the 2010 Winter Olympics) meant that there was insufficient time to secure a private utility and to obtain the necessary approvals for a private system. The city also wanted to showcase new models of heating and to prove their commercial viability by developing a demonstration project. Moreover, the city was able to secure considerable grants and low-cost financing.

The system became fully operational in 2010, only five years after the first feasibility study. The City of Vancouver controlled 17 per cent of the initial system load (25 per cent of the initial floor area) and, as part of a neighbourhood-wide development plan, was able to implement a service-area bylaw to ensure connection of the remaining loads (see section 2.2.4). An estimated 90 per cent of the area’s heating floor space is residential (servicing some 16,000 people), in addition to commercial and institutional facilities. Because the network is publicly owned, connection costs and energy tariffs are transparent, enabling the city to provide building owners with tariff cost comparisons and evidence of savings (e.g., from not having to build and maintain boilers or on-site systems). This encouraged new connections, including from private developers, who often are not interested in building risky heating systems and/or losing control over heat production.

The total cost of the project was CAD\$32 million (US\$31 million) in 2010, with the costs fully covered through utility customer rates. The utility was 100 per cent financed by debt that the City of Vancouver raised through its strong access to credit; however, the rates on the debt were structured as if the project was financed by 60 per cent debt and 40 per cent equity. This was done to demonstrate commercial viability to the private sector and also to give the city flexibility to divest at a future date without any impacts on customer tariffs. The 60:40 ratio is based on the regulated capital structure of private utilities in British Columbia.

The debt raised by the city included: CAD\$17.5 million (US\$17 million) at 5 per cent interest from the Capital Financing Fund, an internal city fund; a CAD\$10.2 million (US\$9.9 million) loan at a low interest rate from the Government of Canada’s federal Gas Tax Fund; and a CAD\$5 million (US\$4.9 million) loan at 1.7 per cent interest from the Federation of Canadian Municipalities Green Municipal Fund. The return allowed to equity was set at 10 per cent, reflecting a baseline 8.47 per cent return set by the British Columbia Utilities Commission for low-risk benchmark utilities, and a 1.53 per cent risk premium determined by the NEU related to construction, operating, financial and revenue risks (Seidman and Pierson, 2013).

Since the development of the SEFC’s district heating network as a demonstration project, one additional district heat network (River District Energy) has been privately developed in the city. The owners of two legacy steam-heat systems also are establishing plans to convert these from natural gas to renewable sources of energy.

SEFC NEU Energy Centre



(Arup, 2014), which aims to improve efficiency through pooled networks, will be far cheaper through public backing (an IRR of 16.6 per cent) than private sector financing (an IRR of 9.24 per cent), even though the anticipated cash flow revenues are the same in both cases. The difference is due to lower risks and financing costs because of public backing.

Public projects with higher IRRs that have been developed as an SPV may be able to afford some commercial or blended debt, taking some of the risk burden off the local authority. Alternatively, projects may be completely or partially financed publicly but with rates that are artificially high, so that they represent rates similar to commercial debt and with ROIs for equity at similar levels as in the private sector (see case study 3.1 on Vancouver). Under such a financial structure, a project can demonstrate the commercial viability of a district energy system while still benefiting from the local authority's complete involvement.

CONTROL: Because the local authority or public utility has complete control and ownership of the district energy project, it has the benefit of receiving all of the profits, which it can then either reinvest in the project (e.g., to reduce energy tariffs) or use to fund other projects. Once the project is built out, costs and revenues will stabilize, and the project will have an asset value above the level of the investment. This provides the local authority with several choices moving forward:

- Continue operating the project, which allows the local authority to retain control of energy tariffs and to use the returned profits to fund other projects.
- **If the project was initially set up as an SPV or subsidiary, then it is easier to sell the project to the private sector.** Assets can be pooled or split, and control of the project can shift (to varying degrees) to the private sector. Such a move could free up funds at the local authority for other projects and is the principle behind a revolving fund (see section 2.3.1). Allowing private actors to partially own the project (i.e., becoming

a public-private partnership) also may result in higher returns, as private actors bring different experiences and may help the company to expand (see case study 3.9 on Cyberjaya). In 2011, Warsaw sold an 85 per cent share of its publicly owned district heating utility to provide funds for essential upgrades to the network (see section 2.3.2).

- If the project was not initially set up as an SPV, then the local authority could establish a company limited by shares and then transfer ownership of the assets to that company, which can then be fully or partially sold to the private sector.
- Finally, there might be a desire for the company to be owned by the community, in which case the shares can be transferred to community organizations. Alternatively, the company may be established as a not-for-profit company limited by guarantee, with members instead of shares.



LONDON

CASE STUDY 3.2

BUNHILL HEAT AND POWER IN LONDON: A "WHOLLY PUBLIC" MODEL

After undertaking a series of heat-mapping exercises of London's Islington Borough, the local Council prioritized the development of a "cluster" of heat comprising five Council-owned housing estates that had existing communal heating systems, as well as two Council-owned leisure centres, including a swimming pool. The resulting district heat network uses a 1.9 MW_{el} CHP plant with thermal storage and serves 850 apartments in addition to the two leisure centres. A second phase being developed will utilize waste heat from a city-owned subway line and a privately owned electricity switching station (Islington Council, 2013).

Islington Council considered connecting the project to an existing, nearby heat network, but because that network charged a high tariff for its heat, the Council would have been unable to meet its affordable warmth objectives. Instead, the Council developed the project internally, as this was deemed far cheaper (by 55 per cent), but it tendered the design, construction and operation of the network (over 10 years) to an external contractor.

The first phase of the project was fully funded by the Council in cash within a discretionary budget, as it was felt that any debt on the project could raise heat tariffs outside the affordable warmth objectives. The first phase also benefited from £4.2 million (US\$6.7 million) in grants from the London Development Agency (now dissolved) and the Homes and Community Agency. The second phase has been funded in cash by the Council (£2.7 million, or US\$4.3 million) as well as from an EU Project CELSIUS grant (£1 million or US\$1.6 million) (Islington Council, 2014). These grants were critical to delivering the project at the tariffs required for affordable warmth objectives.



BERGEN

CASE STUDY 3.3

BKK VARME IN BERGEN: A “WHOLLY PUBLIC” MODEL

In 2003, an SPV, BKK Varme AS, was created to own and operate Bergen’s district heating network. Under a 35-year contract, it receives all of the heat produced by a waste incinerator owned by BIR Avfallsenergi. This heat, piped to the network through a 12 km pipe, constitutes the majority of the heat needed in the district system. The waste incinerator produces electricity and heat but maximizes heat delivered to the network to meet demand. The incinerator burns waste as it arises in Bergen, rather than storing summer waste for incineration in winter when heat demand is higher (as Oslo does).

Although BKK Varme AS is effectively a public utility, the local authority has limited involvement in its management and operations. BKK Varme has two owners: BKK AS, an electricity utility based in Bergen; and BIR AS, a waste management company that owns BIR Avfallsenergi. BKK AS and BIR AS are owned by multiple local authorities, but these authorities do not use their shareholding to direct activities towards local policy objectives. However, the local authority in Bergen has targeted district heating growth in its Climate Action Plan and needs to prioritize and stimulate the use of district heating.

Municipalities directed BIR AS to use energy from the incinerator at an efficiency level of 80 per cent, higher than the 50 per cent required in Norwegian law. Both of these efficiency shares require the use of heat and not just electricity production. After unsuccessfully approaching various industrial players to obtain the heat, BIR AS approached BKK AS to explore the creation of district

heating. The 80 per cent efficiency requirement was considered a crucial factor in the development of district heating.

The local authority granted BKK Varme AS a permit to enable it to connect new buildings to the network. BKK Varme AS has been granted two additional permits, for heat generation from waste wood, in two suburbs of Bergen.

Approximately 25–30 per cent of Bergen’s connected load is from a hospital, which is the location of backup gas boilers. Although this anchor load is important to the business model, it is not viewed as crucial. BKK Varme AS focuses on connecting older buildings that have water-based heating systems (heated by oil, backed up with electricity), as these are far easier to connect than electricity-based systems. The resulting reduction in backup electricity and the connection of new builds has led to avoided network costs. Although initially there was interest in capturing some of these benefits in the business model, it was deemed too difficult

The initial phase of district heating development in Bergen, consisting of the pipeline from the incinerator to the city as well as 100 GWh per year of connected demand, cost NOK600–700 million (US\$84–98 million) and benefited from a national grant of NOK12 million (US\$1.7 million), or 2 per cent of costs. Since the development of BKK Varme AS, the Norwegian government has begun to provide grants of up to 20 per cent through a publicly owned company, Enova. BKK Varme AS will invest NOK200 million (US\$32 million) in district heating and cooling up until 2025 (Hawkey and Webb, 2012).



CASE STUDY 3.4

RENEWABLE HEAT IN BREST: A "WHOLLY PUBLIC" MODEL

The city of Brest and adjacent small cities, collectively known as Brest Métropole, developed a district heat network around the commissioning of a waste incinerator in 1988 that produces 130 GWh of heat (equivalent to 20,000 households) and 20 GWh of electricity per year. The waste-to-energy plant serves 85 per cent of the heat demand in Brest Métropole's 25 km heat network, and, through substitution of fossil fuels, the plant saves 20,000 tons of CO₂ per year. Because over 50 per cent of the district heat is from renewable energy, the system benefits from a reduced VAT rate of 5.5 per cent (normally VAT would be 20 per cent). This is the same VAT reduction that the Paris Urban Heating Company (CPCU) is trying to achieve (see case study 2.10).

The network has plans to double in size by 2017 to 45 km, with additional renewable heat capacity such as seawater heat pumps and biomass boilers added as well as 5 MW of heat storage delivering 2.4 GWh of heat per year during peak demand. This increase in size represents €29 million (US\$36 million) of investment in the network: €20 million (US\$25 million) from the city of Brest to be amortized over 25 years and €9 million (US\$11 million) from a grant (see section 2.3.1).

The network and all production sites are owned by Brest Métropole, which sets the tariffs to promote district heating and connect social housing. The whole system is operated by SAS Dalkia Nord Finistère (DNF), a company that is 49 per cent owned by Sotralval, a subsidiary company of Brest Métropole, and 51 per cent owned by Dalkia, a multi-national energy service company. Dalkia provides the technical expertise in operating the district energy system and also advises Brest Métropole on future investments that the city could make to the system. In this way, the city maintains ownership of the system and controls its future development while benefiting from advice on future extensions from an experienced business partner.

The original section of the network was financed by Dalkia and the new extensions of the network are now financed by Brest Métropole, as the previous contract between Dalkia and the city did not permit a return on any additional finance committed by Dalkia.

3.3 THE "HYBRID PUBLIC AND PRIVATE" BUSINESS MODEL

If a district heating system's technical feasibility study and financial modelling indicate that the project has a return on investment that will attract the private sector, it may be desirable to adopt a "hybrid public and private" model. Here, the local authority is willing to carry some risk and has a desire to exercise some control, but it also wants private sector participation to bring in expertise and/or private capital. A challenge with such projects is ensuring that all parties have a clear, agreed vision of what the objectives are and how they will be achieved.

Under the hybrid approach, the local authority has a wider range of options for business models. Three options discussed here are the public and private joint venture, the concession contract, and the community owned not-for-profit or cooperative.

● 3.3.1 PUBLIC AND PRIVATE JOINT VENTURE

The joint-venture model typically involves the creation of an SPV, with ownership split between the public and private sector.

RISK AND GOVERNANCE: Risk can be shared between partners, each of which may have a skillset related to that risk. The public sector (i.e., local authority) can underwrite the sales risk, guaranteeing to commit to long-term heat/cool off-take contracts, and can deal with regulatory barriers to project development. The

private sector party, meanwhile, can take on the design, construction and operation risk, transferring this risk away from city taxpayers and on to private sector equity holders. The private party can also benefit from connecting to the network, providing the project with guaranteed demand and potentially granting itself preferential rates.

In a pooled asset model, such as with Empower in Dubai (see case study 3.6), the different actors combine skillsets through a single company or utility. In a split asset model, these skillsets are separated into the different functions of the district energy system, such as the public sector being responsible for waste incineration and transmission (see case studies 3.7 on Anshan and 2.11 on Rotterdam) and the private sector for CHP heat production (see case study 4.4 on Yerevan). Between these entities, contracts will exist that define off-take and tariffs.

SOURCES OF FINANCE: In this model, both the private and public sectors provide equity. Debt is based on the project's future cash flow but can be underwritten by either party. The presence of the public sector can mean that other sources of finance become available, such as grants, local authority debt and development bank loans. The city also can offer land as an equity contribution to joint ventures, which can help provide collateral in raising financing. Further, the city can provide specific tax incentives that in effect could act as a source of finance. In a split asset model, each entity will be responsible for sourcing finance for the district energy functions they control.

■ **CONTROL:** In a pooled asset model, governance is typically via a board of directors appointed by each project partner, with board representation reflecting the ownership split and the public/private hybrid model. The exit strategy is either to continue with the status quo, to sell out to the partner or other private sector interests (see case study 3.5 on Toronto) or, conversely, to buy out the partner so that the district energy project becomes wholly municipal.

● 3.3.2 CONCESSION CONTRACT

Under the concession contract model for the private sector, the public authority typically develops a feasibility study of the district energy project and then tenders it to the private sector (usually an energy service company, or ESCO) as a concession that runs for a specified term (see case study 3.8 on London's Olympic Park). The concession contract model for the public-private sector is very similar but usually involves the creation of a utility that is a mixture of public and private ownership (although it can just be public) (see case study 3.9 on Cyberjaya). For example, Empower in Dubai was created through a Royal Decree issued by the Ruler of Dubai and has a concession of 25 years, which may allow the city to buy the 30 per cent stake that is private (see case study 3.6). This utility is then given the concession for the district energy development for a specified time period.

A concession model is particularly applicable for retrofit projects in towns and cities where public streets are used for network routes and where residential, institutional and commercial buildings are connected. The concession provides the option of the city buying back a project after the concession period.

RISK AND GOVERNANCE: In this model, the ESCO or utility with the concession (private sector or public-private) bears completely the risks of designing, building and operating the district energy system. The presence of the local authority as designer of the concession contract is likely to mitigate many of the risks associated with gaining project approvals. The ESCO may be limited in the tariffs it can charge due to local competition or by contractual levels set to avoid monopolization of energy distribution.

The fact that the local authority ultimately may own the system, as well as the contracting/financing complexities associated with a concession model, means that the local authority still takes on significant risk. Additionally, the ESCO may transfer risk to the local authority by requiring guaranteed revenues (via a connection policy). For example, the new development of district energy in Christchurch is expected to be designed, delivered and funded by the private sector, although public facilities will serve as the anchor loads. The local authority is developing feasibility studies and procuring private sector partners to deliver the project.

SOURCES OF FINANCE: ESCOs can vary greatly in size, and this will affect how they finance the district energy system. Large ESCOs have large amounts of capital, allowing them to finance projects internally rather than having to borrow on a project-by-project basis. Large ESCOs evaluate projects individually and will treat each system as a profit centre; however, they rely on their overall corporate balance sheet to raise the capital for system development (Seidman and Pierson, 2013). As with public-private partnerships, the city can provide land to the ESCO, which may then be used to accelerate development and potentially reduce energy tariffs.

CONTROL: The local authority may have limited control of the concession during the concession period. At the end of the term, the assets can be returned to the local authority through a sale. The local authority then has the choice of placing the assets in municipal or community ownership or issuing a fresh concession.



TORONTO

CASE STUDY 3.5

ENWAVE ENERGY CORPORATION IN TORONTO: A POOLED ASSET MODEL

The Toronto District Heating Corporation (TDHC) was originally a non-profit, publicly owned entity that combined the heat networks of five hospital and university campuses. However, legislation limited the power of TDHC in the area of long-term financing, impeding its ability to implement innovative solutions. As a result, TDHC was restructured into the for-profit Enwave Energy Corporation, with 43 per cent city ownership and 53 per cent ownership by BPC Penco Corporation (a subsidiary of the Ontario Municipal Employees Retirement System pension fund). The creation of Enwave has allowed for innovative solutions in cooling, as well as for longer-term financing. Since 1981, it had been known that lake water could be used for cooling in Toronto, yet no significant financial backing was available for such a project. Starting in 2004, Enwave

enabled the development of a deep-water cooling system that is integrated with the city's drinking water system, providing the equivalent of 75,000 tons of refrigeration (263 MW) to large banks and data centres, which require high levels of reliability and stability. The system was financed by public and private bonds, with customers required to sign contracts or letters of intent in order for the company to secure financing. The City Council and Penco have since exited the project, selling Enwave to Brookfield Asset Management for CAD\$480 million (US\$429 million). This netted the City Council CAD\$168 million (US\$150 million), or CAD\$100 million (US\$89 million) more than it had invested.



DUBAI

CASE STUDY 3.6

EMPOWER IN DUBAI: A POOLED ASSET MODEL

Dubai has developed the world's biggest district cooling network, meeting a demand equivalent to 1 million tons of refrigeration annually (3,510 MW). The network requires just half the energy of the air-conditioning units it replaces, and thermal storage makes it possible to reduce electricity use during peak hours. This has enabled Dubai to limit growth in its electricity transmission network – a key objective of the district energy system. The network was created through a public-private partnership between TECOM Investments, a real estate developer and the operator of Dubai's leading business parks, and the public utility Dubai Energy and Water (DEWA). The resulting SPV, called Empower (Emirates Central Cooling Systems Corporation), represents 70 per cent ownership by DEWA and 30 per cent ownership by TECOM. Empower designs, builds and operates Dubai's district cooling network under a 25-year concession contract, with an anticipated ROI of 10–12 per cent over the contract period. The majority ownership by DEWA means that the city's objectives can be fulfilled: the network is built to be expandable and flexible; it uses innovative technology to replace potable water with recycled water such as treated sewage effluent (TSE); it uses energy efficiency measures

to reduce cooling demand; and there is a significant focus on research and development. Both DEWA and TECOM provide anchor loads, including significant loads from government buildings. In addition, the presence of the public sector has been combined with regulations requiring new developments to connect to the district cooling system. Although the use of TSE is very beneficial, it poses potential challenges because the effluent is also used for agriculture in the region (particularly during the summer months when cooling demand is also higher). Housing developers in Dubai sparked the initial demand for district cooling, as they can benefit from the service and maintenance charges associated with supplying their developments with cooling. Through use of an innovative energy efficiency policy, Empower has developed a cooling network that is profitable whether user demand increases or remains the same. Empower actively encourages efficiency measures for cooling – a business model that would not be possible without DEWA's presence in the partnership, since energy efficiency is seen as beneficial to the city. Empower runs campaigns to encourage end-users to be more energy-efficient and will lower the contract price of cooling if a user consumes less than the anticipated amount over three years.

ANSHAN

CASE STUDY 3.7

DISTRICT HEATING IN ANSHAN:
A SPLIT ASSET MODEL

Currently, district heating in Anshan is dominated by a few large district heating companies, some of which are owned by the city and some of which are privately owned. These networks are separate and typically are fuelled by inefficient coal boilers that are not optimized for the load on the network. To modernize its district energy system, Anshan plans to utilize some 1 GW of surplus heat produced by the local Angang Steel plant to heat 50 million m², or some 70 per cent of the city's total heating area. Angang Steel would become the largest heat source for the city.

The local government has been working with Danfoss, a Danish district energy company, and COWI, a Danish district energy consultancy, to develop additional sustainable and integrated heating solutions for the city. The local government is catalyzing this use of waste heat through the development of a new transmission line to capture excess heat, initially from the Angang Steel plant. This transmission line will be owned 60 per cent by the municipally owned Qianfeng district heating company and 40 per cent by FUAN, a private company.

The transmission system will enable future development options such as the connection of geothermal resources as well as two planned CHP plants in the city's north and south. Local heat networks will then tap into the new transmission line, with the networks' existing coal boilers used as peaking boilers on local networks. Many of the existing boilers will be improved and replaced with larger, more-efficient models. The current separated networks suffer from high demand volatility due to the smaller numbers of users, and pooling the networks will reduce the ratio of peak load to base load. Currently, domestic hot water is typically prepared using electric or gas boilers at the individual household level;

the revamped district heating will replace some of this production.

The new heat-capture project represents a US\$64 million investment in a more efficient system that aims to lower carbon intensity and improve local air quality. The local government is providing the finance for the project. A short payback period of three years highlights the significant financial benefits that the project will bring as Anshan closes the loop on waste heat and simultaneously reduces the city's coal consumption by a projected 1.2 million tons. The project will be connected in stages, with 6.7 million m² connected in phase one and 10 million m² in phase two. Angang Steel will receive a set heat tariff for the waste heat of CNY0.11 (1.8 U.S. cents) per kWh. The capital cost of extracting the waste heat from the company's steam turbine will be CNY10 million (US\$1.64 million), only 2.6 per cent of the project's total cost.

In Anshan, the local government's role in ownership of the transmission system has been critical in capturing Angang Steel's waste heat and allowing the optimization of the district energy system in the city. The split-ownership model of private sector production and distribution allows the local government to focus efforts on the transmission line. The provincial government in Liaoning Province, where Anshan is located, has supported the actions of the Anshan government and attaches great importance to the use of industrial surplus heat. Since early 2014, the provincial government has cooperated with Bengang Steel, the city government of Benxi and Danfoss on the province's first replication project, with a scope of 160 MW of surplus heat.

Source: Danfoss, 2014





CASE STUDY 3.8

LONDON'S OLYMPIC PARK: A PRIVATE CONCESSION CONTRACT MODEL

When London's Olympic Development Authority (ODA) assessed the available options for procuring energy for the 2012 Olympic Games, it determined that a long-term concession would result in more cost savings than procuring infrastructure from incumbent utility companies, or engaging in competitive procurement for short-term design-and-build contracts. During the feasibility stage, ODA decided to develop a district heating system, with a limited district cooling network, by installing two tri-generation combined cooling, heat and power (CCHP) energy centres at Stratford City and Kings Yard on the Olympic Park, in combination with large thermal storage.

Two public authorities – ODA and Stratford City Development – engaged in a competitive procurement process for a single, 40-year concession contract to finance, design, build and operate the heating and cooling network and associated energy centres. Applications had to be based on the designs developed by ODA during the feasibility process, although additional applications could be made with a different design. Although biomass gasification and waste-to-gas were considered initially, the scale of demand of the energy centres was deemed too risky for these renewable sources, and no such tenders were received. A 3.5 MW wood chip boiler provides baseload power, adding a renewable element to the investment.

The contract was awarded to the energy service company Cofely, with the resulting concession agreement between Cofely, Stratford City Development Ltd and ODA. Cofely was granted exclusivity to supply heat and cooling for all buildings within Athletes Village, Olympic Park and Stratford City. Because district energy is not regulated in London, the concession provides connection, supply and service levels. Public land and guaranteed connections enabled the financial viability of the project, which cost over £100 million (US\$160 million) and was fully financed by Cofely.

The two energy centres are designed to eventually provide a maximum of 200 MW of heat (up from 100 MW today), 64 MW of cooling (up from 18 MW today, reflecting a 4 MW absorption chiller supplemented by two 7 MW ammonia chillers) and 30 MW of low-carbon electricity (up from 3.5 MW today). In addition, 27.5 MWh of heat storage and 4.7 MWh of cool storage have been developed. The energy centres currently run on gas but are designed to switch between gas and biomass in the future. Most consumers are expected to save 5–10 per cent on their overall energy bills.



CYBERJAYA

CASE STUDY 3.9

PENDINGINAN MEGAJANA SDN BHD
IN CYBERJAYA: A PUBLIC-PRIVATE
CONCESSION CONTRACT MODEL

Malaysia is pioneering district cooling systems to tackle rising electricity demand from air conditioning, which accounts for 30–50 per cent of energy demand from buildings nationwide. Over the past 20 years, the country has installed 11 district cooling systems with a capacity of 190,000 tons of refrigeration (667 MW).

The city of Cyberjaya, located about 50 km south of Kuala Lumpur, implemented district cooling in 1998. It commissioned a local energy service company, Pendinginan Megajana Sdn Bhd (a wholly owned subsidiary of Cyberview Sdn Bhd, which is 92 per cent owned by the Malaysian Ministry of Finance), under a build-own-operate concession, where ownership of the equipment remains with the company. The primary goals were to reduce the capital costs of separately installed individual chillers, to lower operating costs and to demonstrate viability.

The system comprises two district cooling plants with a total chiller capacity of 18,300 refrigerant tons (64.2 MW), built in two stages between 1998 and 2012 and complemented by ice storage (35,500 refrigeration ton-hours; 125 MWh), cold water storage (39,000 refrigeration ton-hours; 137 MWh) and 15 km of pipeline. The system serves 38 large customer

buildings in Cyberjaya. Total project investment between 1998 and 2012 was around US\$50 million, and the project had an IRR of 11.7 per cent over a project duration of 30 years, with a payback period of 8.2 years.

As a result of the project, chiller peak electricity demand has been reduced by 3 MW, and the capital cost for the installed chillers is 18 per cent lower than for using individual chillers. Thermal storage for demand-side management enabled the production of chilled water and ice at reduced costs during the evening, taking advantage of the night-time tariff (which is less than half of the peak-time tariff). It is estimated that 60 per cent of a regular office’s utility bill goes to air conditioning alone, and for data centres, this can reach 80 per cent. Annual cost savings through district cooling are 39 per cent compared to stand-alone systems (ADB, 2013).

Demand for district cooling in Cyberjaya is anticipated to grow by another 10,000–15,000 refrigerant tons over the next three years, which means more plants in the pipeline. The energy service company Cofely recently acquired a 49 per cent stake in Pendinginan Megajana Sdn Bhd. Cofely is anticipated to help develop larger district cooling systems in Cyberjaya (Cofely, 2013).

3.3.3 COMMUNITY-OWNED NOT-FOR-PROFIT OR COOPERATIVE

As another option, a municipality may wish to establish a district energy system as a mutual, community-owned not-for-profit or cooperative. In Copenhagen, all retailers of heat are required to be not-for-profit mutuals, cooperatives, or municipally owned (see case study 3.10).

RISK AND GOVERNANCE: In the not-for-profit or cooperative model, the local authority initially takes on a large share of the risk. Once the mutual is well established, risks to the local authority decrease. Some risks can be passed through to contractors for design and construction.

SOURCES OF FINANCE: In this model, the municipality may need to underwrite the risk, as start-up entities will not have the same covenant strength as the municipality to secure low-cost finance. Once the mutual has paid off this lower-rate finance, the risk on the local authority is lowered significantly. The presence of the local authority can leverage low-cost funds for the project, as occurred in Aberdeen (see case study 3.11).

CONTROL: The governance structure is via representatives elected by the members. In return for debt underwriting, the local authority may require or be offered representation on the board.



Stroget Street, Copenhagen, Denmark.



CASE STUDY 3.10

HØJE TAARSTRUP FJERNVARME IN COPENHAGEN: A COOPERATIVE MODEL

Høje Taarstrup Fjernvarme, one of Copenhagen's largest heat companies, was formed in 1992 by the merger of a cooperative district heating company and a municipal one. Høje Taarstrup Fjernvarme purchases heat from the municipally owned transmission company, which itself buys heat from privately owned power stations in the surrounding areas. Høje Taarstrup Fjernvarme then distributes the heat to its 5,260 customers, including residential, commercial and industrial buildings. Customers connect via an agreement under which they become a member-owner of the cooperative. The governing board is made up of seven members elected by customers and two members nominated by the local authority.

The municipality provides the mutual with a guarantee that underwrites the risk. This allows it to obtain low-cost financing at 1.5 per cent from a mortgage company (a mutual bank); without the guarantee, it would have to pay 2.5 per cent. In 2012, Høje Taarstrup Fjernvarme made a profit of £189,000 (US\$302,000) on heat sales totalling £18.25 million (US\$29.2 million). The low profit margin is because a benefit is passed to the owner-members in the form of low heating rates. The company also provides grants for demand-side energy efficiency projects.

District heating in Denmark has strong legislative backing under a series of Heat Laws. Municipalities are required to undertake heat mapping, using the results to determine the appropriate energy distribution infrastructure. Building owners, including householders, are obliged to connect. This removes a significant risk to the development and financing of district heating projects. To counter the potential for monopoly abuse, all retailers of heat are legally obliged to be not-for-profit and are therefore either cooperative, mutual or municipal companies. The municipal companies own and operate the transmission and/or distribution systems, while the cooperatives and mutuals undertake the retailing of heat directly to customers. Although heat retailers do not compete for customers, they do compete with each other to deliver the lowest heat prices. This is overseen by the Danish Energy Regulatory Authority, which publishes annual lists of the heat prices offered by retailers.



3.4 THE "PRIVATE" BUSINESS MODEL

If a local authority has a proposed district energy project with a high return on investment (usually between 12 and 20 per cent, although it can be 9.5 per cent for lower-risk projects), but the local authority has a low risk tolerance and a relatively low desire for control, it may be able to attract interest from private sector companies. This does not mean that the local authority is removed from the project; many successful privately owned district energy systems still have arms-length local authority involvement. For example, the local authority may have been the original project proponent and/or it could still attract financing and grants for the project. The local authority may help with any connections deemed socially optimal that are too high risk for the private sector. It could also develop initiatives that encourage social or environmental objectives, such as mechanisms that support low-carbon generation.

This section discusses some examples of wholly privately owned SPVs for district energy.

● 3.4.1 WHOLLY PRIVATELY OWNED SPV

When designing a business model for a new district energy system, it is important to consider site-specific circumstances, including the type of project finance that is available. The majority of business models for district energy involve the public sector to some degree, whether as a local policymaker, planner, regulator, or consumer, or more directly through partial or full ownership of projects (see section 2). Public sector involvement can be critical in coordinating multiple, diverse projects around a broader city-wide vision. Even projects with a high degree of private sector control are often still facilitated or supported in some way by the public sector.

Although the business models and ownership structures described here vary significantly, they can be grouped along a continuum from public to private ownership. The relative involvement of the public or private sector depends broadly on two factors: 1) the return on investment for project investors, and 2) the degree of control and risk appetite of the public sector.

RISK AND GOVERNANCE: In this model, risk is carried by the private company, although the company could enter into a Joint Cooperation Agreement (JCA) with the local authority to mitigate risks in planning or expansion, or to encourage connection of demand through planning policies. This is often called a Strategic Partnership Model. In return, the local authority may benefit from reduced tariffs, profit sharing, connection of customers with higher credit risk (who are more likely to be in fuel poverty), and other social or environmental objectives.

SOURCES OF FINANCE: Financing is provided by the private sector company, through either inter-company debt or external commercial debt. The private sector company may require a capital contribution in the form of a connection charge for any public buildings connected to the network. Local or national authorities may be able to attract international loans or grants for the project (see case study 3.12 on Port Louis).

CONTROL: The private sector company determines the governance structure, since the project is wholly owned by the company. The governance structure may include offering the local authority a minor representation on the board of an SPV or on a local project board if the company has entered into a JCA with the local authority.



Port Louis, Mauritius



ABERDEEN

CASE STUDY 3.11

ABERDEEN CITY COUNCIL: A NOT-FOR-PROFIT MODEL

In 1999, Aberdeen City Council adopted an Affordable Warmth Strategy to tackle fuel poverty in the city. The Council commissioned a study to identify the technical solution best able to deliver low-cost heating to residents. This identified water-based communal heating systems connected to CHP. Although the Council could afford to install this technology in one cluster of blocks, it could do so only at the rate of one project every 12 years due to capital constraints. Commercial energy service companies could access third-party investment to accelerate deployment, but the returns required would result in high heating charges to residents, undermining the objective of reducing fuel poverty. The Council therefore established an arms-length not-for-profit company, limited by guarantee based on membership. Members were drawn from the local community, including residents, who nominated board directors, with two seats reserved on the board for the Council.

For the first project, serving 289 apartments in four blocks at Stockethill, the Council entered into a contract with the company to deliver the project based on an annual payment of £219,000 (US\$350,000) over a 10-year term. Based on the security provided by this contract, the company was able to take out a capital loan of £1 million (US\$1.6 million) to deliver the project at a rate of return similar to that available to the City Council. At that point, a government-funded capital grant programme unexpectedly became available, and the company was able to spread the loan finance over two more projects, blending it with grants and the funds otherwise intended for refurbishing the heating systems under the Council's capital investment programme for upgrading the stock.



PORT LOUIS

CASE STUDY 3.12

PORT LOUIS'S SEA WATER AIR CONDITIONING (SWAC) PROJECT: A "PRIVATE" BUSINESS MODEL

As part of the road map to develop its "ocean economy", Mauritius is initiating a district cooling system that would use sea water for air-conditioning purposes. The first-of-its-kind SWAC project on the island (and in Africa) will pump water at 5°C from 1,000 metres below sea level to cool buildings in the heart of the capital city, Port Louis. The system is expected to provide cooling, through 5.5 km of pipes, to some 60 high-density buildings (both public and private) in the city by 2016.

The project will allow Mauritius to reduce its power supply, provided mostly through fossil fuel-based plants, by about 26 MW. This represents 6 per cent of the country's forecast peak electricity demand in 2014 of 464 MW (National Assembly, 2011). It will also enable the City of Port Louis to reduce its carbon footprint by 40,000 tons of CO₂ annually. The water pumped from the sea will be made available to entrepreneurs to promote and develop various applications in the field of ocean industries (Cunha, 2014).

The SWAC system is being developed by a local company, Sotravic Ltd., at an estimated cost of MUR4 billion (US\$130 million) and will be financed mainly through private funding from local banks and international financial institutions. The role of the government of Mauritius is to promote the scheme to attract concessional finance from development banks. Already, the African Development Bank's Sustainable Energy Fund for Africa (SEFA) has given a project preparation grant of US\$1 million to finance the initial development stage of the SWAC system in Port Louis (Ah Sue, 2014; Capital, 2014; AfDB, 2014). The project is expected to be extended to a second city, Ebene, to replace the conventional air-conditioning systems of data centres.

3.5 EXPANDING THE BUSINESS MODEL VIA ADDITIONAL INNOVATIVE PRACTICES

Countries can pursue district heating and cooling through a variety of business models, and the choice of model will depend on the economic and financial returns on investment as well as on the degree to which the public sector wishes to control the district energy project.

In developing countries, there is huge potential for district energy in both cooling and heating, depending on the local climate and requirements. Energy markets in many of these countries are less liberalized and significantly less privatized than in developed countries. As has been highlighted throughout this report, district energy requires strong public sector involvement in project development and operation, and the model of publicly owned energy services in many developing countries may provide a strong platform for project development. In some countries, problems such as access to capital, expertise and institutional inefficiencies may need to be addressed.

District cooling has huge potential in both developed and developing countries. In Kuwait City, for example, air-conditioning demand accounts for 70 per cent of peak power demand and over 50 per cent of annual energy consumption. District cooling could reduce peak power demand by 46 per cent and annual electricity consumption by 44 per cent compared to a conventional air-cooled system (Ben-Nakhi, 2011).

District cooling is a technology that is slowly building traction in some developing country cities because of its ability to alleviate stresses on power systems caused by air conditioning (see case studies 3.9 on Cyberjaya and 3.12 on Port Louis). The benefits of district cooling are felt by various stakeholders. Consumers benefit from lower and/or more stable cooling costs (if the system is well placed) and from not having to house and maintain individual cooling solutions. Meanwhile, municipal, regional or national electricity utilities are able to provide less electricity at peak demand and overall, reducing the need for transmission system upgrades and capacity additions. Finally, the local economy could potentially benefit greatly from fewer blackouts, reduced need for

backup generation in individual buildings, lower electricity prices, and cheaper and easier reduction of refrigerants such as HCFCs and HFCs in traditional air-conditioning units (UNEP, 2014), as described in section 1.1.1.

In many developing countries, utilities are publicly owned and may be responsible for producing, transmitting and distributing electricity. An important way to account for the wider benefits of district cooling is to include such a local/national electricity utility in the business model for district energy. This can be done directly (as Dubai has done; see case study 3.6) or indirectly through local, regional or national government ownership, with this ownership providing strong connections to publicly owned electricity utilities.

This is particularly important in a non-liberalized market structure where electricity prices may be regulated. In such markets, without strong electricity price signals, a privately owned district cooling system may not be incentivized or have the permission to: develop cold storage (which can help shift electricity demand from peak load); connect particular user groups; develop combined power and cooling; innovatively use waste heat sources for absorption cooling; access sources of free cooling; or lower electricity consumption as much as possible during certain periods of the day. For example, in many countries, independent power producers cannot develop projects to sell electricity to the regional/national grid and thus may lack the incentive to develop combined power and cooling plants. The presence of a publicly owned utility in the business model would enable a district cooling project to develop such plants.

The publicly owned nature of power utilities or government subsidiaries is also beneficial to the business model, as described in sections 3.2 and 3.3. Such benefits could include access to

anchor loads, easier planning, better data, integration with other utilities and cheaper electricity. A publicly owned district cooling utility in a hot developing country city would be well placed to provide services and to develop in line with municipal, regional and national interests. However, the presence of the private sector in a business model is beneficial as a provider of capital, demand load, experience and technology. International ESCOs will be important in developing district cooling in some hot developing country cities, and their importance should be weighed against having a strong public sector role in projects. As such, models such as public and private joint ventures can enable district cooling projects to access the benefits of both the public and private sectors, as described in section 3.3.1.

District cooling is a technology that will need to be demonstrated in a city before city-wide deployment could be investigated. A lack of data on cooling demand and a lack of funds to fully understand the effects of this demand at a city and national level (see section 2.2.1) mean that initial projects should be developed that target localized, high-consuming sectors.