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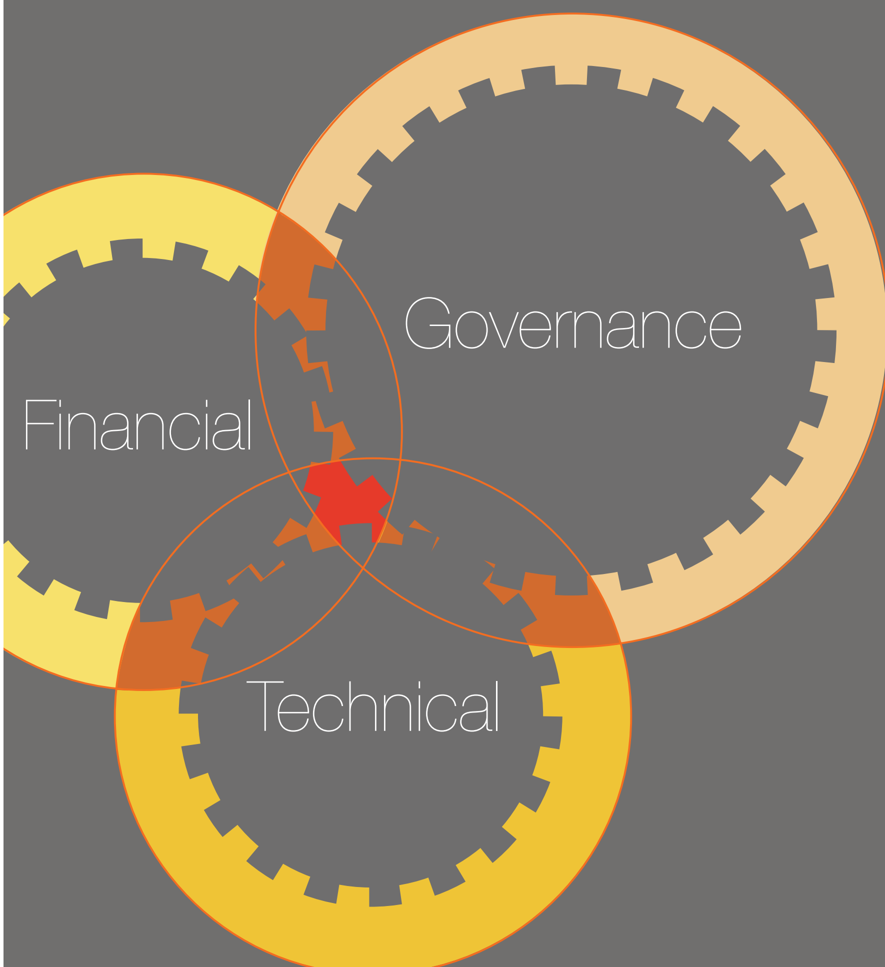
INTERNATIONAL ENERGY AGENCY
Technology Collaboration Programme on District Heating and Cooling including Combined Heat and Power

iea Energy Technology Network

Annex XI Final Report

Governance Models and Strategic Decision-Making Processes for Deploying Thermal Grids



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Governance Models and Strategic Decision-Making Processes for Deploying Thermal Grids

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ABOUT THE INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA) is an intergovernmental organization that serves as energy policy advisor to 28 member countries in their effort to ensure reliable, affordable and clean energy for their citizens. Founded during the oil crisis of 1973-1974, the IEA was initially established to coordinate measures in times of oil supply emergencies.

As energy markets have changed, so has the IEA. Its mandate has broadened to incorporate the “Three E’s” of balanced energy policy making: energy security, economic development and environmental protection. Current work focuses on climate change policies, market reform, energy technology collaboration and outreach to the rest of the world, especially major consumers and producers of energy like China, India, Russia and the OPEC countries.

With a staff of nearly 200 who are mainly energy experts and statisticians from its 28 member countries, the IEA conducts a broad program of energy research, data compilation, publications and public dissemination of the latest energy policy analysis and recommendations on good practices.

ABOUT IEA DHC

The Energy Technology Initiative on District Heating and Cooling including Combined Heat and Power was founded in 1983. It organizes and funds international research which deals with the design, performance, operation and deployment of district heating and cooling systems. The initiative is dedicated to helping to make district heating and cooling and combined heat and power effective tools for energy conservation and the reduction of environmental impacts caused by supplying heating and cooling.

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EXECUTIVE SUMMARY

District energy (DE) systems are recognized worldwide for advancing social, environmental, urban sustainability and economic development objectives, while providing economic value to the communities, cities, campuses and districts they serve.

Heating and cooling solutions deployed at a community or district scale, rather than by individual buildings, offer solutions to many challenges:

- Grappling with the round-the-clock demands and energy intensity levels of key sectors such as hospitals, research and education campuses, and data centers
- Supporting urban growth with a more resilient energy infrastructure
- De-carbonizing the energy infrastructure to meet climate action goals
- Creating an inviting environment of economic development and business enterprise
- Providing electric grid support, peak load management and enhanced efficiency through technologies such as thermal energy storage (TES) and combined heat and power (CHP)

District Energy Systems as Vehicles Supporting Multiple Objectives

District energy systems make up the backbone of the efficient, reliable and resilient infrastructure that supports heating and cooling needs in many cities, communities, hospitals, airports and campuses. They play a critical role in supporting education, research, commerce, industry and a vibrant community life for local economies.

DE systems are able to leverage scale to incorporate local resources, resulting in job development and retention while circulating economic benefits in the local economies. By aggregating the heating and cooling loads of dozens or even hundreds of buildings, DE systems reach economies of scale that enable integration of renewable technologies like lake and sea water cooling in Toronto and Stockholm.

The Seoul metropolitan city government funded extraction of landfill gas (LFG) from the Sangam landfill to create a unique opportunity for KDHC, the district heating (DH) provider, to help meet environmental and economic objectives by deploying CHP capacity that delivers thermal energy to customers in conjunction with producing local electricity for the Korea Electric Power Company.

Waste-to-Energy (WtE) systems in Paris support multiple objectives such as increasing the share of renewables and integrating geothermal resources while retaining the aesthetics of iconic buildings by eschewing cooling towers on rooftops. The Aarhus City Council's adoption of a climate plan calling for DH to be CO_2-neutral by 2030 provided market confidence in the private sector to move away from coal and oil toward biomass.

Warmtebedrijf Rotterdam, the largest WtE plant in Europe, repurposes waste heat from industrial activities on the harbor and the local incinerator to supply DH in the community. By requiring that customers connect to the DH supplier, the city was able to de-risk the project economics and attract a viable private sector partner.

In the UK, the DH systems in Aberdeen and Wick demonstrate how communities can effectively solve fuel poverty and improve quality of life.

Innovation in the use of local resources is showcased in Vancouver through its use of recovered heat from sewers. The Pionen data center in Stockholm is an example of a thermal "prosumer" model that allows data center consumers of cooling to also become providers of the heat they generate back to the local DH provider, Fortum Värme.

Birmingham is an example of developing a city center heat network by interconnecting multiple systems and leveraging private investment from Engie.

The city of Phoenix benefits from the local district cooling (DC) system owned and operated by a private company, NRG, as an economic development tool, with DC costs being less than individual building-scale cooling solutions. Through deployment of large-scale TES, the DC system is able to reduce the overall costs by cutting 10 MW of peak electric demand from the grid, freeing up capacity for other needs while reducing the need to tap costlier, often dirtier, peak electric resources.

The University of Oklahoma, faced with capital limitations, needed to improve reliability of service and renew aging campus utility system infrastructure. It was able to attract private financing by awarding a 50-year concession agreement to Corix Utilities for operation and maintenance of the campus system that serves a community of 30,000 students.

Success Stories, Best Practices and Lessons Learned

There is a significant body of work showcasing the accomplishments of DE systems and their success in meeting a range of objectives. This report is structured as a guide to help practitioners, policymakers, customers and communities explore more deeply the factors underlying the success of these systems. It highlights what approaches, best practices and strategies lead to the progression of projects from concept to delivery and sustain them through their productive long lifecycles.

The stories of Sangam, South Korea; Aberdeen, Birmingham and Wick in the UK; Aarhus, Denmark; Paris, France; Rotterdam in the Netherlands; the Pionen data center in Stockholm, Sweden; Toronto and Vancouver in Canada; and Phoenix and the University of Oklahoma in the USA represent diverse approaches for moving a system from concept to operation and along the way, using creative rate structures and financing mechanisms to sustain mature systems.

Technology, Finance, Business Models and Governance

While technology solutions must be designed and constructed with best practices, even more essential to a system's success is ensuring its economic viability through sustainable business models for service delivery to attract end-users and financing.

The choice of business models and type of financing is determined by system objectives and the specific stage of the system lifecycle, which could be new system deployment, expansion of an existing system to meet growing load demands, or the renewal of assets that have reached the end of their useful lives. Participation of communities and local governments opens up options for public-private partnership business models that can reduce the cost of finance and lead to greater rate stability.

A business model that works to support a successful project is characterized by the appropriate balance between risk and control.

The ownership and management models range from a pure public sector venture to a purely private sector approach. In between, a range of hybrid options involving varying blends of both private and public sector financing, design, operation, fuel supply, day-to-day management and decision-making are possible. The key differentiating factors are:

- **Control:** the degree of control via governance over project objectives
- **Risk:** the degree of risk the project is willing to carry to exercise control
- **Finance:** ability of the project to provide a return on capital relative to hurdle rates and costs of capital

The importance of strong and appropriate governance cannot be overstated. The role of governance is ongoing and includes shepherding the objectives, overseeing the use of best practice design and implementing customer service.

Policy with a Purpose

Of particular value are policies aimed at reducing market uncertainties such as customer connection and uptake. Supportive local policies help to attract private capital and accelerate deployment. While often led by local policy, there is a need for alignment and for the development of mutually reinforcing policies at all levels of government.

Key Factors for Success

For a project to successfully navigate through the different lifecycle stages, maintain momentum and enable all participants to work toward project objectives, attention must be paid to key factors for good decision-making. Five key factors have been identified as critical components of strategies for success. They are:

1. **Risk:** identifying, allocating and managing risk
2. **Information:** gathering and disseminating information needed for decision-making
3. **Money:** managing funds to align with the system lifecycle stage needs
4. **People:** including appropriate people and experts as needed in decision-making
5. **Tools:** using available tools to improve decision-making

Careful planning, information gathering and strong financial management are critical to managing risks and objectives. It is invaluable to have good project teams who leverage best practices and rely on useful technical and project resources available through a variety of organizations that support DE.

Stakeholder Engagement and Capacity Building

By their nature, DE projects affect many groups and can be influenced by many stakeholders who can determine their success or failure. It is important to understand their motivations and concerns. Equally important is the role of skilled staff to support DE systems through their lifecycles. These skills often need to be outsourced or developed through capacity building efforts.

1 INTRODUCTION

1.1 Background

The changing global energy landscape faces a variety of challenges in providing the energy infrastructure needed to meet the electricity, heating and cooling needs of an energy-driven world. A great deal of attention has been paid to addressing the challenges on the electricity side of the energy infrastructure, but the thermal side does not get the attention it needs.

Heating and cooling solutions deployed at a scale larger than an individual building and the creation of thermal grids hold a great deal of potential in meeting many challenges including:

- Meeting demand from emerging economies that are also dealing with the challenges of fuel poverty and lack of energy infrastructure
- Grappling with the round-the-clock demands and energy intensity levels of various sectors such as hospitals, emergency response and data centers
- Supporting urban growth through a resilient energy infrastructure that can maintain operations during extreme weather conditions
- De-carbonizing the energy infrastructure to meet climate action goals

DE systems make up the backbone of the efficient, reliable and resilient infrastructure that supports the heating and cooling of buildings in many cities, communities, hospitals, airports and campuses.

Underlying the success of these systems and the critical role they play in supporting education, research, commerce and industry and vibrant city life are creative solutions that leverage local resources, deploy innovative technologies, integrate renewable energy resources and incorporate efficiency through good system design, construction, optimization and operation by well-trained staff and operators.

However, while solid technical and engineering practices are essential to the success of a DE system, even more fundamental are viable economic and financial structures in conjunction with sustainable business models supported by appropriate governance models that will attract sufficient end-users and facilitate financing for new system deployment.

1.2 Thermal Grids

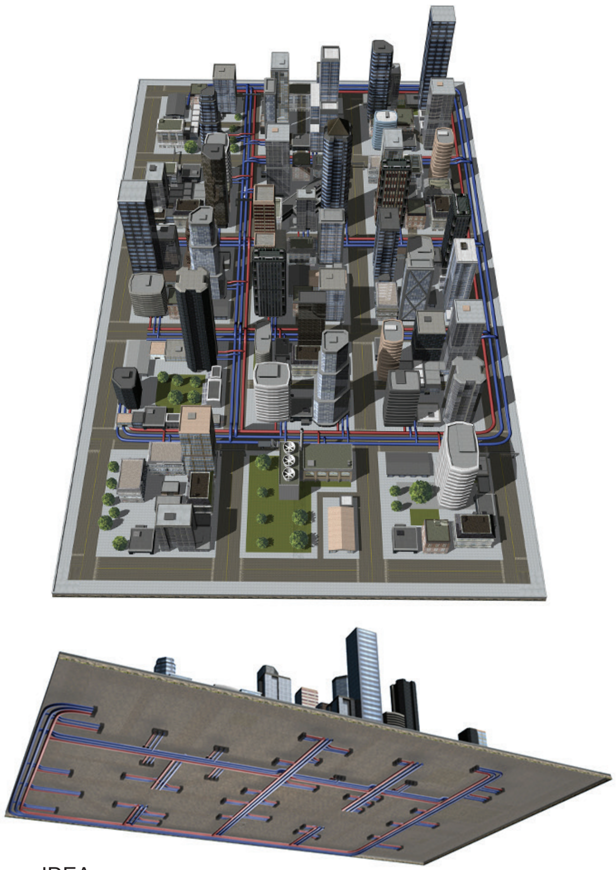
This report is about Governance Models and Strategic Decision-Making Processes for Deploying Thermal Grids. It does not define thermal grids, but describes what they can be in different situations. Thermal grids are inherently flexible and aggregate a wide variety of resources including production, storage and controllable demands. They are bigger than one single building but can be as small as two buildings connected together and/or as large as an entire region interconnected by heat transmission pipes. Thermal grids maximize energy efficiency while also increasing energy reliability for all connected users. The presence of the grid itself enables the deployment of locally available resources in a manner not possible on an individual building-by-building basis. At its core, a thermal grid is a highly localized solution that addresses local needs by taking advantage of local resources and opportunities.

Thermal grids can provide cooling (district cooling) or heating (district heating) and are often referred to broadly as district energy. DE can also include community-scale electricity grids, which are often called microgrids. The projects discussed in this paper are primarily thermal grids, but many of them include electricity generation, such as with CHP systems, which generate both thermal and electrical energy. Community-scale or campus-scale energy grids incorporate resources and address needs that are highly location-specific; that is why so many of these DE projects appear to be unique to the location in which they exist. While this is true, there are many similarities among projects, and many lessons to be learned from successful ones that directly apply to new projects. For convenience, this report will use the broad term district energy (DE) when referring to any of these systems.

1.3 What Is District Energy?

DE systems (IDEA, 2016) are local energy networks that provide multiple buildings with hot water/steam (“district heating”) and/or chilled water (“district cooling”). A central plant produces the steam, hot water or chilled water, which is then piped underground to buildings for space heating, domestic hot water heating and air conditioning (See Figure 1.1.)

FIGURE 1.1: UNDERGROUND PIPES PROVIDE THERMAL ENERGY TO BUILDINGS CONNECTED TO DE



Source: IDEA.

1.4 Benefits of District Energy

Buildings served by a DE system don't need to install, own or operate their own boilers, furnaces, chillers or cooling towers. The DE system does that work for them, providing valuable benefits (IDEA, 2016) including:

- Improved energy efficiency
- Enhanced environmental protection
- Fuel flexibility
- Ease of operation and maintenance
- Reliability
- Comfort and convenience for customers
- Decreased lifecycle costs
- Decreased building capital costs
- Improved architectural design flexibility

Throughout the world, DE systems bring cost-effective, efficient and resilient energy services to buildings of all varieties. They offer campuses, municipalities, cities, and neighborhoods a host of benefits that are not available from traditional energy services.

The United Nations Environment Programme District Energy in Cities Report further details the multiple benefits (UNEP, 2014) of DE systems listed below:

- Greenhouse gas emissions reductions
- Air pollution reductions
- Energy-efficiency improvements
- Use of local and renewable resources
- Resilience and energy access
- Green economy

Despite its many benefits, there remains significant untapped potential for DE.

1.5 Strategies for Success

It is important to incorporate strategies from successful DE systems and pay heed to the lessons learned for continued success. DE systems are larger in scale than building-level systems and require an understanding of the composition and needs of customers in the district they serve.

In contrast to building-level systems, the initial capital investment needed to set up a DE system needs to be managed and aligned with the time frames for end users in the specific target market.

This process can be complex and long-term, and requires attention to the techno-economic feasibility as well as the environmental and social objectives of the system.

Those who wish to deploy DE systems must develop strategies and solutions that meet the technical and economic needs of a variety of parties; are attractive for investment; are coordinated with local land use, energy, and transportation plans; and are timed in a way so as to align with other investment and development activities. Additionally, the role of local government is critical but can vary considerably from city to city, neighborhood to neighborhood, and country to country.

At a minimum, successful DE systems must deliver reliable, efficient and competitively priced energy services while potentially supporting other community objectives such as de-carbonizing the energy portfolio, reducing fuel poverty and strengthening energy security or resiliency.

1.6 Approach and Focus of this Report

Much has been written about the wide variety of DE systems in place today, from the large, well-established urban DH systems serving many thousands of customers in cities like Paris, New York or Moscow to the relatively new DC systems experiencing dramatic growth in cities like Dubai or Abu Dhabi in the United Arab Emirates.

What has not been explored, however, is the need for an evolving business model that allows for an appropriate alignment of the technology, financing and governance structures that enable these systems to successfully move through their development stages and then through their entire lifecycles.

While technology challenges exist, this guide will focus on strategies, key activities, tools, financing and engagement that result in structuring a DE system that is well-planned, designed, built and operated throughout the major stages of its lifecycle (see Figure 1.2), often many decades long.

Based on case studies from Canada, Denmark, France, Germany, South Korea, Netherlands, Sweden, UK and USA, this report draws on best practices, experience and enabling policy to focus on the challenges and benefits of the various governance and financing models in place around the world today. It also identifies the major drivers for project development or reinvestment, to explore how different aspects of projects have motivated certain stakeholders to support these long and complex processes.

This report will outline which benefits have been prime drivers and which governance and financial structures have helped produce different benefits to different stakeholders. The intent is to provide multiple lenses through which a city, campus, or neighborhood can view their unique DE challenges and opportunities.

Every effort has been made to identify the aspects of these structures that are transferable to other locations, and to emphasize the findings, lessons, and approaches that are relevant and actionable for localities around the world.

1.7 Key Factors for Success

For a project to successfully navigate through the different lifecycle stages, maintain momentum and enable all participants to work toward project objectives, attention must be paid to key factors that will enable good decision-making.

Five key factors (see Table 1.1) have been identified. They will be used in the report highlight strategies for success.

1.8 Report Structure

This report is aimed to serve as a guide and a toolbox for would-be developers, political leaders, building owners and city planners with a variety of tools and contexts that will enable them to better analyze and address their own local circumstances.

Chapter 2 addresses the political, economic,

FIGURE 1.2: DE SYSTEM LIFECYCLE STAGES

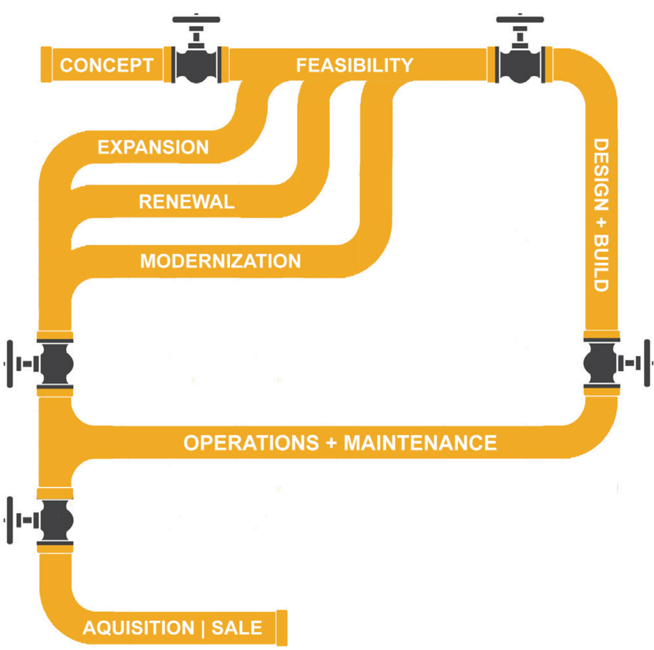


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TABLE 1.1: KEY FACTORS FOR SUCCESS

KEY FACTOR	BRIEF DESCRIPTION
RISK	Identifying, allocating and managing risk
INFORMATION	Gathering and disseminating information needed for decision-making
MONEY	Managing funds to align with the system lifecycle stage needs
PEOPLE	Including appropriate people and experts in decision-making
TOOLS	Using available tools to improve decision-making

technological and social context. It covers the main trends and drivers affecting DE today. Drawing from case study examples, it highlights best practices and successful approaches for setting objectives along economic, environmental, political and social dimensions.

Chapter 3 looks at community-based energy planning for successful projects and provides an understanding of what it takes for a community to deploy a DE system, including potential roles needed for a successful projects, various data and tools for assessing technical potential, and strategies that link technical assessment with policy interplay and local, regional and national incentives.

Chapter 4 describes the various business models that have been used for DE projects along the public private continuum. Relative strengths and weaknesses are presented as an aid to choosing an appropriate business model. Case studies are used to highlight various approaches to financing and governance and to demonstrate the development of a business model over time.

Chapter 5 uses the DE lifecycle stages to identify risks, key success factors, best practices and key activities as an aid for navigating through each stage of the life cycle.

Chapter 6 focuses on approaches to stakeholder engagement that enable successful decision-making and outcomes for DE deployment.

Chapter 7 provides information on capacity building aimed at addressing the common problem of lack of adequate skills and resources faced by communities and developers.

Chapter 8 is devoted to summarizing DE enabling policies in Canada, Denmark, South Korea, the United Kingdom and USA.

In conclusion, Chapter 9 presents conclusions and key messages.

Two appendices are provided:

Appendix A is a compilation of 12 comprehensive cases studies with system description, drivers and objectives, and details on financing and governance. The case studies include examples of strategies for success along with outlined key success factors.

Appendix B provides a partial list of useful tools. Excel files are provided for using some of the tools developed as part of this project.

2 THE POLITICAL, ECONOMIC, TECHNOLOGICAL AND SOCIAL CONTEXT

2.1 Introduction

Today DE systems include some of the most innovative energy grids that support increasingly large areas of end use such as municipal downtowns, university and college campuses, data centers, airports, malls, military bases, and hotels.

DH systems are seeing modernization and renewal while DC systems are now growing at a faster rate as developing countries and the Middle East deploy cooling to support rapid urban development. Comfort cooling is no longer considered a luxury but rather a fundamental component of a building in most climates, and a critical necessity for attracting business.

New systems that respond to local needs and address local barriers are driven by a variety of desires and opportunities. This chapter explores the major trends and drivers impacting DE development today, and how these drivers can shape the resulting system both now and in the future.

DE solutions are location-specific, and every system has its own story to tell.

2.2 Trends and Challenges Shaping District Energy Deployment Today

Major changes in the way cities are developed have ushered in a period of intense energy resource experimentation and innovation. The lenses through which cities, developers, building owners and institutions think about their energy resources have changed. Below we identify some of the major political, economic, social and technological trends influencing DE development.

2.2.1 Resiliency Goals and Critical Facilities Requirements

In many cases, DE resources provide multiple buildings with highly reliable power, heat and cooling that can withstand damaging weather or other disruptions. This was evident in the United States during Superstorm Sandy, the deadliest and most destructive hurricane of the 2012 Atlantic hurricane season which resulted in over $70 billion US dollars in damages in 24 states in the USA and caused extensive damage throughout Ontario and Quebec in Canada. While 8 million homes lost power, medical and college campuses continued to provide their buildings with critical energy services while the surrounding neighborhoods had to go without. In recognition of this benefit of district systems, localities concerned about their resiliency in the face of catastrophic weather events made worse by climate change are asking or requiring critical facilities – facilities that must continue to operate during catastrophes, such as hospitals and wastewater treatment plants – to engage in CHP and CHP-based DE feasibility studies when building new facilities or undertaking major renovations (Rackley & Hampson, 2013). District-scale systems are increasingly being found in cities' resiliency plans, supported by organizations such as the Rockefeller Foundation and C40 Cities.

Microgrids are specifically being pursued for their resiliency benefits. Individual US states deeply affected by Superstorm Sandy, such as New York and New Jersey, have developed specific programs and policies designed to stimulate the development of district-scale systems that are able to disconnect from the grid and offer connected buildings reliable energy services when the grid goes down. These resiliency concerns have brought DE back into the policy discussions at local and regional levels around the world.

2.2.2 4th Generation District Heating and Hot Water Conversions

The first generation of DH used steam as a heat carrier. The second and third generations evolved to using pressurized hot water supplied at temperatures above 100° C and below 100° C respectively. Newer DH systems have changed to respond to the reduced heat demand of buildings and more efficient housing stock resulting from increased energy efficiency code requirements. These systems, referred to as "4th generation," use pressurized hot water but operate at lower temperatures between 30°-70° C. They have the ability to integrate a much more heterogeneous resource mix including renewables, storage and flexible dispatch. These new system designs are "smart thermal grids” capable of more directly interacting with the electric grid in a way not previously seen (Lund, et al., 2014).

The move to 4th generation DH systems is possible when a system undergoes major expansion or renovation as well as in brand new DH system development. Examples of recent 4th generation DH systems include University of British Columbia (UBC) in Vancouver, Canada, where the university underwent a major renovation to switch its thermal distribution piping network from steam supply to hot water. The UBC project also involved substantial conversion of the customer building heating systems from steam radiators to hot water. Another example of recent 4th generation DH are the efforts to capture waste heat from the London, UK Underground system and use it as a heat resource within existing DH systems.

2.2.3 Net-Zero Goals Embedded in Development

“Net-zero energy” and “net-zero carbon” goals for new developments and neighborhoods are also becoming prevalent around the world. These goals aim to couple substantial onsite energy generation with deep energy efficiency gains to yield developments where the net energy or net emissions generated over the course of a year is zero or less. While individual net-zero buildings are possible, it can be much more cost-effective to achieve net-zero by integrating a DE system into the development (Campbell & Olgyay, 2016), (Office of Sustainable Communities, 2015).

In this way, building loads can be aggregated to smooth load curves and the costs of locally available renewable resources can be spread among a larger number of buildings, taking advantage of economies of scale.

2.2.4 Changing Electric Mix

Around the world, electric grids are seeing major changes as coal generation is retired, the costs of certain renewable resources fall, and policies to increase deployment of less CO_2-intensive resources are adopted. In some cases, such as in the EU, DH infrastructure is seen as a vital accompaniment to these changing electric grids, using low-emissions heat resources for heating and cooling needs, and reserving electric resources for energy demands that truly require electricity, such as electronics and lighting (Connolly, et al., 2014), (Connolly, et al., 2012). The changing conversation about how a future energy system should perform in terms of environmental goals is causing new consideration of DH and its unique role in meeting thermal needs.

2.2.5 Growth of Thermal District Cooling

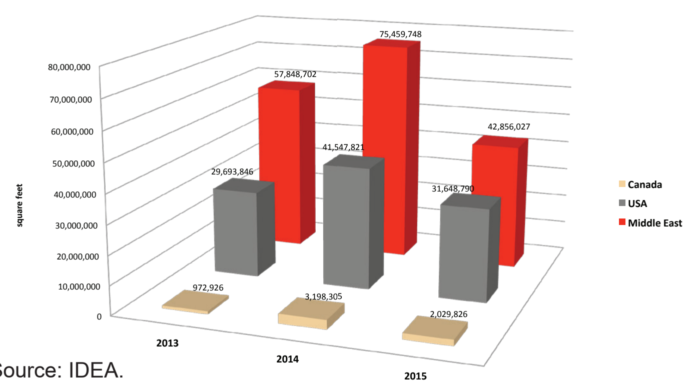
The International District Energy Association annually tracks the addition of new customer buildings to DE systems in terms of new buildings by type and use and in terms of size (customer square footage area). In recent years, a majority of new customer space served has been connected to DC, rather than DH, systems (see Figure 2.1). This is due in part to the significant recent deployment of very large DC systems in the Middle East. DC is growing as a share of overall DE systems, and that is bringing DE to regions of the world not previously familiar with DE. Additionally, areas of the world that did not previously require cooling services are beginning to respond to customer demand for such services. Paris and Toronto are examples of cities with large-scale DC systems.

Hot water pipe installation at University of British Columbia. Photo by UBC.

FIGURE 2.1: BUILDING SPACE SERVED BY DISTRICT ENERGY

District Energy Industry Growth: Canada, USA & Middle East

Annual additions of customer building space (sq ft)



Source: IDEA.

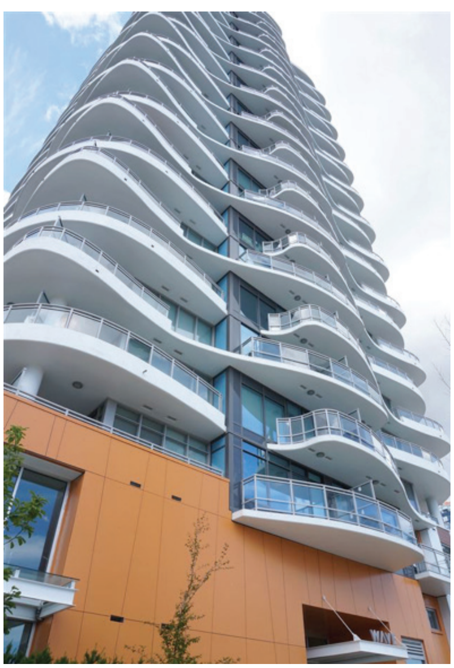
2.2.6 Nodal and Smaller System Development

Another trend impacting DE deployment is the interest and investment in smaller DE systems that grow organically in a nodal fashion. In some cases, this is due to a reluctance to undertake a major development effort at one time, but instead take advantage of smaller opportunities as they emerge, several buildings at a time. In Surrey, Canada, Surrey City Energy has begun to develop smaller nodal DE systems that it expects it will later bring together in a more comprehensive fashion. Identification of waste heat resources, such as from data centers, is often driving these smaller systems, bringing heat resources to a small number of adjacent buildings. New developments that were not immediately adjacent to an established district network can be served by temporary natural gas boilers, with an expectation that the after the pipe infrastructure has been developed, these buildings will switch over to a larger supply, such as excess thermal supply capacity from a geo-exchange bank built by Surrey City Energy. In time these smaller nodes can be fully connected to become a larger system in the aggregate, ultimately maximizing the full economies of scale of a district system. DE is increasingly developed as a small thermal grid connecting a handful of buildings, or multiple nodes spread across a city and later connected into a broader thermal grid. It can include significant renewable resources, and can dynamically leverage thermal storage to respond to rapid shifts in demand.

2.2.7 Thermal and Electric Grid Integration

District energy systems with electric generation resources, such as CHP, and flexible demands and storage such as hot water storage tanks, are often able to operate in a manner that responds in part to electric system price signals. The added flexibility can be lucrative for DE systems that reside in non-vertically integrated electric markets. Markets that have significant uncertainty around intermittent renewables place value on resources that can be called upon regardless of weather or season. DE-connected resources can leverage their flexibility to store energy when it is advantageous to make excess, and to utilize storage resources when there is an immediate local or grid-level need. A 6.5 million gallon chilled water storage tank in St. Paul, USA reduces peak electric demand and offers firm cooling capacity for extreme weather events.

By integrating storage capabilities, DE systems can shift heat production to accommodate electricity fluctuations, as through a heat pump, or address an electricity shortfall, as when a system utilizes thermal storage instead of generating additional heat. One recent trend is the use of DE systems to help monetize the excess electricity generated by wind during times of lower electricity demand. By integrating electric boilers within a DE system, a district system can turn off or turn down other thermal generation resources and utilize the low-cost excess electricity available on the grid to generate thermal heat resources for dis-



The 28-story condominium Wave Building, the first private building to connect to the nodal Surrey City Energy district energy system. Photo by I Love False Creek.

Thermal energy storage tank, District Energy St. Paul. Photo by Ever-Green Energy.

tribution throughout the system. A variety of storage and generation resources allows this flexibility.

2.2.8 Integration of Renewable Resources

At Princeton University and the University of California, San Diego in the US, district heating and cooling systems connected to thermal storage are integrating solar thermal and other types of renewable thermal resources within their DE boundaries. The electric infrastructure that is a part of these systems can integrate photovoltaic resources as well, with the flexibility of the connected CHP system available to respond to the output of the PV system.

Hamilton Community Energy's McMaster Innovation Park in Canada became one of the first systems in Ontario to provide heating and cooling services through a "hybrid" DE system that integrates renewable geo-exchange and solar thermal technology with a conventional natural gas-fired DE system.

Other DE systems are integrating reduced carbon fuels such as biomass and biogas produced from local activities such as wastewater treatment. In Aarhus, Denmark, waste heat from incinerating local refuse makes up a significant portion of the total system heat supply. While waste incineration is not carbon-free, substantial pollution control measures in newer incinerators yield heat resources that are producing net emissions reductions over business-as-usual.

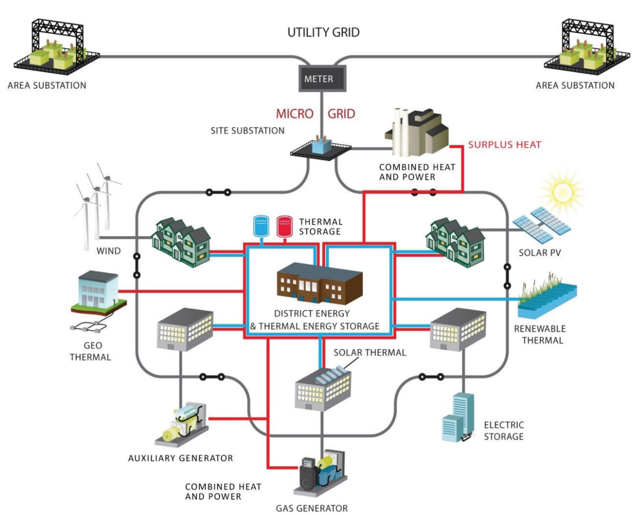
2.2.9 Smart Cities

From IBM to Nest to Amazon to Google, companies are selling products and services designed to connect different building components and systems via the Internet of Things. For cities this means drivers can know how many parking spaces are available in a lot, building managers can know which 15-minute interval is most lucrative for turning down lights on a certain floor, and emergency planners can automatically shed non-essential loads in preparation for a disaster, saving sensitive equipment in case the grid acts erratically. Fundamental to the concept of smart, connected cities is the idea that cities can have more control over their energy use. While "smart cities" may be merely a buzz word, cities are indeed investing in systems that let them better observe and influence how energy is used. Public and large commercial buildings are increasingly subject to energy benchmarking requirements and energy efficiency and renewable energy standards. For many, a district-scale solution helps meet onsite energy needs while also providing the flexibility to integrate automated loads, energy storage and other components that allow it to provide real benefits to the local grid.

2.2.10 Real Estate Development and Financing Trends

Coming off the global recession of 2008, cities are still struggling with taking on major redevelopment projects that would lend themselves well to DE.

FIGURE 2.2: INTEGRATED ELECTRIC AND THERMAL SYSTEM WITH A VARIETY OF RESOURCES



Source: IDEA.

McMaster Innovation Park in Hamilton, Ontario, Canada. Photo by Daisy Energy 2016.

Cities are also challenged with shrinking budgets, and grand-scale DE systems are often considered too big and too risky to be fully led by cities. In part, this explains why some cities are opting to lean more heavily on the private sector, which has been playing an increasingly larger role in DE project development. While this can be beneficial to DE development, it can also exclude critical local decision-makers from the design and development process, leaving important local needs and opportunities unaddressed.

Since DE systems are real assets serving other real assets, trends in real estate affect DE deployment. According to (Siedman & Pierson, 2013), there are five distinct development trends that are driving DE today. These are:

- Existing systems undertaking significant retrofits or expansions to meet new needs or address impending resource constraints
- Brand-new greenfield developments for "single users," such as at new medical centers, where wholly new DE is woven into the broad master plan
- New developments that are built adjacent to existing DE systems and are designed to connect to the expanding existing system
- Brand-new greenfield developments for multi-user developments, such as dense mixed-used neighborhoods, that are built to utilize a newly planned DE system
- New DE systems developed to serve an existing mixed-use, "multi-user" area (Siedman & Pierson, 2013)

Increasingly, new real estate developments are outsourcing DE system design, development and operations, and the role of the private sector in DE deployment and management is growing (Siedman & Pierson, 2013). They are using their own funds to make some of the major investments, with the expectation that revenues from operating the system will justify the investment. This relieves cities from having to identify and secure the financing themselves, but it can – as discussed later in this report – reduce the amount of control a city maintains over its district system.

2.2.11 Constantly Evolving Political Landscape on Energy and Climate

Finally, DE systems are affected by the political climate of the city, region, and country in which they reside. With major political change occurring around the world, DE developers must make decisions about investment without sometimes fully knowing whether relevant policies will change, expire or be added in the near term. With the ratification in December 2016 of the Paris Agreement, most countries in the world have now committed to making real reductions in greenhouse gas emissions in the near future. These commitments will likely include efforts to explore district-scale systems where pragmatic and practical, as numerous studies have shown the critical role DE will play in a low-carbon economy (Connolly, et al., 2014), (Connolly, et al., 2012), (United Nations Environment Programme [UNEP], 2015).

The European Union has identified DE as a critical resource for meeting energy and emissions goals, and each nation must respond to EU goals for consideration of DE. However, there are yet few national-level commitments to utilizing DE as a primary mechanism for achieving emissions reductions. With the impending exit of the UK from the EU, the top-down political pressure for meeting EU energy and climate goals remains in flux. Thus, DE systems around the world are being developed in ever-changing political contexts, though some countries, such as the UK and Denmark, have adopted policies that very explicitly look to DE for its greenhouse gas reduction benefits. In the absence of stable energy policies, DE is sometimes viewed as a "no regrets" option, capable of integrating future resources as they become available and offering users steady and predictable energy rates and reliable service.

Even if countries have strong goals for emissions reductions, most binding renewable energy, energy efficiency and greenhouse gas targets are applied on a per-utility, per-sector or per-geographic area scale. Depending on the lens through which the targets are developed, DE is sometimes viewed as outside the scope, encompassing more than just electric demand, for example. Utilities tasked with achieving a set amount of electric demand reduction can find it difficult to integrate DE – which includes significant thermal energy efficiency opportunities – into their efforts, since regulatory and legislative bodies often fail to clearly articulate how thermal efficiency savings could be considered within broader savings targets. Similarly, renewable energy targets will often be applied as a percentage of electric generation. Deploying thermal renewable energy resources may not count toward a utility, state, or country's renewable goals.

There are specific examples discussed in Chapter 8 on how to address and potentially overcome unclear policy and environmental goals that were designed without explicitly taking into account the role of DE.

2.3 What Is Driving District Energy Development Today?

Cities pursue DE for multiple reasons. The flexibility and adaptability of a DE system is well-suited to the ever-changing needs of cities and towns as they address new challenges, identify new opportunities and rethink existing waste streams. Broad drivers for investment in new DE systems typically fall into four major categories:

- Economic drivers, whereby specifically economic goals and challenges are met and addressed by a DE solution uniquely suited to address those needs
- Environmental drivers, whereby broad goals or requirements to hit environmental targets encourage the deployment of environmentally responsible DE resources
- Social drivers, whereby existing societal needs can be addressed and supported as a direct or indirect byproduct of a new DE system investment
- Political drivers and constraints, whereby exogenous factors influence the consideration and shape of a new DE system

For each locality, local leaders must determine which goals are higher priority than others, and identify which ones must be addressed sooner rather than later. This will help color the size, shape, scale, governance and financial arrangement of any DE resources designed to meet local needs. While certain goals and frameworks will encourage a city to move in one direction, other drivers may at times be viewed as constraints. For instance, previous negative experiences with large infrastructure projects or poorly structured emissions reduction goals that political leaders are actively fighting might dramatically shape a DE system's design and financial arrangement.

To better understand how different economic, environmental, social and political drivers can yield specific DE solutions, the following section profiles a variety of drivers identified within the case studies found in Appendix A: Case Studies. These drivers encouraged very different solutions, based on the broader local contexts, but many of them are familiar to cities of all different sizes and types.

2.3.1 Economic Drivers

District energy systems can frequently provide significant revenue generation opportunities for the cities or entities that own or host them. Such systems offer a reliable new source of income while meeting other needs, which can drive the development of new projects.

2.3.1.1 Revenue Generation

In **Paris**, the concession arrangement in place yields a substantial annual dividend and concession fee for the city. A total of €9 million is collected in concession fees and dividends each year, and an additional €1 million is collected annually from another concessionaire. The city maintains control over the specific tariffs used to charge customers for their energy consumption.

In **Toronto**, when the system was only partially owned by the city, the city enjoyed annual dividends and user fees that helped strengthen the municipal coffers. When the city determined that the system was an attractive asset to sell, and it needed money for other operating needs, the city of Toronto – in collaboration with the majority owner OMERS – sold the district heating and cooling system to a private entity for a substantial profit once the time was right.

In **Sangam**, the city enjoys a regular revenue stream for the waste from its waste management system, which the DE system pays for as its primary fuel. This offers a revenue stream for something that had previously been considered a waste product that had to be managed.

2.3.1.2 Strategic Restructuring

Sometimes the structure of a district system will change to respond to new economic constraints. In **Norman**, USA, the University of Oklahoma needed to reduce its capital and operating expenses in response to reduced public funds, so it aimed to privatize the DE system operations. The university wanted to focus its limited funds on its core operations – namely, academic and research activities. It thus entered into a 50-year concession arrangement with Corix, which freed up much of the university's dedicated operating capital and allows it to continue enjoying cost-of-service annual rates for the DE products, which are indexed to other utilities in Oklahoma. The university still owns the major DE assets, while Corix covers all the costs related to operations and maintenance, as well as future construction and investment.

2.3.1.3 Increasing Local Economic Competitiveness

By keeping energy rates low and stable for residents, reducing overall energy consumption due to added efficiency, and proving long-term price assurance on energy rates, DE offers cities a great opportunity to meet energy needs while driving economic development.

In **Aarhus**, Denmark, the city has long used its comparatively low heating rates as a means to attract new businesses to the area. Each year the national government makes public detailed information about how Danish cities' heat costs compare to one another. Cities with lower heat costs typically tout their rates in their efforts to attract new businesses to their area.

Similarly, in **Phoenix**, USA the private DE system owner regularly reaches out to developers to help them understand how the system will provide cooling services that are cheaper than individual, building-scale solutions. Additionally, the DC system in Phoenix helps developers understand the technical details of connection, since such an energy system may be unfamiliar to developers. These services help attract businesses interested in energy-related advisory services, since cooling costs can comprise such a large part of a building's energy costs in that region. The city of Phoenix advertises these benefits when it works to attract new businesses to the area.

In **Vancouver**, Canada, the Southeast False Creek DE system rate structure does not front-load the initial capital investments, so early adopters aren't penalized for connecting early to the system. In this way, the system is able to entice developers to connect to the new system now, with the understanding that they will not be bearing an undue amount of the up-front capital costs, but rather sharing them with those that connect later down the line. This helps attract new development investment.

2.3.1.4 Boosting Value of Existing Resources

District energy can often take advantage of fuel and resources that could not meet heating and cooling needs absent a DE system.

In **Wick**, UK, where biomass resources now provide heat to connected loads, residents had previously relied on costly oil and petroleum for their heat, because the town was not served by a natural gas pipeline. Biomass resources had always been available but were not cost-effective or viable as a fuel for a wide swath of the town until the investment in the DH system was made. Other examples include Cologne, Germany, where heat from the sewers will heat connected buildings via the deployment of heat exchangers in the sewers and inlet and return pipes in manholes, adding value to an existing infrastructure system.

Similarly, in **Toronto** and **Vancouver**, Canada, latent thermal energy resources in the lake and the sewer system, respectively, only became valuable economic assets when they were turned into a resource by the DE systems.

DE systems bring to scale resources that would not make sense on a building-by-building level. Many times, new systems are driven by the fact that a fuel is identified, but could not be used cost-effectively on an individual building scale.

In **Wick**, UK, in addition to the existing biomass resources, waste heat that had been available from a nearby whisky distillery was finally able to be used for a productive purpose. The recognition that these resources already existed but were not being taken advantage of helped drive the system forward.

In **Sangam**, South Korea, the landfill gas that is used by the district system was already available, and by using solid waste for this productive purpose, the city could reduce the amount of waste that would otherwise stagnate in landfills. Land is very scarce in Sangam, and thus the added economic development benefit of freeing up land for other, higher-value uses helped drive the new system development as well.

Sewer heat, Cologne, Germany. Photo by Stadtentwässerungsbetriebe Köln, AöR.

2.3.2 Environmental Drivers

Increasingly, DE systems are pursued because it is clear that the most cost-effective way to meet emissions targets is with a district system. Indeed, a detailed analysis of different scenarios to meet the European Commission's 2050 energy goals found that investing in new and existing DH systems in Europe is required in order to most cost-effectively reduce emissions and meet emissions targets (Connolly, et al., 2012).

The expectation of environmental benefits drives DE system development because of two main characteristics of DE systems: their increased efficiency and their ability to integrate renewable energy resources, including low- and no-carbon local resources such as waste heat.

2.3.2.1 Meeting Greenhouse Gas Goals

Stemming from a desire to reduce greenhouse gases from its existing district system, which had long relied on fossil fuels, **Aarhus**, Denmark made significant new investment in DE. A goal of having a CO_2-neutral heating network in place by 2030, driven by broader national goals to completely phase out oil and natural gas for heating use by 2030, prompted the city to thoughtfully consider its various alternatives and select a path forward. In **Paris**, the city's Climate Protection Plan was informed by the European Union's 2020 environmental goals and included explicit plans to replace significant electric resistance heating with new DE investment. The Paris plan also recommended pooling together investments in generation and distribution of energy resources in order to reduce the costs of new investments. This helped guide the selection of a district system and allowed concession agreements to integrate environmental goals in their design.

In **Vancouver**, Canada, the primary driver of investment in its Southeast False Creek system was to support the Olympic Games housing development, while pursuing carbon dioxide reduction goals. However, a fundamental aspect of the system planning and development was to highlight the business case for investment in such a system, to show developers that such a system was economically viable and indeed preferable to business-as-usual heating resources.

2.3.2.2 Stimulating Growth of Renewable Energy

District energy has a very specific benefit in the quest to utilize more renewable resources and fewer fossil fuels. This is because district systems can operate at a scale greater than on a building-by-building basis. Countries and cities sometimes see renewable goals in and of themselves driving DE investment, not only for emissions benefits but also for the broader benefits of stimulating and strengthening the market for renewable energy resources. Additionally, DE often takes advantage of existing renewable resources, and the identification of such resources is what prompts a city to seriously consider investment in DE assets that will make the most of the identified resources.

In **Sangam**, South Korea, the city responded to national goals requiring DH resources to be at least 10% renewable by 2022. With the establishment of waste-to-energy as a renewable resource, the city was driven to take advantage of its existing waste resources and make productive use of them.

In **Paris**, France, newly identified geothermal resources were found to be cost-effective for both heating and cooling, prompting investment in the district assets necessary to take full advantage of the resource. The aggregation of buildings and the requirement that new buildings undertake heat master plans helps ensure that the significant investment in geothermal will continue to be spread over a growing number of customers, reducing fixed costs for everyone.

2.3.3 Social Drivers

District energy resources offer broader benefits to society that frequently drive investment. District systems can be highly resilient in the face of natural and other disasters, and they can also directly address and mitigate fuel poverty. Addressing both of these issues can significantly strengthen communities.

2.3.3.1 Supporting Economic and Physical Resiliency

In **Wick**, UK, the city faced two major challenges: a high resiliency risk related to its substantial reliance on imported fuels, and a large portion of its population experiencing fuel poverty. By recognizing and leveraging its available wood resources, and mapping how such resources could most cost-effectively provide heating resources to residents, Wick was able to stimulate investment in new resources that were far less reliant on imports, and met residents' heating needs in a much more cost effective way, releasing them from the hard challenges of fuel poverty. Additionally, Wick aimed to include customers from a variety of classes in order to ensure that the reliable industrial and commercial heating demands could help keep system capacity factors high and reduce seasonal demand reduction risks. This kept rates lower for all users.

In **Phoenix**, USA, maintaining a cooling system is a critical resiliency component of buildings in that region. With outdoor temperatures frequently exceeding 100° F, highly reliable cooling systems can be a matter of life or death. The high reliability of the cooling system is driving more connections to the system, including city- and county-owned buildings, as city leaders and building owners recognize the significant reliability benefits of relying on the district system during the region's hottest summer days. Further, the district system takes cooling load off of the electric system, freeing up capacity on the electric infrastructure and reducing costs associated with operating at and near peak system demand. Much of the cooling capacity uses large-scale ice storage technology to leverage lower-cost electricity at night and avoid expensive peak power in the afternoons.

In **Aberdeen**, UK, the system has built in reliability and resiliency as part of its business plan, developing smaller clusters of buildings with single heating nodes first, and then developing long-term plans to connect the nodes to integrate into a larger system. Once the nodes are connected, if one node fails, the system would be designed so that one node could meet the needs of an adjacent node until the failed one could be restored. This would also allow the system to enjoy the resiliency benefits of relying on multiple fuels. Resiliency and reliability were only some of the drivers in Aberdeen. Addressing fuel poverty was a primary reason the city chose to move to a district system. An assessment of local heating behaviors found that many residents were under-heating their homes. Investment was thus targeted to solutions that would serve those under-heated areas with low-cost resources. Further, any revenue surpluses are reinvested in ways that hold down rates for all users to further reduce fuel poverty.

2.3.3.2 Strengthening Communities

District energy offers local governments and leaders more direct control over the energy infrastructure serving their buildings and citizens. This can drive interest and investment, and can be an attractive driver for cities to take a leadership role in encouraging new or expanded DE investment.

In **Sangam**, South Korea, the city determined that large housing developments must utilize DE, and the government competitively selects a company to offer those services. This ensures that the new developments will offer future tenants low-cost energy, impacting a large portion of the population immediately, because so many people reside in these housing developments. As an additional driver, the city was able to transform what was formerly a landfill into a desirable residential area.

In **Paris**, France, the concession arrangement allows for the city to exert some downward pressure on energy prices for "social housing," which allows the city to keep the services affordable for residents who often have significant strains on their finances. In situations where the city has sought private ownership and management of a DE system, there are still ample examples of mutually attractive concession-type arrangements that allow the city to maintain some degree of control and management over the system, watching for rate impacts on residents and working to align DE system goals with those of the city or region.

In **Vancouver**, Canada, a rate stabilization fund helps keep rate increases in check. The cost for this fund was embedded in the initial assessment of capital costs, so that over the long term, rates will pay back the rate stabilization fund "investments."

In **Birmingham**, UK and **Norman**, USA, rates to customers are benchmarked to pre-established market indices for energy products, offering assurance that rates to customers will stay reasonable. This is a common approach that helps ensure that the customers do not end up paying a burden for a poorly designed or managed system.

Cities frequently target DE development in areas that are under-invested and underutilized. In Vancouver, the area developed with a new DE system had not previously held much in terms of productive use. The city has worked to make the area attractive for new development, in part due to the DE system, which has helped to rehabilitate the area.

2.3.4 Political Drivers and Constraints

Political leaders across the political spectrum typically approach new development projects and social campaigns with a desire to reduce the risk exposure of their constituents and organizations. At the same time, local leaders and citizens desire to make the decisions that affect their local infrastructure and livelihoods, including the energy infrastructure that serves their homes, offices, hospitals and educational institutions. This is why local efforts to regain control and ownership of utility infrastructure have blossomed in the past decade. Below we discuss how different types of political drivers and constraints have led political and community leaders to identify DE solutions that specifically address the unique political contexts in which they are placed.

2.3.4.1 Risk Minimization

When cities themselves are making investments in DE, they are often statutorily required to assess the financial risk of such investments and only invest in projects deemed prudent. Other times they are limited in the amount of debt financing and bond issuances they can access, thus limiting the scope and scale of capital projects. In some cases, this means that projects that are cost-effective over the long term simply cannot be approved because of the constraints in place limiting risk. In other cases, though the city itself is not making major capital investments, it finds that the only way to attract private capital to make those investments is to dramatically reduce the real and perceived risks of the project.

In many cases, DE systems are designed to signal to investors that a reliable and stable customer base is guaranteed. This can take many forms.

In **Birmingham**, UK, potential users of the DE system's energy products issued a tender for a 25-year concession to a selected special purpose vehicle. As part of the tender, the city, a nearby university and a nearby hospital agreed to enter into a guaranteed offtake arrangement for the life of the agreement. This gave the concessionaire the confidence of a captive and guaranteed customer base.

In **Phoenix**, USA, guaranteed connection by city-owned and city-managed facilities helped establish a critical mass of load that signaled to the private sector investors that investments in system build-out would be prudent.

In **Aberdeen**, UK, the city council signaled a long-term reliable customer base by building a 48-year exclusive service delivery agreement into the contract for DH services.

And in **Aarhus**, Denmark, the city published multiple detailed plans for moving its DE system to a CO_2-neutral resource mix that would be palatable to the city, which allowed potential investors in various generation resources to know up front which types of resources would be well-received by the city.

Sometimes the stepped nature of district system investment is designed explicitly to reduce risk.

In **Aberdeen**, UK, adjacent and nearby groups of buildings were grouped together to develop heat islands, which are served by their own heat resources. Eventually, Aberdeen expects to connect these various nodes into a larger interconnected system, boosting system resilience. Risk is also reduced as the budget for the DE nonprofit is wholly separate from that of the city council. This ensures that the city does not have to absorb losses from the district system.

In **Wick**, UK, residents can pre-pay for their heating meters before they're installed, which helps the system avoid bad debt and connect already committed customers

In **Norman**, USA, at the University of Oklahoma the structure of the new ownership and management arrangement was designed to isolate the financial outlay and risk to the system itself, and free up limited capital that the university desired to target toward its fundamental missions of education and research. The state did not want to reduce its bond rating by taking on more debt, and so sought a governance and financial structure that would leave it with more cash on hand.

2.4 Success Strategy: Managing Drivers and Challenges

The drivers and constraints outlined in this chapter have influenced the projects discussed in this report to varying degrees. It is often a challenge to manage the different drivers for a DE project. A city may have economic development as a driver but face the challenge of limited capital, and may also be risk-averse to borrowing. How can city leaders optimize the design and business structure of a system to meet the challenge and develop a DE solution to provide the greatest benefit to a neighborhood or city?

A strategy for success requires paying attention to what is compelling to the stakeholders and ensuring ongoing communications about reassessing critical issues.

3 COMMUNITY-BASED ENERGY PLANNING FOR SUCCESSFUL PROJECTS

3.1 Communities and Local Energy Infrastructure

Until recently, for a majority of property owners, businesses, and local governments, energy has been little more than a utility and a bill to pay. Similarly, land-use planners and property developers have not needed to be concerned about the energy requirements of tenants, residents and building owners. But the growing cost of traditional energy arrangements, concern about national and local energy security, and the possible threat of climate change are increasingly focusing attention onto local energy opportunities.

Municipal leaders faced with growing economic, social and sustainability challenges are increasingly interested in local energy production as a means of addressing them. Energy can be a significant driver for the health and welfare of residents, and the growth and development of business, as well as energy stability for cities and communities of all sizes.

City and state governments are increasingly working to make their cities, towns and communities attractive places to live and work. They are also striving to make them inviting for business, industry and research enterprises to locate in by providing a robust, efficient and resilient energy infrastructure.

The term community energy is used broadly in this chapter to cover other references such as municipal energy and neighborhood energy. What they have in common is the use of local community energy resources, and the key roles played by cities, municipalities or community-based NGO's.

Communities grappling with resiliency after storms and flooding are deploying community energy electric microgrids that are aimed at "keeping the lights on" through disruptions caused by weather or human error. CHP enables the microgrids to "island" from the grid during an outage and provide power and thermal energy to the community until the grid returns to normal operation.

Availability of resilient thermal energy supplements the "lights on" objective with the equally important objective of keeping the "heating and cooling on."

3.2 Role of Thermal Networks

Thermal DE networks are essential to "keeping the heat and cooling on" and also serve to provide aggregate thermal loads that help make CHP viable.

Thus, as community energy evolves, DE networks continue to play a vital role as a backbone for community energy in enabling the integration of CHP and renewable energy technologies.

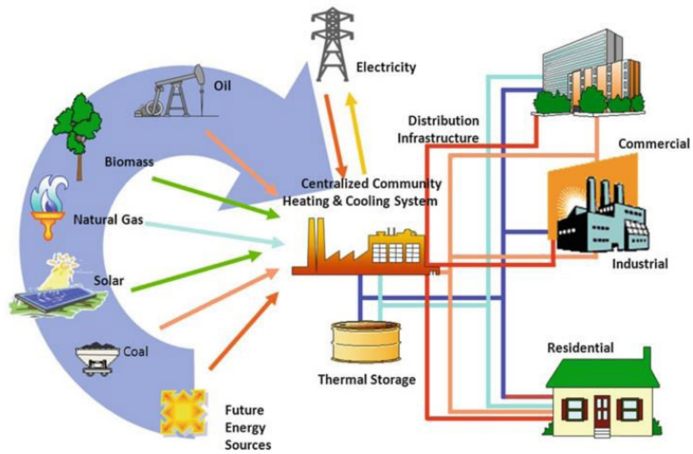
3.3 Benefits of Thermal Community Energy

The trends and drivers affecting DE today highlighted in Chapter 2 have opened up unprecedented opportunities for communities to make money, restore depleted budgets and put local energy assets to more productive use, while meeting wider social and environmental objectives. To take advantage of the diverse benefits of thermal community energy, many municipalities and public sector organizations, as well as businesses and landowners, are actively considering becoming energy producers as well as consumers by developing energy projects themselves or forming partnerships with the private sector to develop more sustainable properties and communities.

Cities, towns, municipalities and communities recognize several benefits arising from developing a local thermal energy infrastructure based on DE:

- **High efficiency and low cost:**
  Producing and distributing thermal energy at a local level is inherently efficient in converting primary energy into usable energy, particularly when combined with power generation through CHP. This higher efficiency leads to lower costs over the long term, especially when using local fuels.
- **Local control and multiplier effect:**
  Local operational control ensures that investment decisions are being made close to the point of impact. Investing in the local energy infrastructure results in the multiplier effect of local job creation and keeping money recirculating in the local economy rather than flowing out when it is spent to import fuels.
- **Flexibility and resilience:**
  The ability of DE networks to take heat from

FIGURE 3.1: FUTURE-PROOFING COMMUNITIES WITH DE



Source: District Energy St. Paul.

multiple sources, fuels, and technologies makes it very flexible. Communities have a more secure energy supply as they are not solely dependent on a single source or imported fuel supplies. Developing DE networks alongside gas and electricity networks improves their energy resilience. DE networks allow town and city managers to secure the optimum supply position. DE provides a platform that can help communities meet their near-term energy needs while envisioning a "future-proof" (see Figure 3.1), resilient and low-carbon energy infrastructure that can accommodate a variety of energy solutions including TES, CHP and integration of renewables. Emerging technologies like heat pumps, fuel cells or biofuels can be easily and rapidly retrofitted into central plants, without the need to install equipment in each building.

- **Reducing environmental footprint:** High resource efficiency in using fossil fuels and the ability to make use of renewable fuels reduces GHG emissions, thus making a valuable local contribution to the global threat of climate change.

3.4 How Can Communities Plan and Prepare for Successful Projects?

Community leaders responsible for framing strategic approaches to energy, and championing and developing community energy projects often feel they lack the knowledge and expertise to do so.

In order for a community to get ready to deploy community energy infrastructure and leverage opportunities and drivers that support community energy, it has been helpful to develop a local **Community Energy Plan (CEP**) that aligns with national and regional goals and ensures that energy is considered as an integral part of the overall planning and development process. A CEP serves as a guide and roadmap for interweaving growth and development project objectives with energy and climate goals. It helps integrate energy infrastructure options and evaluation into land use, zoning, design and project development processes. It serves as a valuable tool of reference for community municipal staff, as well as project developers. Developing a community energy plan leads to an understanding of opportunities, risks and options, and creates a basis for making decisions and creating a portfolio of projects to pursue.

3.5 Developing Community Energy Plans

There are several guides and approaches available for community energy planning aimed at supporting mayors, planners, community leaders, real estate developers and economic development officials who are interested in planning more sustainable urban energy infrastructure, creating community energy master plans and implementing DE systems in cities, communities and towns.

They are designed to equip key decision-makers with the knowledge and understanding to make confident and informed decisions entailed in the analysis, planning, development and delivery of DE systems. The following is a partial list of guides:

- USA - *Community Energy: Planning, Development and Delivery-USA* (King, Community Energy, 2012)
- Canada - *Natural Resources Canada Community Energy Planning-2007* (NRCAN, 2007)
- UK - *Community Energy: Planning, Development and Delivery* (King & Shaw, 2010)

These guides focus on community-based energy planning for successful projects and provide an understanding of what it takes for a community to deploy a DE system, including potential roles needed for successful projects; data and tools for assessing technical potential; strategies that link technical assessment with policy interplay; and local, regional and national incentives.

While the process may vary, successful community energy plans must incorporate several key activities. (See Figure 3.2.)

3.5.1 Visualizing and Realizing Community Energy Potential Through Energy and Heat Maps

Energy maps help identify local energy opportunities in development areas and inform growth options and help prioritize investment by:

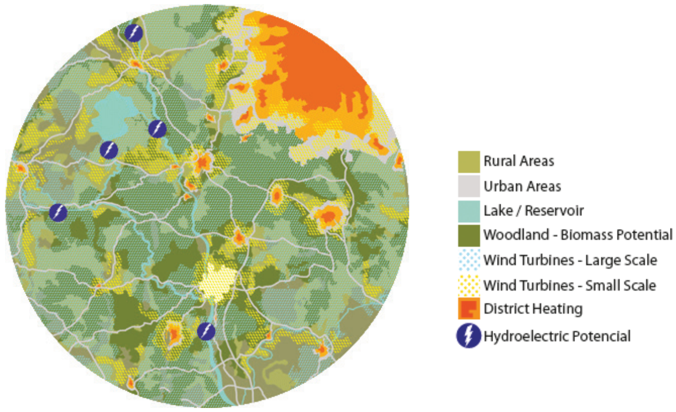
- Excluding inappropriate areas (low density; rural)
- Classifying unique energy character areas and density

Figure 3.3 is an example of an energy map that visualizes rural versus urban opportunities and the potential for a variety of energy options including DE.

FIGURE 3.2: KEY ACTIVITIES FOR A COMMUNITY ENERGY PLAN

Source: IDEA.

FIGURE 3.3: ENERGY MAP



Source: Affiliated Engineers.

SPOTLIGHT ON SUCCESS: LONDON

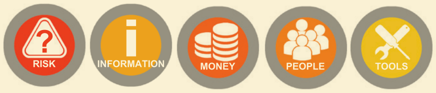


Photo by Tom Corser, Creative Commons.

The city of London, UK, has taken many steps to de-risk projects. The people leading these initiatives include the mayor, who wants to ensure that 25% of London's energy supply comes from decentralized energy by 2025. To achieve this aim, a decentralized energy program to support and quicken uptake of DH was created in 2008 with an initial focus on finding opportunities for DH networks through heat mapping and energy master planning. Other goals included building capacity within local councils to run projects and to ensure planning policies encouraged decentralized energy in new developments.

Money was made available beginning in 2011 to continue support for the Decentralized Energy for London program, with support from the European Investment Bank's European Local Energy Assistance (ELENA) facility (European Investment Bank, 2016).

By the end of July 2015, this program had helped bring 13 DE projects to market and attracted over £100m worth of investment.

This was succeeded in April 2016 by the Energy for London (EfL) program, which is part funded by the European Investment Bank. It will help London to bring in large-scale DE projects and accelerate carbon dioxide savings.

continued…

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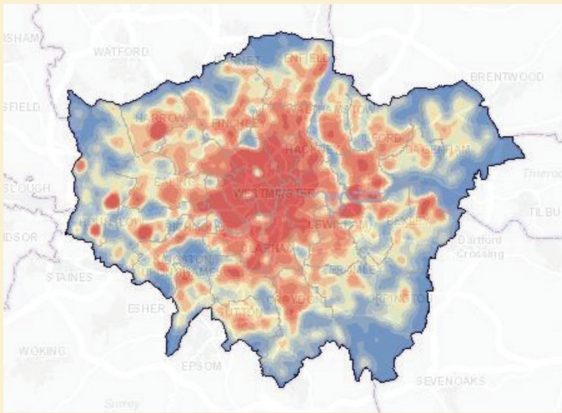
FIGURE 3.4: LONDON HEAT MAP



Source: Greater London Authority.

The London Heat Map (London Heat Map, 2015) was built as an **online tool** to help the boroughs' developers, investors, utilities and the public find information on opportunities for decentralized energy projects in London. Increasing interest in decentralized energy has created fresh opportunities for utility companies and investors in London. (See Figure 3.4.)

The London Plan now requires developers to consider connecting to existing or new DH networks. The mayor has helped put a fresh focus on decentralized energy. This has helped create a market for DE projects to succeed. A number of viable projects are now under consideration.

The heat map provides local information to help identify and develop DE opportunities. This includes data on:

- Major energy consumers
- Fuel consumption and CO_2 emissions
- Energy supply plants
- Community heating networks
- Heat density

Local councils can use the map to help develop energy master plans. These can, in turn, help shape policies in local development frameworks and climate change strategies.

Developers can use the map to help them meet the decentralized energy policies in the London Plan.

Ramboll Energy was appointed by six different London boroughs to perform a heat mapping study as part of the London Development Agency's (LDA) Decentralized Energy Master Planning Program (DEMaP).

The work involved the following activities:

- Collecting heat consumption data for a prescribed typology of existing and proposed buildings in a format for the LDA to populate its heat mapping database
- Identifying and mapping major heat sources as well as existing and proposed DH schemes
- Providing advice and support to the borough to interpret and act upon the result of the heat mapping
- Identifying potential areas for the development of further DH networks in the borough

Ramboll discussed with the individual boroughs their requirements on how the results could feed into and compliment the emerging Local Development Frameworks.

The heat demand data for priority buildings in the boroughs was assembled using as much actual energy consumption data as possible. Buildings were mapped using Ordinance Survey co-ordinates. The heat maps were then analyzed and clusters of buildings and development areas were identified that have the best potential for delivering future DH networks. The work further explored the potential of opportunities within neighboring boroughs, identifying areas that could be considered for inclusion.

3.5.2 Exploring Thermal Community Energy Opportunities

Urban growth and community climate action goals create opportunities for exploring community energy solutions that can contribute several levels of benefit.

The potential to reduce emissions and energy costs can play an important role in the wider shaping of livable cities, guided by growth and development decisions that ensure that a city's scale, density and urban design encourage civic engagement across all sectors of the population.

In these settings, communities can describe areas where there are opportunities to locate thermal energy facilities close to potential users and link them. Linking sources and users through a DE network can improve capital efficiency, conserve space, improve operating efficiency through better load management, and create opportunities for community-scale resource use, conservation and energy efficiency. For example, manufacturing facilities may generate excess heat that can be supplied for the benefit of others in a DE network. Similarly, large, occasional-use facilities, such as convention centers, stadiums and arenas may allow the redirection of under-utilized energy capacity to surrounding buildings.

Other opportunities (King, Community Energy, 2012) for a community to consider exploring DE options include:

- When the heating or cooling system in an existing building is approaching the end of its life and needs replacing
- When an existing building is being refurbished, or a brownfield environmental cleanup redevelopment is being undertaken, and there is an opportunity to upgrade the building fabric and energy systems
- When a new building or greenfield development is being planned, particularly transit-oriented developments
- If a community or building manager has concerns about energy security, price volatility, long-term cost, or simply wants to make a difference
- If congestion of electricity distribution networks and supply security are issues
- If a business opportunity to profit from the sale of energy presents itself

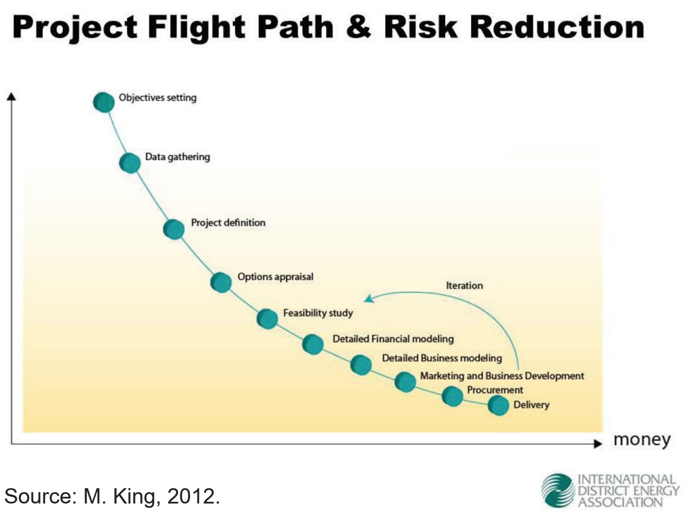
3.6 Leveraging Related and Supporting Plans

As cities undertake urban renewal, plan new development or the revitalization of existing industrial brownfield sites, they can consider local energy opportunities for DE deployment as part of a more comprehensive development plan.

Communities with existing climate action plans, land use plans, energy plans, energy studies, building energy use data benchmarks, and heat maps can build on them to explore opportunities to integrate DE.

Based on local parameters, planners and government leaders should identify their community's priorities and build community energy plans to see how local energy resources can contribute to sustainability and economic goals.

FIGURE 3.5: IDEA COMMUNITY ENERGY: PLANNING, DEVELOPMENT AND DELIVERY



Source: M. King, 2012.

3.7 Moving from Community Energy Plans to Projects

Community energy plans provide useful information for potential projects. The process of navigating a project is similar to that of navigating a flight. At each stage of the project flight path (see Figure 3.5) there is a need to handle the relevant risks and provide the needed funds and resources.

Various stakeholders need to be engaged and different levels of information need to be gathered for decision-making. Chapter 6 on stakeholder management provides useful information on this important strategy for success and includes a tool developed for the important first activity of objectives setting with stakeholders.

Chapter 7 additionally provides information on capacity building which is aimed at addressing the common problem of lack of adequate skills and resources faced by communities and developers.

4 BUSINESS MODELS AND STRUCTURES OF GOVERNANCE

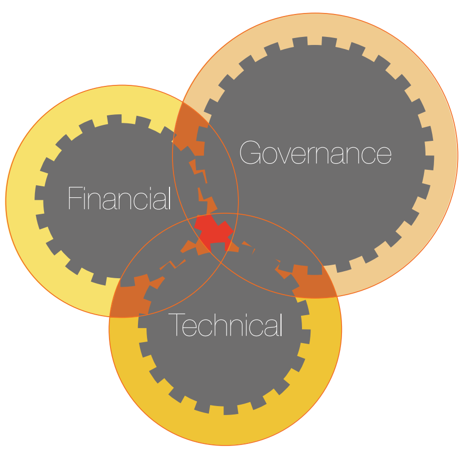
4.1 Building on Technology

The underlying technology of DE is well understood, yet many well-intentioned projects do not complete the journey from concept to service. Occasionally existing systems face the challenge of retaining customers in the face of competition from other building-based thermal sources.

Having a plan, a project and an aspiration to provide energy services is not enough to ensure project delivery. While feasibility studies establish the technical and economic viability of a project, they do not provide the path forward to project delivery and sustained operation.

Technology design and selection are important aspects of any DE project, but it is even more critical (see Figure 4.1) to connect the technology with a business model that includes stakeholder objectives, appropriate ownership, financing and governance.

FIGURE 4.1: CRITICAL ASPECTS OF A BUSINESS MODEL



4.2 Allocating and Mitigating Risk

Understanding Risk

All projects have risk attached to them. This is not a negative as it flags up issues that require attention and helps prioritize action to manage them and reduce the risk. The key issue is to identify risks and understand them, as unmanaged risks can be potentially dangerous.

Once identified and understood they should be allocated to the party best able to manage them. However, passing them to an external party to manage will increase costs as they will price the risk into their charges. Wherever possible, therefore, project developers should endeavor to manage any risks internally as far they can.

The key risks of developing, owning and operating thermal systems and network include:

- **Design risk:** Inappropriate selection of technologies, equipment size and design parameters such as operating temperatures and pressures can lead to increased capital cost and produce an adverse impact system performance.
- **Construction risk:** Delays in construction schedules due to unanticipated project phasing changes, delays in equipment procurement or the encountering of unforeseen subterranean obstructions result in schedule and budget overruns.
- **Demand risk:** For new build developments this risk can arise if proposed buildings fail to be built due to a downturn in the property market or customers do not sign connection agreements. Demand risk is substantially reduced if the project developer owns, controls or has major influence over the buildings to be connected. For established systems this is a risk when customers fail to connect, pay for or consume the predicted amounts of energy.
- **Operational risk:** This is a risk that results from lack of or poor commissioning. It is critical to ensure that the system is operating efficiently before it is accepted as complete from the contractor. Also important is the need to then maintain the system to operate to the standard to which it was designed. Risk is reduced with sufficient resilience and back-up to cope with unexpected outages.
- **Commercial risk:** It is necessary to balance pricing of service and customer payments with the cost of service delivery and return on investment. Diligent fuel price management, spreading the fixed costs of the system over a large number of customers, and rate or tariff design are useful tools.
- **Capacity risk:** Each stage of a project needs specific skills and competencies. Often it is necessary

to build in-house capacity and leverage expertise where it is available.

- **Financial risk:** It is critical that the project is able to deliver return on investment relative to the sources of capital available.
- **Control over objectives risk:** The project needs to be on track to deliver the wider objectives set forth by stakeholders such as land use, steering network expansion, carbon targets, affordability and fuel security. This risk is managed by the degree of control exercised through a governance structure to steer the project toward its objectives.

TOOLS

Methodologies for analyzing and managing risk can be found in many organizations including local municipal authorities, most of whom have a standardized risk matrix tool and experience with managing risk on other projects. Nevertheless, project developers should commence development activities by hosting a risk workshop to identify risks and develop a project risk register. This should form a key management tool for the project. It should be referenced at every project meeting and reviewed at dedicated quarterly meetings. If it is a first heat network project then persons experienced in the development and operation of heat network projects should be involved as there will be risks that are particular to them.

Assembling the risk register as an electronic spreadsheet will assist in organizing risks into categories and prioritizing according to the probability of impact so that the most impending risks are easily identified.

4.3 The Spectrum of Business Models

The most common way of characterizing business models for DE is by ownership type. The ownership spectrum ranges from the wholly public sector to a wholly private sector. In between, a range of hybrid options involving varying blends of both private and public sector financing, design, operation, fuel supply, day-to-day management and decision-making are possible. See Figure 4.2 for an overview of the business model spectrum.

The key differentiating factors are:

- **Control:** Reflecting the need to achieve the owner's specific objectives, the degree of control required via governance to direct the project toward its objectives
- **Risk:** Reflecting the appetite of the project owner to accept risk, the degree of risk the project sponsor is willing to carry in order to exercise that control
- **Finance:** Reflecting the ability of the project to provide a return on capital higher than the hurdle rate of the owner, that is the level of return on investment the project is able to deliver relative to the sources of capital available

This chapter describes the business models commonly in use and explains the allocation of different risks and the strengths and weaknesses of each model. Case studies are used to highlight key success strategies and lessons learned.

Detailed case studies are available in Appendix A: Case Studies.

4.4 The Public Sector Business Models

In this group of models a governmental body – municipal, state or national – owns, operates and controls the DE system.

Common variants include:

Public Internal Department

In this model the DE system project is developed within a department of a governmental body. The governmental body acts as the local authority that has full ownership of the system. The project is funded from the public balance sheet of the local authority.

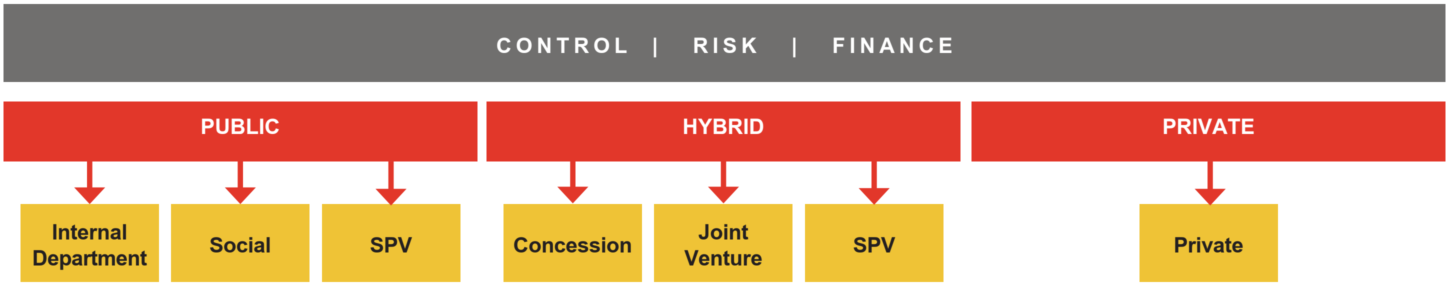
Public Social

In this model the municipality establishes a DE system as a community-owned not-for-profit cooperative owned by the members of the local social community. It is more common in European countries such as Denmark where heat customers become members of a cooperative that owns the physical system. They can vote for representatives who select the board members who control the company.

Public Special Purpose Vehicle (SPV)

This model consists of a special purpose vehicle, which is a wholly owned subsidiary independent from the local authority. It is created with the purpose of owning, operating and maintaining a DE system. One or more public sector entities may own shares in the SPV. It is typically established as a company limited by guarantee based on shares owned by the participating organizations.

FIGURE 4.2: OVERVIEW OF BUSINESS MODEL SPECTRUM



4.4.1 Public Internal Department Cases

The following case studies provide examples of systems that adopted a Public Internal Department model. General background information and specifics of financing and governance, as well as the development of the business model over time, are included to show key features of the Internal Department model.

Public Internal Department Case Example #1: AffaldVarme Aarhus, Aarhus, Denmark
Financing cost-effective CO_2-neutral heat sources

The new Lisbjerg biomass-fueled CHP plant, ready for commissioning. Photo by Aarhus Kommune.

AffaldVarme Aarhus is a municipal-owned and -operated DH system that serves 315,000 customers in the Danish town of Aarhus. Its heat is largely derived from an oil- and coal-fueled CHP system as well as local waste incineration activities. With the approval of the city council, AffaldVarme Aarhus invested in a CHP plant that will burn straw and other biomass resources in Lisbjerg, adjacent to the waste incinerator The CHP plant began providing the system with heat in fall 2016, and will eventually supply about 20% of the system's total heat, with the waste incineration plant providing an additional 20%. A larger CHP plant that also supplies AffaldVarme Arhus, the Studstrup Power Station, is owned by DONG Energy. In order to meet Aarhus' environmental goals, Studstrup needed to provide cleaner heat as well. DONG and Aarhus worked together to develop a financing scheme that encouraged the private company to make investments to begin burning biomass instead of coal.

Development of Business Model over time

- City established public DH company as an arm of city government with involvement of regional heat plants including an incineration plant and electric generator
- The system grew to heat 95% of the homes in Aarhus and expanded to incorporate several nearby towns into one integrated system
- New environmental goals drove city to lead new effort to work directly with private sector heat suppliers to obtain the heat supply they needed and develop new business models regarding investment

Financing

In order to add heating capacity and move to cleaner energy sources while maintaining stable energy prices for customers, AffaldVarme Aarhus supported a financing model approved by the national energy regulatory body, the Danish Energy Regulatory Authority (DERA). This model resulted in investment in the Studstrup CHP plant owned by Dong Energy. DERA approved the arrangement after determining that the upgrade would maintain low and stable energy prices for customers (Energitilsynet, 2012). The arrangement had to be structured in a manner that encouraged DONG Energy to make the long-term investments necessary to upgrade the targeted units. AffaldVarme Aarhus covered 80% of the costs associated with the biomass conversion, and DONG took on 20% of the costs associated with service life extension (Sekretariatet for Energitilsynet, 2012).

Governance

Cities are responsible for their own DH planning activities and coordinate closely with each other and DERA. In 2010 the Aarhus city council approved a plan to make necessary investments in the DH system toward the goal of being CO_2-neutral. As DH companies in Denmark are typically run as not-for-profits, DERA pays close attention to the impact of new investments on consumers.

Cities ask their DH companies to present ideas to serve new developments. Aarhus and the DH company work together to develop climate and energy-related goals. The city council approved the AffaldVarme Aarhus investment in the Lisbjerg CHP plant.

Public Internal Department Case Example #2: Southeast False Creek Neighborhood Energy Utility, Vancouver Canada

Establishment of a new transparent utility

Stacks that also serve as public art in Southeast False Creek. Photo by David Dodge, Green Energy Futures, Creative Commons.

The Southeast False Creek (SEFC) DH system was designed around capturing and utilizing waste heat from sewage as the main energy source. This unique system makes productive use of the heat present in the city's sewer system, which is recovered and then boosted in temperature via two electric-driven heat pumps to supply space and water heating to over 4,300 residential units. SEFC is the first raw sewage heat recovery plant in North America (Baber & Damecour, 2008).

It was developed by the city government as an explicit strategy to meet carbon dioxide reduction goals. The city continues to own and operate it today as the Neighborhood Energy Utility (NEU), with its own franchise agreement for the area it serves.

Development of Business Model Over Time

- City identified greenfield development for environmental performance during planning stages, and DE was seen as a critical component
- City leveraged its strong financial rating to obtain full financing; business model requires connection to DE utility
- Maturation of neighborhood energy utility yields regular assessment of rates and comfort with business model for future deployment; public oversight maintained

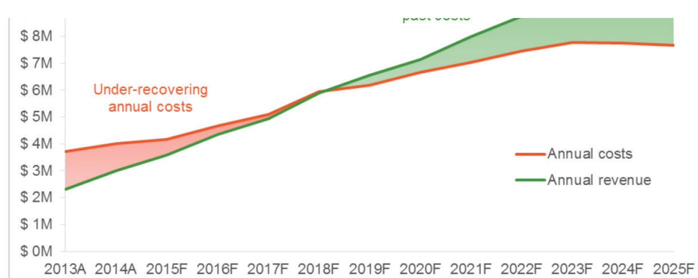
Rate/Tariff Design

In order to encourage early adoption and equitably spread the cost of connection so that the greenhouse goals could be met early on, NEU was structured to recover more of its fixed costs later in its lifespan. Thus greenhouse gas reductions could occur immediately and customers that connected to the system early on would not need to cover all of the up-front capital costs. Figure 4.3 shows how the rate recovery is expected to occur over time, with more of the costs being recovered as the system matures.

Financing

The initial annual operating shortfalls were significant due to the high up-front capital costs, and the city uses its rate stabilization fund as a kind of credit line for these kinds of initial capital projects (Crowe, 2013). The rate stabilization fund was financed by the Capital Financing Fund, which is the utility-wide capital fund. Thus, the costs of providing a rate stabilization fund were included in the initial assessment of

FIGURE 4.3: VANCOUVER'S SOUTHEAST FALSE CREEK APPROACH TO COST RECOVERY VIA RATES



Source: Baber, 2015.

overall system costs. Rates are currently structured so that 57% of a customer's bill is based on fixed costs and the remaining 43% is variable. This ratio is subject to change as the utility's finances are reassessed annually. The total costs for the system were levelized through rates over 25 years, and annual operating shortfalls can be covered by reserve funds set aside for rate stabilization (Ostergaard, 2012).

Governance

The city council has full oversight over the utility. It annually reviews and re-sets rates if necessary (Ostergaard, 2012), paying particular attention to what customers are paying, how that compares to alternatives and whether the utility can continue to justify necessary investments. The council must approve all system expansions and participates in a comprehensive rate review every five years (Crowe, 2013). The fully public nature of the system means that finances are very transparent, and regulators are able to address financial challenges and approve rate changes in a manner that is also highly transparent.

4.4.2 Public Social

The following case studies provide examples of systems that adopted a Public Social model. General background information and specifics of financing and governance as well as the development of the business model over time are included to show key features of the Public Social model.

Public Social Case Example #1:
Aberdeen Heat and Power Co., Aberdeen, UK
A not-for-profit approach to addressing fuel poverty

Seaton CHP Energy Centre. Photo by Michael King.

In 1999 Aberdeen City Council adopted an Affordable Warmth Strategy to tackle fuel poverty in the city. In part this strategy determined that investment in its own housing stock should be focused on its least thermally efficient properties.

The council commissioned a study to identify the technical solution best able to deliver low-cost heating to residents. The study concluded that this goal could best be achieved with water-based communal heating systems connected to CHP.

The council established an arm's-length not-for-profit company limited by guarantee based on member ownership and entered into a 48-year framework agreement with the company providing it with exclusivity in delivering district heat and CHP projects in council-owned property. This term was deemed sufficient to retrofit all 59 blocks. Using a blended financing arrangement, the company has now completed a total of five projects serving approximately 2,600 flats and 14 public buildings.

Development of Business Model over time

- Council establishes arm's-length not-for-profit company and sets out clear objectives
- Not-for-profit company's focused management and ring-fenced budget allows rapid network expansion
- Not-for-profit company establishes wholly owned for-profit subsidiary to retail to commercial customers

Financing

For the first project the council entered into a contract with the company to deliver the project based on an annual payment of £219,000 over a ten-year term. Based on the security provided by this contract the company was able to secure a £1 million capital loan from a commercial bank to deliver the project. Availability of a government-funded Community Energy Program and grants from government and utility energy efficiency programs as well as council funds otherwise intended for refurbishing the existing individual heating systems in the housing stock enabled the use of the loan for two other projects. The company has taken on £1 million of additional commercial debt to finance additional generating capacity to meet expanding demand.

As a not-for-profit, surpluses generated by the company are re-invested in the business. Revenues from electricity sales and non-residential heat sales are used to hold down heat charges for residential customers. Charges are set to cover costs and ensure that they do not exceed the council definition of affordable warmth: 10% of disposable income for the poorest household type (a single pensioner on welfare). The company has been able to reduce heating costs for householders by 40%.

Governance

An arm's-length not-for-profit company was formed as a company limited by guarantee based on membership. Residents and other community members nominate board directors, with two seats reserved for the elected councilors. The company is structured into task orientated sub-groups that report to the full board. At first, all activities were contracted out to specialist providers. These have progressively been brought in-house to be undertaken by an expanding number of employed staff.

4.4.3 Public Special Purpose Vehicle (SPV)

Public Special Purpose Vehicle Case Example #1:

An example of this business model is the Lee Valley Heat Network Ltd., an SPV, wholly owned by the Enfield London Borough Council, which is the local authority for the London Borough of Enfield in Greater London. The SPV has been established to develop and operate a DH network primarily fed by the Edmonton Eco Park Energy from Waste plant and provide a heat service to residential and commercial developments in and around the Borough of Enfield. The company will develop and operate other estate renewal heat networks within or outside the Borough of Enfield which are supplied from separate heat sources. The SPV has the trading name of energetik.

Financing

The capital requirement for the energetik business plan is £85 million and has benefited from a development grant of £3.7m from the Greater London Authority (GLA). Enfield Council has received funding for the project from a series of loans: £6m from the London Energy Efficiency Fund, matched by £6m from the European Investment Bank (EIB).

Governance

It operates independently from the council through a two-tier management structure.

a) Control is vested in a holding company, whose board consists of key councilors and officers representing the council as sole shareholder plus two non-executive directors
b) Delivery of heat takes place through an operating company staffed by suitable experienced officers

An agreement determines thresholds for decision-making for each tier.

4.5 The Public-Private Business Models

A hybrid public-private model is established in order to share risk between the public and private sectors and to allow access to capital available at lower rates to the public sector. These hybrid public-private partnership models may be structured as a concession, joint ventures or a SPV.

Concession

The concession is a type of public-private model where the public sector initiates the project, undertakes initial development and continues to own the assets but contracts with a private operator as the concessionaire for a specified period of time, after which the contract may be renewed.

The public partner will typically guarantee long-term heat loads. Guaranteeing the thermal demand over a long period allows the commercial energy services companies to design, build, finance, and operate and maintain (DBFO) the project over the course of the term.

Joint Venture

A joint venture is typically established as a company limited by guarantee based on shares with ownership of those shares allocated to one or more partners dependent on equity invested by each partner. This equity may take the form of cash, other forms of equity such as land, or expertise and skills. A public sector partner may contribute equity in the form of land and may provide access to lower-cost debt capital. A private sector partner, typically an energy company, may provide skills and expertise, shorter private sector procurement and access to external capital. Although such capital will be at a higher cost it can be mixed with public sector capital to derive a blended rate.

Special Purpose Vehicle

This model consists of a special purpose vehicle, which is a wholly owned subsidiary created with the purpose of owning, operating and maintaining a DE system. Ownership of shares is split between public and private entities.

INFORMATION

Establishing a joint venture, SPV, or awarding a concession requires specialized legal assistance. The purposes for the company and its structure will need to be defined in the memorandum of understanding and the articles of association. In addition, there will be a suite of contracts defining relationships necessary for the provision of the energy services.

4.5.1 Public-Private Concession Cases

The following case studies provide examples of systems that adopted a Public-Private Concession model. General background information and specifics of financing and governance, as well as the development of the business model over time, are included to show key features of the Concession model.

Public-Private Concession Case Example #1: Paris District Heating and Cooling, Paris, France
Moving climate action through urban district energy networks

Louvre Museum. Photo by Creative Commons.

The city of Paris boasts both district heating and cooling networks that have served the city for several decades. A DH network serves Paris and 12 municipalities in its metropolitan area. Most Parisian monuments – including its 21 hospitals, the Louvre museum, 50% of its public buildings and 50% of the social housing.

District heating is provided by CPCU (Paris Urban Heating Company), which as a private company, obtained its first concession from Paris in 1927 to produce and deliver steam to public buildings. CPCU has eight power production sites, two of which are CHP plants, while three are waste-to-energy (WtE) plants. Steam from the combustion process is used to generate electricity, a small part of which is used by the plants, with the majority being sold to EDF to supply the electricity grid.

District cooling is provided by CLIMESPACE, a subsidiary of ENGIE that has been a concession holder with the city of Paris since 1991 to develop and operate the Paris DC system – the largest cooling scheme in Europe. At three of the largest production sites, the DC network makes use of the ‘free cooling’ by using cold water from the River Seine to pre-cool water before it enters electric chillers, thereby reducing electricity consumption, cost and CO_2 emissions while improving efficiency (ClimateSolutions, 2015).

Development of Business Model Over Time

- Started with objectives to reduce air pollution, serve social housing and maintain aesthetic of building rooftops
- Expanded district heating and cooling networks while leveraging diverse renewable fuel sources
- Met environmental objectives through substantial use of renewables.
- Now planning connected networks

Financing

Paris has utilized the concession type of public-private partnership for its DH and DC infrastructure development and operation. Climespace had a 30-year concession contract from the city of Paris. The concession that was due to expire at the end of 2017 was extended by seven years until 2024 in order to allow it to recoup an investment of €170 million in the network. The French authorities committed to tender the concession anew in 2024 or operate it directly.

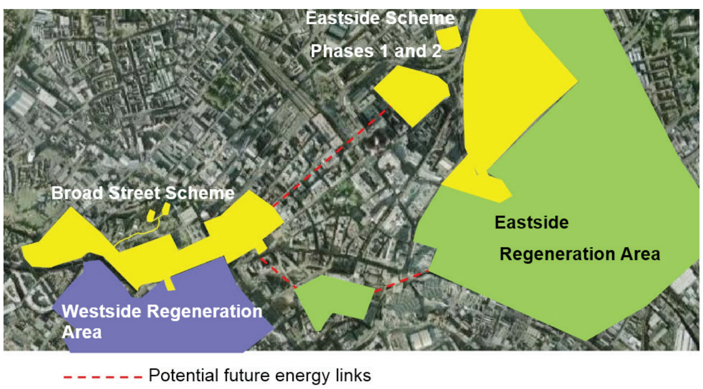
Governance

The combination of city ownership and the use of a concession model have allowed Paris to maintain a high degree of control over district heating and cooling development, while also benefiting from the efficiency improvements and capital investment contributed by the private sector.

The concession contract specifies tariffs that Climespace can charge to its customers. These tariffs vary depending on time-of-use and the size of the energy transfer station that a building requires. An annual concession review enables the city to manage the multiple objectives in partnership with the concessionaire.

The contract has undergone several amendments including environmental management. CPCU is required to develop a multi-year program of environmental initiatives and describe its implementation in an annual report. The contract also stipulates that CPCU absorb all of the steam generated by the incineration of household waste, within the limits of its operating requirements. The concession contract sets a maximum price for the heat delivered, indexed against the share of renewable heat generated to promote their share in the energy mix. The city can also require a special low price for those in social housing.

Public-Private Concession Case Example #2: Birmingham District Energy, Birmingham, UK
Developing a city center heat network



Map of Broad Street and Eastside district energy systems. Source: Cofely District Energy.

Plans for developing Birmingham's city center arena, conference center, commercial and retail facilities provided an opportunity for engineering staff at the Birmingham City Council to install gas-fired CHP to support a heat network. With a culture inclined to obtaining services from the private sector and an emphasis on short-term competitive pricing, the council was unwilling to provide direct investment. Passing on the financial risk of high upfront costs resulted in less control over network expansion decisions.

Grants from a new central government program led to a partnership in 2003 with Aston University and Birmingham Children's Hospital to tender a contract for a 25-year concession to develop a heat network serving several buildings in the city center. For this project the city appointed Utilicom, a French company later acquired by GDF Suez, re-branded as Cofely District Energy and now known as ENGIE. The company established a wholly owned SPV, Birmingham District Energy Company (BDEC). The project has been developed as two separate heat networks – Broad Street and Eastside.

Development of Business Model Over Time

- Developed early technical understanding and feasibility
- Overcame risk aversion and lack of investment through a long-term contract
- While covering investment risk the contract limits network expansion and requires negotiation

Financing

The project benefited from a £700,000 grant from the government's Community Energy Program. The remainder of the £1.86 million project was financed by Cofely District Energy (previously GDF Suez, now ENGIE) under a 25-year design, build, finance and operate contract concession under which the partnering tendering organizations, the city council, Aston University and the Children's Hospital agreed to buy energy from the company for the life of the concession.

Governance

BDEC is a wholly owned subsidiary of ENGIE. All directors are ENGIE employees. Under the concession contract BDEC established three networks with 7.5 MW CHP capacity serving 10 major buildings with heat, cooling and power. BDEC assumes all development, retail risk and control over network development. Further extensions must meet ENGIE's investment criteria. The council cannot determine the investment strategy, and its ambition for future expansion must be pursued through contractual negotiation. Tight definition of the contract precluded third-party heat suppliers accessing the network and potentially undercutting the agreed pricing structure. Energy charges are benchmarked to the market but with an efficiency driver built in.

Public-Private Concession Case Example #3: University of Oklahoma, Norman, USA

College campus leverages private sector

Ellison Hall, University of Oklahoma. Photo by Creative Commons.

The University of Oklahoma (OU) is a research university located in Norman, USA. Until 2006, the north and south sides of campus were served by DH and DC systems that were more than fifty years old. The campus is also served by a CHP system that reduces regional carbon dioxide emissions by an estimated 25,000 metric tons per year.

With anticipated campus growth, reduced availability of public funds, and burdened with aging and inefficient utility infrastructure, the university solicited bids for the management, operation, maintenance, renewal and reconstruction of its multi-utility system. In 2010 the Board of Regents authorized a nationwide solicitation to seek alternative private financing and monetization of utility assets to enable reallocation of public funds to the academic and research missions of OU.

Development of Business Model Over Time

- OU central plant started producing steam and electricity in 1948
- Until 2006, OU funded system expansion and added cooling to keep up with campus growth
- Diminished availability of funds led OU to award private concession to operate and maintain systems and address renewal of its aging infrastructure

Financing

Corix Utilities (Oklahoma) Inc., a subsidiary of Corix Infrastructure Inc. of Vancouver, B.C., was selected by OU to purchase a 50-year concession to invest in and design, build, operate and maintain the steam, electrical, natural gas, chilled-water, potable water and waste water systems (Corix, 2012).

The initial acquisition price was $118 million and the total 50-year capital investment is estimated at over $600 million. The concession agreement is structured to mirror regulated utilities in Oklahoma and uses cost-of-service-based annual rates.

Governance

The concession agreement allows OU to continue to own all utility infrastructure assets while Corix Utilities is responsible for day-to-day operations and maintenance and the funding of all future utility renewal and capital improvements. As part of the transition, Corix retained the incumbent employees from OU. Fuel, electricity and water procurement continues to be done by OU.

Corix prepares a cost-of-service study in preparation for rate setting every year in coordination with OU procurement and finance staff. A university-appointed independent “regulator” with an industry and legal background reviews the annual cost-of-service study and approves the pass-thru rate for the utility services for OU. The Board of Regents and the university facilities and capital planning and projects staff work in partnership with Corix to plan future master planning and upgrades to utility systems.

4.5.2 Public-Private Joint Venture Cases

The following case studies provide examples of systems that adopted a Public-Private Joint Venture model. General background information and specifics of financing and governance as well as the development of the business model over time are included to show key features of the Joint Venture operation.

Public-Private Joint Venture Case Example #1: Rotterdam District Heating, Rotterdam, Netherlands

Leveraging extensive waste heat resources

Rotterdam as seen from the Euromast tower. Photo by Mlefter, Creative Commons.

Rotterdam's DH system, Warmtebedrijf Rotterdam, repurposes a substantial amount of waste heat, primarily from industrial activities on the harbor and the local waste incinerator. Other heat sources include a local sewage plant and data center (Warmtebedrijf Rotterdam, 2015). The incinerator, AVR, is the largest waste-to-power plant in Europe, supplying electricity and steam to local users (AVR, 2016b). The fuel sources include both household and industrial waste streams from as far away as Italy and Ireland, which ship waste to the AVR via barge (AVR, 2016a). A separate biomass generator located at AVR utilizes local waste wood.

Warmtebedrijf Rotterdam, primarily owned by the municipality of Rotterdam, is focused on creating a waste heat chain between the port and the residential part of Rotterdam. A 26 km pipe network called the New Heatway and two heat distribution companies – Eneco for the north part of town and Nuon for the south part – enable sustainable use of industrial waste heat to warm up Rotterdam households. The New Heatway is a public-private joint venture, whose partners include the Province of South Holland, the Municipality of Rotterdam, WoonBron Housing Corporation and E.On, the Netherlands' largest energy provider. Design, development and maintenance of the New Heatway is the responsibility of Visser & Smit Hanab, a private company.

Development of Business Model Over time

- City recognized initial plan to take advantage of waste heat resources was not viable; had to reconsider role of local government in system development
- City took lead in establishing new organization with business model conducive to making needed near-term investments to reduce risk
- City leadership and early investment stimulated new investment by private sector, aided by de-risking activities such as requiring connection to network

Financing

Warmtebedrijf Rotterdam was founded in 2010 as a joint venture between the Municipality of Rotterdam and E.ON Benelux. The city of Rotterdam invested €38 million in Warmtebedrijf Rotterdam. The city also underwrote a €149.5 million bank loan and sought the involvement and investment of the private utility company E.On. The city benefited significantly from a €27 million grant from the national government of the Netherlands that was meant to ascribe monetary value to the social benefits of the CO_2 and NOx reductions (UNEP, 2015).

The investment in the new DH company was structured as an equity investment by the city, which gave Warmtebedrijf Rotterdam the confidence to make all the investments necessary to complete the entire connection and affirm that it was a public service utility.

Warmtebedrijf Rotterdam has two components:

- Warmtebedrijf Exploitatie N.V., which is focused primarily on customer-facing activities, such as managing contracts, business development, and final dispatch of heat and electricity. The main partners of Warmtebedrijf Exploitatie N.V. are the municipality of Rotterdam and E.ON, Benelux
- Warmtebedrijf Infra NV, which takes on the debt for major infrastructure projects (Warmtebedrijf Rotterdam, 2015). The main partners of Warmtebedrijf Exploitatie N.V. are the municipality of Rotterdam and E.ON, Benelux

These two components of Warmtebedrijf Rotterdam operate under a 30-year user agreement, which includes payment from Warmtebedrijf Exploitatie NV to Warmtebedrijf Infra NV for use of its transmission pipes. Warmtebedrijf Infra NV then uses those payments to help cover its investment and maintenance costs.

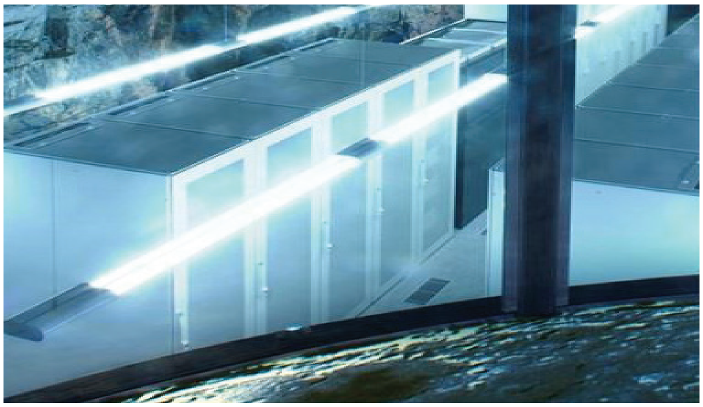
Governance

The city used its authority to help secure the necessary demand to make the systems economically viable. As part of their concession arrangements, Eneco and Nuon must purchase wholesale heat from Warmtebedrijf Rotterdam. The city requires connection of new buildings in targeted zones that coincide with the established concession areas served by Eneco and Nuon. Thus, the two distribution companies have been able to invest in additional network upgrades because of their exclusive concessions and the reliable heat supply of Warmtebedrijf Rotterdam. Additionally, Eneco and Nuon's rates and profits are heavily regulated, and rates to customers must be lower than what the business-as-usual alternative would be (UNEP, 2015). Warmtebedrijf Rotterdam-supplied heat is distributed to end users via the heat networks of Eneco and Nuon, which have both been granted exclusive concessions by Warmtebedrijf Rotterdam to serve two different areas of the city.

The city also worked directly with potential large consumers, such as housing developments and building developers, to obtain their commitment to connection in already developed areas (UNEP, 2015).

Public-Private Joint Venture Case Example #2: Fortum Värme and Stockholm Bahnhof Data Center, Stockholm, Sweden

Open District Heating – embracing the consumer as producer



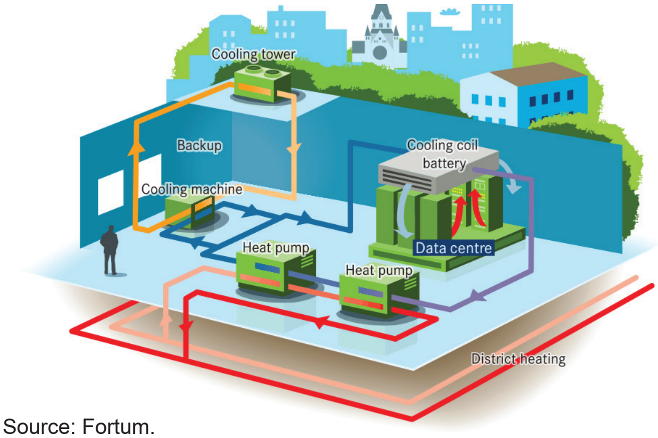
Pionen Data Center. Photo by Fortum.

Fortum Värme AB is a joint venture district heating and cooling company formed by the Finnish energy company Fortum and the city of Stockholm in the early 1990s. It is the leading supplier of DE in the Stockholm area, with 10,000 district heating and cooling industrial and household customers. In Stockholm, DC is mainly based on using 'free cooling' from the Baltic Sea. Frigid water at 6° C (43 °F), drawn from 100 ft. below the surface of the sea, absorbs the heat from malls, office buildings and data centers. Today, Stockholm has over 2,400 km of heating pipe and 294 km of chilled-water pipe (Fortum, 2013).

The "Prosumer" Business Model

In 2012, Fortum Värme developed a new business model called Open District Heating™, with the city of Stockholm, Bahnhof, Coop, ICA, Stiftelsen Stora Sköndal and Hemköp (see Figure 4.4). This innovative solution turns data center waste heat energy into a DH energy source. A growing number of data centers are redirecting the heat from their hot aisles to nearby homes, offices, greenhouses and even swimming pools. The ability to re-use excess heat from servers

FIGURE 4.4: OPEN DISTRICT HEATING™ FOR BAHNHOF PIONEN



Source: Fortum.

is being built into new data centers, helping to improve the energy efficiency profile of these facilities. Having a large DH network makes Stockholm an ideal location for data centers aiming to be net-zero. This model is referred to as a "prosumer" model.

An example of the "prosumer" model is the Pionen data center owned and operated by Internet company Bahnhof. Located in a nuclear bomb shelter, it houses over 8,000 servers. The data center cooling plant includes two heat pumps connected in series, with a total cooling output of 694 kW and a heat output of 975 kW. During normal operation the plant supplies around 600 kW of excess heat to the DH system at a delivery temperature of 68° C. The heat pump design enables them to be directly connected to the DH network, whose local pumping capacity can absorb the additional pressure drop (IEA Insight Series, 2016). The heat generated by the servers is harnessed to provide heating to hundreds of apartments because Pionen is located in one of Sweden's most densely populated areas, in Södermalm in Stockholm.

Rate/Tariff Design

Open District Heating™ is aimed at developing the future district heating and cooling markets through recycling waste heat by purchasing it from cooling customers. It allows customers to compete with Fortum Värme. If the customer can deliver heat at a lower cost, Fortum will buy it.

Customers with excess heat and located close to the DH or DC networks may sell the energy to Fortum Värme at a market price based on a price model that takes into account time and temperature level, with the highest prices paid for heat delivered during cold days at a temperature level high enough to meet the requirements of the DH customers.

Fortum Värme publishes day-ahead price per MWH based on the weather forecast for Stockholm and sets a market price of residual heat based on production cost (Fortum Corporation, 2004).

The following rate structures are offered:

Open spot market price on heating ("first-rate heating"): Purchase price depends on outdoor temperature as "first-rate" DH is delivered on feed lines. The supplier has an option on delivering and gets paid by delivery at the current price.

Open returned heating price ("second-rate heating"): Purchase price depends on outdoor temperature as "second-rate" DH is delivered on return lines. The supplier has an option on delivering and gets paid by delivery at the current price.

Open residual heating price ("residual heating"): Purchase price depends on delivery temperature during December-March when "residual heat" is delivered on DC return lines. The supplier has an option on delivering and gets paid by delivery at the current price.

Development of Business Model Over Time

- Developed joint venture company to leverage 'free cooling' from the Baltic Sea and meet carbon objectives
- City of Stockholm reduced its financial role and encouraged greater private financing
- Fortum developed Open District Heating™, an innovative "prosumer" business model to engage customers and reuse waste heat

Financing

Bahnhof has invested a total of $522,000 (Swedish Krona [SEK] 3.4 million) in the new Pionen cooling plant, including heat pumps, pipe installation, hot tapping, electrical work, control equipment, construction and insulation. Payback times are estimated to be in the range of three to five years. Fortum Värme has invested $200,000 (SEK 1.3 million) in the new supply pipeline from Bahnhof's plant to the DH network (IEA Insight Series, 2016). Fortum Värme borrowing is done through public loan programs as well as long-term bilateral loans from the European Investment Bank and the Nordic Investment Bank. In addition to medium-term notes and short-term commercial paper, it also has access to an open-ended long-term loan commitment which serves as a revolving credit line (Fortum, 2015).

Governance

In summer 2014, Stockholms Stadshus AB acquired the city's share in the joint venture with Fortum Värme. Stockholms Stadshus AB is owned by the city of Stockholm and serves as a unifying function for most of the city's limited liability companies. Stockholm City Council has delegated the governance, planning and operational follow-up to the board of directors of Stockholms Stadshus AB to ensure that Fortum Värme implements the City Council's owner directives and achieves set targets, as well as ensuring the optimal utilization of financial resources (StadhusAB Stockholm, 2014).

4.5.3 Public-Private Special Purpose Vehicle (SPV) Cases

The following case study provides an example of a system that adopted a Public SPV model. General background information and specifics of financing and governance as well as the development of the business model over time are included to show key features of the Public SPV operation.

Public SPV Case Example #1: Sangam District Heating and Cooling, Sangam, South Korea

Miracle on the Han River – raising a city with district heating

Sangam Integrated District Heating Plant. Photo by Taeyoon Yoon.

Located to the west of central Seoul, the Sangam-dong neighborhood spans the northern banks of the Han River. It is home to the iconic Daegu Stadium, a World Cup host venue.

The Sangam area was originally a massive landfill where Seoul had dumped its municipal household and industrial solid waste. After closing that landfill in the early 1990s, Seoul installed gas extracting pipes and incineration facilities to recover landfill gas (LFG).

Based on a long-term contract with Seoul, the Korea District Heating Corp. (KDHC) built an integrated energy supply facility to add an incinerator to process municipal solid waste into solid recovered fuel (SRF). In addition, the Sangam system supplements its heating supply via pipelines connected to the nearby KDHC CHP facility. Cooling is provided by absorption chillers.

Sangam is Korea's first district-type community energy system (CES) to be constructed by KDHC in the Sangam housing development zone and the first to use LFG for DH in Korea. The CES business generates heat from small-scale heating resources and supplies electricity to certain clusters of buildings (KDHC, 2009). It also supplies cooling to Sangam customers using a combination of absorption chillers, turbo refrigerators and ice storage systems (KDHC Tzu-LangTan, 2016).

Nationally, KDHC supplies DE to over 2,000 commercial buildings and 1.3 million households in its franchise area, representing a 55-60% national market share with revenues of $1.8 billion in 2015.

The backbone of its distribution system is the Seoul Metropolitan DH pipeline network consisting of 3,830 km of supply and return pipes. The DH division provides cogeneration plants and massive-scale heat generation to supply apartments, businesses and commercial buildings. The district cooling division uses surplus heat from the cogeneration plants and alternative electric energy resources to supply hot or chilled water. The community energy system division generates heat from small-scale heating resources and supplies electricity to groups of buildings such as in Sangam. The company also sells electricity to Korea Electric Power Corp. (KEPCO) through the Korea Power Exchange.

Development of Business Model Over Time

- Multiple public entities formed an enterprise (KDHC) for the purpose of saving energy and improving living standards by providing efficient DH to 1.3 million homes
- Seoul government invested in LFG pipeline project to make the massive Sangam landfill available as a LFG resource for DH
- Seoul metropolitan DH network continued to expand. Designating DH zones helped reduce risk for DH suppliers

Financing

The long-term contract with the Seoul Metropolitan Government enabled KDHC to utilize waste fuels and operate the WtE facilities. Seoul derives revenues of $5.5 million annually from the sale of waste fuels to KDHC. The government invested $138 million in the LFG project, while KDHC invested around $150 million in the pipelines to connect the nearby CHP plant to secure heat supply to the Sangam area and extend the Seoul metropolitan DH network.

KDHC manages its projects via debt and equity financing.

Governance

KDHC was founded in 1985 as a public enterprise for the purpose of promoting energy conservation and improving living standards through the efficient use of DH. The Korean government remains KDHC's largest shareholder, owning a 34.6% stake, while state-owned KEPCO holds 19.6%. Other shareholders are government-owned Korea Energy Management Corp. (KEMCO), the Seoul metropolitan government, employees and the general public. Shareholders can make revisions to the company's articles of incorporation, decide on the appointment of directors and approve the settlement of accounts at the general shareholders' meeting.

4.6 The Private Business Models

In the private business model, the private sector fully owns, operates and controls the DE project and finances it through debt and/or equity. Financing costs for the private sector are higher than those for public sector sources. This results in higher expectation on the rate of return on investment

4.6.1 Private Business Model Cases

The following case studies provide examples of systems that adopted a Private model. General background information and specifics of financing and governance, as well as the development of the business model over time, are included to show key features of the Private model.

Private Case Example #1: NRG Phoenix, Phoenix, USA

Leveraging ice storage for customer savings

Chase Field, home of the Arizona Diamondbacks and location of a chiller plant. Photo by NRG.

The Arizona Diamondbacks, a Major League Baseball team, played 80 home games in the Chase Field stadium. Cooling for these popular events was provided initially by 8,000 tons of peak chiller capacity. During an energy audit performed in 1999, it was determined that while the ballpark was operating at peak efficiencies, the majority of its 8,000 tons of installed chiller capacity remained unused as capacity was only tapped for the Diamondbacks' 80 home games per year. During that same time period, Northwind Phoenix was completing a study to determine the feasibility of developing a DC system for downtown Phoenix. The Diamondbacks and Northwind could immediately see the benefits of building a DC plant that combined the under-utilized 8,000 tons of cooling capacity at Chase field with a new ice-storage chilled water facility to handle peak event loads.

The current system, owned by NRG Phoenix, produces and distributes chilled water to hotels, Chase Field, the Phoenix Convention Center, government buildings, biomedical research facilities and other customers. The system alleviates stress on the electric grid by using nighttime power to make ice in giant steel coils, which is stored and used for daytime cooling needs. Ice melts during the day and chilled water enters the DC system at 34° F (1° C) (Perfette, 2009). This approach can eliminate as much as 10 MW of electric demand from the grid, freeing up capacity for other needs and reducing the need to tap costlier, often dirtier, peak electric resources.

Development of Business Model Over Time

- Existing ice chillers served one customer (the baseball stadium); owners were reconsidering how to maximize existing assets
- Private owner made investments in existing assets to enable increased capacity; system grew organically, adding capacity as demand grew
- System sold when original parent company decided to refocus its business; acquired by company with history of successful DE operation

Financing

The Phoenix DC system has always operated as a non-regulated, private, for-profit company, able to make investments in response to market demand. The company has followed a typical growth strategy by investing in new assets as opportunities are identified.

Governance

The Phoenix DC system is not subject to energy regulations and so it does not need to satisfy an externally developed cost-benefit analysis when making decisions about new investments. The city does not offer any incentives to NRG, nor does it get involved in system planning or operations.

Private Case Example #2: Enwave District Cooling, Toronto, Canada

Urban waters keeping Toronto cool

Intake pipes being deployed in Lake Ontario. Photo by Enwave Toronto.

In Toronto's downtown core, 40 million sq ft spread across 140 buildings are cooled by a closed-loop DC system that uses the cold water lying at the bottom of Lake Ontario as its cooling source. In the winter, as the air cools the lake surface, the denser and cooler water sinks to the bottom, where it stays close to 4° C all year, even as the top of the lake warms a bit during the summer. Underwater pipes in this deep lake water cooling system – the world's largest – bring cool water from the lake to a series of heat exchangers which connect to a separate loop that cools the connected buildings. By using this naturally occurring resource, the system avoids 90%, or 61 MW, of electrical demand that would otherwise be required to cool each building separately.

Development of Business Model Over Time

- Public not-for-profit initially developed to provide low-cost heating to residents; limitations of business model hindered expansion
- Developed special-purpose business model to allow greater flexibility and financial risk-taking while retaining public oversight
- Completed sale of system to private company, yielding significant revenue for the city

Financing

The Toronto system's initial investors and shareholders were the Province of Ontario, the University of Toronto, several hospitals and the city of Toronto. It was recognized that the company had to change its business structure to attract outside capital if it was to make the investments necessary to bring the deep lake water cooling concept to fruition. Natural Resources Canada, a department of the Canadian government, financed much of the engineering assessments to better understand the cooling potential of lake water. Around that time, the Ontario Municipal Employees Retirement Savings System (OMERS) pension fund was looking to invest in infrastructure projects (Spears, 2013).

The system ownership was restructured as the private corporation Enwave in 2000, with the city of Toronto owning a 43% stake in the company and OMERS owning the remaining 57%. The new business structure gave the company the flexibility to make the major capital investments necessary to fully realize the deep lake water cooling objective. The cooling project was officially launched in 2004, financed in part by public and private bonds that were secured via customer letters of intent (Preservation Green Lab, 2010).

Brookfield Asset Management paid $480 million CAD to acquire Enwave District in 2012.The profit made by the Toronto City Council on the sale of its 43% stake in Enwave to Brookfield Assets for $168 million CAD was the largest windfall the council had ever received.

Governance

Enwave works in close partnership with the city of Toronto. The city of Toronto and OMERS appointed Enwave's board of directors (Fotinos, 2007), who weighed in on investment decisions. The Toronto City Council had to approve the sale of Enwave to Brookfield and consider whether the terms were beneficial to the city. With the purchase by Brookfield, however, the city no longer has direct control over the operations and investments of the company.

Private Case Example #3: Wick District Heating, Wick, UK

A journey through ownerships

Aerial view of Wick-Caithness County town. Photo by Government of Scotland.

Wick is a Scottish town at the northernmost tip of mainland Britain. It is not connected to the national natural gas grid. Residents rely on costly oil and LPG from a public network to heat their homes and buildings. In 2003 the local municipality, Highland Council, received funding support from the Scottish government to undertake heat mapping in the town and assess wood fuel availability in the local region. This identified clusters of heat demand and plentiful wood fuel resource. Another government-funded study in 2004 detailed the design of a heat network connecting a whisky distillery, adjacent 270 social housing units, public buildings and the regional hospital. Caithness Heat & Power was established as a not-for-profit company between Inverhouse Distillery, Highland Council and Pultneytown Peoples' Project, a local charity.

In 2005 a CHP unit using an innovative wood fuel gasifier was added with an aim to create revenues by selling electricity to the distillery via a private wire connection as well as access revenue support available for renewably generated power. However, the gasifier proved to be problematic and the project was forced to burn higher-cost diesel fuel to meet its contractual obligation to supply electricity to the distillery. Furthermore, burning fossil fuel did not attract the revenue support for renewably generated electricity. Consequently, the project was losing money. In 2008 the council was forced to take over the company and financially support the project. The assets were auctioned to recoup the council's investment.

Ignis Energy, a private company purchase the assets including the distribution network, customer connections and boiler assets – but not the CHP unit. The project thus reduced its debt burden and avoided the technically problematic generator. The development of large industrial and institutional customers allows Ignis Energy to continue to deliver a low tariff for residential customers while maintaining the original goal of providing affordable heat.

Development of Business Model Over Time

- Mission and vision underpinned by early load mapping and technical feasibility study
- Initial vision retained. Project re-configured. Management replaced. Risk transferred to equity investor
- De-risked project attracted institutional investors through transfer of ownership

Financing

In 2016, Ignis Energy, the owner and operator of the Wick District Heating scheme was bought out 100% by the Green Investment Bank and Equitex for £10 million. Management and operation and maintenance have been contracted out (The Association for Decentralised Energy [ADE], 2016).

Governance

Caithness Heat & Power was established by Highland Council as a not-for-profit partnership among the distillery, Pultneytown Peoples' Project and the council, with representatives from each sitting on the board. When the council took over the company it installed six elected councilors as directors. A private investor-owned company, Ignis took over the assets and rescued the project before selling to an institutional investor that has contracted out the management and development functions. The project has moved through several business models, starting from a public-social, transitioning to a public and then to a private utility.

INFORMATION

There are a number of private companies operating in the DE market, with specialized expertise in the design, construction, operation, and optimization of central plants and DE networks.

Recently, larger utility companies and financial entities have entered this market, to acquire existing DE companies with a number of years' operational track record. By this point costs and revenues variations characteristic of the development phase have stabilized and the project has been de-risked. Investors will easily be able to determine whether the project will provide a stable return on capital for their investment.

Private companies may also be interested in extending existing systems.

4.7 Comparing Business Models

The level of control, risk, the investment required, ownership and management structures and expected rates of return guide the choice of business models and governance structures. See Table 4.1 for a summary of strengths and weaknesses of the various business models.

TABLE 4.1: STRENGTHS AND WEAKNESSES OF VARIOUS BUSINESS MODELS

PUBLIC SECTOR MODELS		
	STRENGTHS	WEAKNESSES
INTERNAL DEPARTMENT	• Access to lower-cost public sector financing • Generate revenue for municipality • Deliver aggregate demand and provide public sector anchor loads and reduce demand risk • Better control on flexible development and network growth • Internal oversight and regulation • Greater control on objectives such as carbon savings and affordable tariffs	• May have limited ability to raise public debt • Lack of ring-fenced budget can create risk on internal department municipal budgets • Need to develop internal skills and build capacity • Must comply with longer public sector procurement process
SOCIAL	• Not-for-profit approach allows lower tariffs • Better control on flexible development and network growth • Greater control on objectives such as carbon savings and affordable tariffs	• Cannot rely on credit rating of public organization • Cannot exit to other owners – owned in perpetuity by members and cannot access equity funding.
SPV	• Can secure lower-cost public finance via its public sector parent, particularly if the heat customers are public entities • Parent outsources technical risk to SPV • Separate SPV business plan and budget insulate parent organization • Greater control over objectives such as carbon savings and affordable tariffs	• Must provide financing • Must carry commercial risk • Must comply with longer public sector procurement process
PUBLIC-PRIVATE HYBRID MODELS		
	STRENGTHS	WEAKNESSES
CONCESSION	• Leverage third-party financing • Technical and commercial risk transferred to concession operator • Concessionaire provides necessary skills • Shorter private sector procurement process • Ability to align with the social and environmental objectives of the public sector	• Reduced control for public partner • Loss of flexibility – concessionaire may decline to accept heat from sources not under its control or connect customers where cost of connection exceeds higher hurdle rate • Liabilities are consolidated into public sector accounts • Customers see public partner guarantor of last resort in conflict situations • Need to provide higher private sector rates of return may result in higher tariffs
JOINT VENTURE	• Can draw on public and private sector financing to achieve a blended rate • Medium degree of control allows flexible development • Risk shared between partners • Separate business plan • Can choose private sector procurement route • Risk shared between partners	• Possible early exit by a partner may compromise strategic objectives and constrain flexibility • Return on capital requirements will determine tariff rates • Longer procurement process required by public partner
SPV	• Outsource technical risk to SPV • Separate SPV business plan and budget insulate parent organization	• Must provide financing • Must carry commercial risk

Table 4.1 Continued…

Table 4.1 Continued…

PRIVATE MODEL		
	STRENGTHS	**WEAKNESSES**
	• Access to capital • Ability to leverage expertise in technology and best practices • Shorter project development time due to proven track record and project management skills	• Higher rate of return expected • Tariffs higher compared to public model • Cannot access low-cost infrastructure funding available to public sector • Customers are tied into a private company and tariffs

4.8 Critical Steps for Choosing Business Models

Objectives

The most critical factor in choosing a business model is identifying the objectives for the project. These may be carbon reduction, affordable energy or economic development with local jobs. DE Systems can also provide revenue streams to offset constrained budgets.

Increasingly, cities, municipalities and other local authorities are concerned with energy security to improve the resilience of their areas in the face of a variety of challenges ranging from severe weather events to economic volatility. While localized DE can contribute to achieving all of these objectives, it is important to prioritize them as this will define the degree of control that needs to be exercised over the project in order for it to deliver the desired outcomes.

De-Risking

Investors, lenders and contractors participating in a project will take account of risk when calculating their fee or required return on capital. Action taken by project developers to lower risk, such as demand risk by securing customer contracts or shortening the procurement risk, will consequently reduce costs over the long-term project lifecycle and increase the likelihood of success.

Assessing risk helps focus attention on the important aspects of the project - whether that be the initial design, the technology choice and performance of the technology, the access and guarantees over fuel prices and supplies, the level of maintenance, heat pricing formula, or dealing with bad debts and uncertain heat loads.

Managing the risks of a project is therefore an important activity that needs to be addressed in a dedicated workshop. This will seek to identify each risk, describe it, assess its likelihood and severity of its impact, allocate its management to the stakeholder best place to do so, develop a mitigation strategy and then assess its likely impact, severity and forward management after that implementation of the strategy. This activity should be compiled into a risk register that is regularly re-visited over the life of the project. This activity will reduce risk but never entirely eradicate it, and it therefore requires continual attention and management.

Money

Once the objectives are prioritized and the projects has been de-risked to the extent possible, the model chosen is determined by access to and use of capital for the initial and subsequent investments.

Public sources of capital, if available, will expect lower rates of return than private sources.

Financing costs can be reduced by the public sector's ability to access capital with debt finance rates lower than those of the private sector. However, this debt is on "the books" and limits borrowing for future public infrastructure. Off-book financing is generally preferred. Public entity investment therefore has lower expectations on the rate of return. In the UK, low-cost public finance from the Public Works Loan Board can be obtained for 3.5%. Consequently, projects can be viable with a return on capital as low as 6% – although the threshold varies between different public bodies. Municipalities in Canada are generally cautious when borrowing from the provincial lending agency. Their maximum debt allowed is limited by their population ($/person) and must be applied to issues that are for the benefit of all.

Privately owned ESCO's will use commercial or corporate debt and will therefore require a return on capital above 12%-15%. If the project matches this expectation then this route is closed off unless the host organization is prepared to make a capital injection to improve the rate of return.

Public-private models sit between these two positions and will depend on the structuring of debt and equity, particularly if it is split between two or more parties as in a joint venture model.

5 DISTRICT ENERGY LIFECYCLE AND STRATEGIES FOR SUCCESS

5.1 District Energy Lifecycle

Securing a viable future for DE entails that systems deliver value, meet objectives, attract positive attention and stand out as best practice sites.

Systems that fail at any point during their journey through the system lifecycle impose a cost on stakeholders and have a negative impact on the brand of DE.

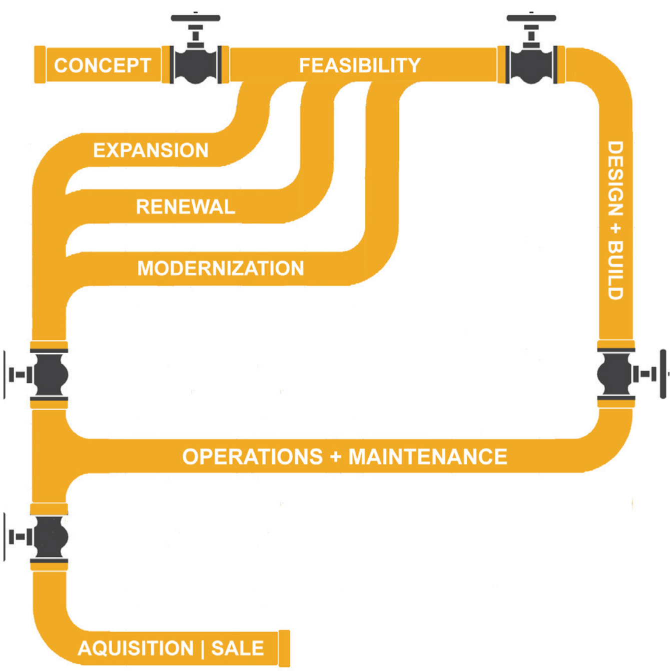
District energy systems by nature have a lengthy trajectory from concept to realization and then continue to be in service for up to fifty years or more, often experiencing phases of expansion, renewal, modernization and even changes in ownership.

Figure 5.1 shows the typical stages of a DE project and a district/system lifecycle.

5.2 Stages of the Lifecycle

These categories of stages are distinct but do not necessarily flow in a linear fashion – sometimes expansion needs require new feasibility assessments and the build-out of new components. Below are the major categories of system development.

FIGURE 5.1: STAGES OF DE PROJECT/SYSTEM LIFECYCLE



Source: IDEA.

Concept

Municipalities, cities and towns as well as campuses, businesses and industry engage in setting sustainability, economic development and urban development objectives. Planning staff, neighborhood groups and experts develop climate action plans, transportation studies, energy maps and campus utility master plans. The development of new greenfield districts or the rejuvenation of brownfield sites offer early-stage opportunities to explore DE as a possible solution. At this stage, an early concept of the envisioned systems is developed.

Feasibility

At this stage, the potential district is identified and the objectives are defined. The project scope and scale, and phasing of the development timeline, are outlined, with the intent of pursuing technical and economic study of various options to determine viability of project scope and economics.

Design Build

This stage is where in-depth attention is paid to the technical aspects of the system. The selected option is designed and engineered, systems components are procured and the DE system is built and installed.

Operations and Maintenance

This stage can span decades and requires knowledge of the system and how best to operate and optimize performance.

Expansion

During the long life of DE systems, especially in campus, hospital and research sectors, it is necessary to expand the capacity of the system to meet the added loads from growth.

Renewal

District energy systems have long useful lives. Mature and aging systems require infusion of capital for replacing end-of-life assets. Renewal is a stage where aging assets are reviewed for needed replacement.

Modernization

As technology offerings evolve and systems mature, opportunities to modernize and improve the design for increased efficiency by converting from steam to hot water systems, changing to biomass fuels, adding CHP and solar thermal, adding thermal energy storage and DC, and integrating renewable resources into the thermal grid become available.

Sale & Acquisition

Systems that are established and in operation can change ownership. The sale may be between two private parties, from public to private, private to public, or private to private.

5.3 Managing Success at Every Stage

Each project stage has different risk and financial needs and requires stage-specific information and tools for decision-makers.

As projects move from pre-concept to full feasibility analysis to design, the various ways in which the risk and information are shared, the money to fund the project is identified and deployed, and the people and stakeholders are motivated to support and work toward project milestones are fundamental to whether the project succeeds or fails.

For a project to successfully navigate through the different stages, project leaders need to maintain momentum and enable all participants to work toward project objectives. To ensure this, the following critical dimensions must be well-defined, understood and acted upon strategically.

Identifying risks and allocating them

The key is to identify risks and understand them. Unmanaged risks can be potentially dangerous. Once identified and understood they should be allocated to the party best able to manage them. However, passing them to an external party to manage will increase costs, since risk will be priced into their charges. Thus, managing risk internally might be a cheaper solution.

Obtaining, using and disseminating good quality data

The quality of data will impact project design and performance. It is important to leverage all available sources of relevant data. These could include best practices, industry reports, technical resources and project profiles. They should be used to gain early insights, dispel myths and disseminate facts among all stakeholders. Locally available data (such as building performance and benchmarking data) can often be obtained faster and more inexpensively than new building energy use profiles.

Seeking and obtaining appropriate levels of funding

It is important to align the type and level of funding with the stage of the project. Grants, public funds, utility incentives, project finance, revenue bonds and equity are some of the options. De-risking activities can attract private capital and minimize the needed additional external financing.

Making sure to have the right people with the needed expertise

A key element to managing risk is to have the relevant skills to do so. See chapter 7.0 on Capacity Building. Dedicated staff and focused day-to-day management of initial stage activities is critical to project success.

Using available tools to help gather information needed for decision-making.

Most major technical and economic decisions can be aided with existing tools. See Appendix B: Tools for a partial list of useful tools.

5.4 Best Practices and Strategies for Success

This section highlights the potential risks in each stage of development and provides a list of critical activities and best practices that will help set the stage for a successful transition to the next project stage.

Concept Stage

Risks:

- Information is preliminary in nature
- Objectives may not be well defined and may compete
- Anchor loads may not be identified or immediately available
- The project is not well understood
- Funds are inadequate

Best Practices

- Identify project champion and key stakeholders
- Clarify stakeholder objectives and develop collective buy-in
- Identify and understand various project risks
- Build public support for project, engage stakeholders and communicate vision
- Define the district geographically, and define the expected phasing and buildout timelines
- Explore potential thermal demand and local resources through energy and heat mapping
- Make assumptions on potential loads using existing tools and information on existing buildings
- Identify known and future development in land use plans
- Assess data availability and gaps; begin to identify potential data sources
- Pursue grants/public funds to develop early state concept designs
- Conduct first order screening for a quick high-level analysis of a DE/CHP alternative: use with appropriate assumptions and high level estimates of costs and revenues to enable an early go/no go decision

Feasibility Stage

Risks:

RISK

- Development risk from misaligned project phasing and buildout timelines
- Demand risk from customer connection delays
- Technical risk of poor equipment performance
- Lack of ability to raise needed funds

Best Practices

- Refine definition of project and assumptions
- Explore availability of grants and public funding for feasibility study
- Review piping routes and topology for installing distribution system
- Verify zoning and land use requirements
- Use lifecycle costing and funding to undertake financial and technical analysis
- Perform a sensitivity analysis and stress test assumptions to mitigate any optimism bias
- Build risk register to identify and allocate ownership of risks and mitigation strategies
- Assess design and technical risk, where system fails to perform to design specifications
- Anticipate and analyze development risk, such as real estate development that proceeds faster or slower than is needed customer connection timelines. Delays in system buildout can also affect delivered services to customers
- Identify anchor customers and estimate customer-generated revenue to cover initial investment costs
- Conduct marketing targeted to potential initial customer base
- Conduct a preliminary cost of service study to determine rates and return on investment options and build potential service rate/tariff structure for customers

Design Build Stage

Risks:

RISK

- Poor design that negatively impacts system performance
- Over-sizing of capacity, tying up available capital and yielding poor system performance at partial loads
- Changes in phasing of development resulting in construction delays with budget impact
- Design and planning approvals
- Financing approvals
- Procurement practices
- Right-of-way issues

Best Practices

- Avoid over-sizing system, while factoring in identified future development
- Target clusters to undertake nodal development and manage future growth
- Plan for enough available physical space in new developments for modular production facility growth
- Test design of system through commissioning before final system sign-off. This entails checking the installed system to ensure it performs according to design, and any variances are remedied. This minimizes sub-optimal operations, energy and financial losses, and customer complaints
- Use proven jointing techniques and ensure close supervision
- Provide for contingency funds of 20-30% to cover unforeseen circumstances including challenging piping routes

- Implement measuring, monitoring and metering to help optimize system and customer service
- Develop suite of contracts including connection agreement, customer thermal and maintenance contracts, and other necessary agreements
- Include contract language to allow for potential future sales of assets
- Risks associated with design, planning and financing approvals and procurement practices and resolving Right-of-way issues are challenging and often outside the control of the project

Operations and Maintenance Stage

Risks:

- Suboptimal technology training of operations staff
- Inadequate investment in maintenance impacting system performance
- Some customer contracts not delivering expected revenue due to poor demand forecast

Best Practices

- Allocate funds and resources for operations and maintenance to avoid degradation of system performance, such as poor delta T and system losses
- Set aside funds for major maintenance and capital renewal
- Explore long-term services agreements with major equipment suppliers and/or appropriate insurance products to mitigate equipment performance risk
- Consider the allocation of fixed costs in the tariff/rate design to avoid unintended burdens on provider and customers. Scale connection charges and fixed charges as a function of customer demand
- Calculate potential commercial risk, such as with customers exiting, or with price fluctuations or poorly designed tariff structure
- Leverage diurnal and seasonal rate tariffs if available to reduce production costs
- Take advantage of modeling and optimization tools (e.g., Termis, etc.) to regularly re-explore areas of savings through increased efficiency
- Develop skills and competencies for operators and staff
- Encourage staff attendance at webinars, workshops and conferences for skills building

Expansion Stage

Risks:

- Getting the sizing right
- Integration of new assets into existing system
- System interruptions, both planned and unplanned
- Ability to secure financing

Best Practices

- Assess the appropriate level of expansion based on current demand, projected demand, and expected increased efficiency of building loads
- Revisit system optimization to identify near-term opportunities
- Re-commission renewed system for system performance
- Review financing options

Renewal Stage

Risks:

- Aging system with losses related to poor or deferred maintenance
- Increased failures and reduction in overall system reliability
- Reduced service quality to specific customers with compromised equipment or components

Best Practices

- Assess opportunities for modernization in conjunction with equipment replacement
- Consider new opportunities to connect to additional buildings
- Revisit sizing and system optimization
- Re-commission renewed system for system performance
- Review financing options

Modernization Stage

Risks:

- Technical challenges of integrating new technologies into existing resource mix
- Lack of availability of new required skills sets

Best Practices

- Identify opportunities for CHP, renewable fuels and waste heat early on

- Analyze next generation technology options, such as lower temperature heat, thermal energy storage, new waste resources, innovative controls and optimization tools, and integration of renewable generation
- Consider new opportunities to connect to additional buildings
- Take advantage of new refinancing opportunities to move to lower-cost sources of capital

Sale & Acquisition Stage

Risks:

- Loss of ownership that results in changing objectives
- Market will not support estimated sales price

Best Practices

- Before a sale, undertake stakeholder outreach and engagement to address concerns and provide information.
- Ensure customer service continuity is covered by provisions in legal contracts

See Table 5.1 for activities that help manage success at each stage of the lifecycle.

Paying attention to the risks for each stage in the lifecycle while managing stakeholder objectives with limited resources can be challenging. It requires careful planning, information gathering, and strong money management. It is invaluable to have good project teams who will leverage best practices and rely on useful technical and project resources available through a variety of organizations that support DE.

TABLE 5.1: SUMMARY OF ACTIVITIES USEFUL FOR MANAGING THE PROJECT/SYSTEM LIFECYCLE

ACTIVITY	DATA NEEDS AND CONSIDERATIONS	LEAD	SUPPORT
Preliminary planning City/district plan/ master plan Climate action plan	• Location and demands of new development • Existing energy demands • Existing energy installations • Resource assessment • Emissions reduction	• Planners • Economic development officers • Government officials • Project developer	• Engineering, planning or sustainability consultants • Community members, stakeholders and interest groups • Planning bodies, project developers
Objectives setting	• Economics and cost-effectiveness • Environmental benefits and emissions reductions • Energy security	• Government officials • Planners • Economic development officers • Project developer	• Planning bodies, project developers
Data gathering	• Development density • Demand loads • Mix of uses • Age of buildings • Anchor loads • Barriers and opportunities • Energy mapping	• Project developer	• Engineering, planning, master planning consultants • Building owners, managers
Project definition	• Prioritize clusters with maximum density, diversity and anchors, and identify key buildings to be connected	• Project developer	• Engineering, planning, master planning consultants
Options appraisal	• Detailed analysis of options	• Project developer	• Engineering, planning, master planning consultants

Table 5.1 Continued…

Table 5.1 Continued…

Feasibility study	• Detailed analysis of data • Technical feasibility • Financial viability • Phasing	• Project developer	• Engineering consultants
Financial modeling	• Detailed financial viability assessment • Capital cost • Operational cost • Revenue	• Project developer	• Consultants • Financial advisors
Business modeling	• Project type • Attitude to risk • Desire for long-term control • Regulation • Access to finance and the desired internal rate of return	• Project developer • Government officials	• Consultants • Legal advisers • Tax and/or bond counsel
Marketing and business development	• Target audience • Likely customer base	• Project developer	• Consultants • Architectural and business community • Other project developers
Project procurement and delivery	• Level of public/private sector involvement • Overall project viability	• Project developer	• Engineering consultants • Procurement officers • Legal advisers

6 STAKEHOLDER ENGAGEMENT

6.1 Defining Stakeholders

A stakeholder is a group or individual who is affected by or can affect the success of an organization (Freeman, 1984).

Stakeholders can show interest as well as influence objectives, policies and actions. Some examples of key stakeholders are creditors, directors, employees, government agencies, owners, suppliers, labor unions, and the community from which the business draws its resources.

Direct Stakeholders

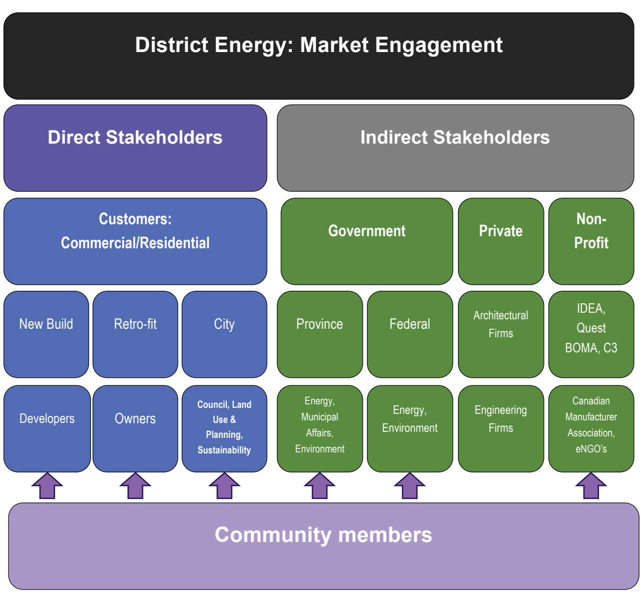
Stakeholders with a direct interest (financial, societal, and environmental) in the form and nature of the DE initiative can include project developers, investors, municipal planners, public groups and local retail groups.

Indirect Stakeholders

Stakeholders who are not directly involved in a project but bring political, economic and social objectives to bear on the project, such as economic development of the community, creating jobs, alleviating fuel poverty and promoting sustainable energy. These include government agencies, community organizations and public and private entities.

Figure 6.1 shows a more comprehensive listing of direct and indirect stakeholders in Canada.

FIGURE 6.1: TYPICAL DIRECT AND INDIRECT STAKEHOLDERS



Source: Adapted from Bohan, 2015.

6.2 Importance of Stakeholders for Success

Projects, initiatives and organizations all benefit from support they receive from stakeholders. While technical and economic feasibility and governance are necessary ingredients for success, the role played by stakeholders can determine the success or failure of projects. It is therefore important to understanding the objectives and concerns of key stakeholders and endeavors to align project objectives with stakeholder interests. It is better to have stakeholders as allies than adversaries. DE projects and systems by nature benefit and affect many groups and are influenced by many constituents. Successful projects aim to bring direct stakeholders and indirect stakeholders together to develop common objectives. This chapter aims to provide a process for managing stakeholders and identifies strategies for creating and developing positive relationships and successfully engaging them as allies.

6.3 A Process for Stakeholder Engagement

In order for a project proposal to make a successful journey from objectives setting to delivery it is critical to align objectives, garner consent and support, and ease barriers while steering the project forward.

Key challenges for stakeholder engagement should include:

- Listening to and understanding stakeholder motivations, challenges and concerns
- Maintaining clear lines of communication
- Providing information needed for decision-making
- Educating stakeholders on project attributes, costs and benefits
- Creating synergy of resources, knowledge and influence from diverse stakeholders
- Striving toward common goals and solutions

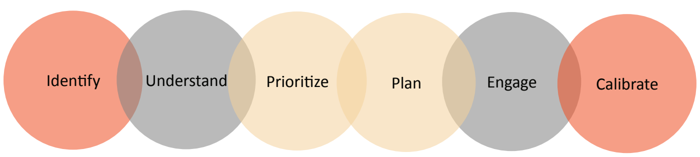
It is natural for project developers to focus on the project specifics and not paying sufficient attention to stakeholders as it can be time consuming and may not show immediate payoffs.

It is also natural for project teams to devote a lot of time and attention to a "squeaky wheel" stakeholder. What is needed is a balanced approach and a manageable process to leverage stakeholders as allies and supporters.

Effective stakeholder engagement must include the key process steps shown in Figure 6.2.

Work done by the Carbon Trust (Andrews Tipper, 2014) explores similar approaches. The Carbon Trust has developed an innovative Excel-based Heat Network Stakeholder Engagement Tool (SET) which can be used to inform an engagement strategy, capture, and repot on engagement outcomes, using the Carbon Trust's five-step approach to stakeholder engagement. See Appendix B for more detail on this tool.

FIGURE 6.2: KEY STEPS IN STAKEHOLDER ENGAGEMENT



6.3.1 Identify Stakeholder Groups

It is worth taking the time to identify as many direct and indirect stakeholders as possible at the outset. They will tend to fall into the following main categories:

ENABLING: Provide resources and maintains support. When this relationship falters, resources may no longer be available. **Example**: Investors, customers

FUNCTIONAL: Help with the working of the projects. **Example**: project developer, engineers, project staff, suppliers

NORMATIVE: Share objectives and goals. **Example**: IDEA, ADE, DBDH, UNEP, IEA DHC CHP, Euroheat and Power, Natural Resources Canada, Danish Board of District Heating, Dansk Fjernvarme, Svensk Fjärrvärme

DISRUPTIVE: Not all stakeholders are aligned with the project and may play a role in blocking it. **Example**: competition, business-as-usual proponents

DIFFUSED: Have infrequent interaction with the project, and become involved based on the actions of the organization. **Example**: media, the community, activists, other special interest groups.

A brainstorming workshop with project staff can help identify stakeholders. As part of the workshop it is useful to ask questions aimed at capturing and collating pertinent information, such as:

- What aspects of the project is a stakeholder interested in?
- What is important to the stakeholder?
- How interested are they in the outcomes? (low, medium, high)
- How much influence do they have over the project? (low, medium, high)
- How much does the project impact them? (low, medium, high)
- How can they contribute to the project?
- How may they impede the project?

TOOLS

IDEA has created a simple Excel-based tool that provides a fairly comprehensive list of stakeholders (Appendix B: Tools, 2016). Table 6.1 shows a list that may be amended based on the specific project.

TABLE 6.1: PARTIAL LIST OF POTENTIAL STAKEHOLDERS

Mayor
Municipal agency energy staff
Economic development staff
Sustainability staff
Urban planners
Regulators
Project developer
Project staff
Architect/Engineers
Contractors
Suppliers and supply chain
District energy utilities
Customers – anchor
Customers – potential
Competition
Building facility managers
Building owners
Grant providers
Lenders
Investors
Rating agencies
National Labs, UNEP, NRCAN, IEA DHC CHP Collaborative
Trade associations (e.g., IDEA, DBDH, ADE, UKDEA, AGFW, Euroheat & Power)
Media and Press
Local labor unions
Student groups
Environmental NGO's
Academic institutions

The tool further allows stakeholders to be organized by type of contribution. A positive contribution is identified by a plus sign while a negative one is represented by a minus sign. (See Table 6.2.)

6.3.2 Understand

6.3.2.1 Influence and Interest

Understanding the interest and influence levels of stakeholders will be important in prioritizing the level of effort and targeting various types of strategies.

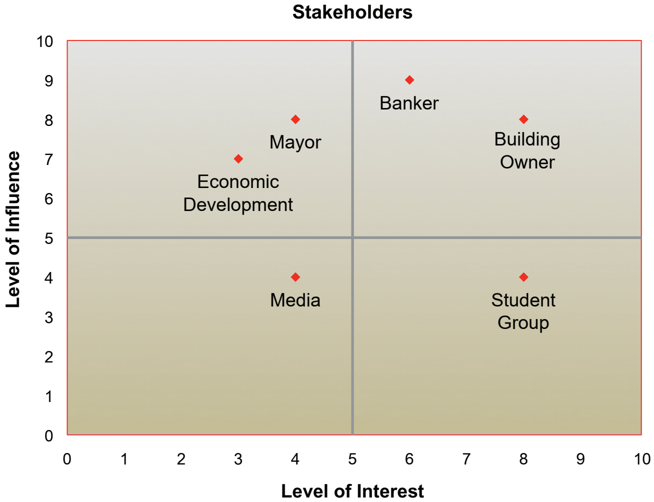
It is useful to recognize and cultivate the potential influence flowing between different categories or groups of stakeholders. Mayors and municipal energy and economic development staff can play a role in influencing project developers. Engineering firms that have delivered successful projects and local DE utilities can have a positive influence on investors.

IDEA has created a tool (Appendix B: Tools, 2016) that can be used to map the interest and influence levels of key stakeholders. (See Figure 6.3.)

TABLE 6.2: STAKEHOLDERS BY TYPE OF CONTRIBUTION

STAKEHOLDERS: HOW CAN THEY HELP?	MITIGATE RISK	SHARE INFORMATION	HELP WITH MONEY	PROVIDE PEOPLE
Municipal agency energy staff	+	+	+	+
Economic development staff	+	+	+	+
Sustainability staff		+		+
Urban planners	+	+		+
Regulators	+	+		
Project developer	+	+		+
Project staff	+	+	+	+
Architect/engineers				
Contractors	+	+		+
Suppliers and supply chain	+	+		
District energy utilities	+		+	
Customers – anchor	+			
Customers – potential	+			
Competition	-			
Building facility managers	-	+		
Building owners	+/-	+		
Grant providers	+		+	
Lenders	+		+	
Investors	+		+	
Rating agencies	+		+	
National Labs, UNEP, NRCAN, IEA DHC CHP Collaborative	+		+	
Experts & Trade associations (eg., IDEA, DBDH, UKDEA, AGFW, Euroheat & Power, ADE, Carbon Trust)		+		
Media and press		+		
Local labor unions		+		
Student groups		+		+
Environmental NGO's		+		
Academic institutions	+	+		+

FIGURE 6.3: IDEA STAKEHOLDER INTEREST/INFLUENCE TOOL



Source: IDEA.

6.3.2.2 Motivations and Barriers

Stakeholders approach projects with a variety of motivations and barriers. Table 6.3 provides a sample.

Listening should be at the heart of any stakeholder engagement. This will enable you to understand what each stakeholder needs and how you can address their needs through your project. Understanding their barriers will help to move stakeholders from being potential adversaries to being allies.

Table 6.3 gives some possible examples of barriers and motivators, but it is vital to explore individual issues with each of your stakeholders. Basing your interaction on assumptions will lead to poor results.

TABLE 6.3: EXAMPLE STAKEHOLDER MOTIVATIONS AND BARRIERS

STAKEHOLDER GROUP	MOTIVATIONS	BARRIERS
Residential customers	Cost savings, space gains, low maintenance, green energy, safety, improved system control	Disruption during installation, monopoly supply, reliability concerns, lack of understanding of technology, reluctance to change, timing (new heating systems are normally an emergency purchase). Lack of trust of developer
Municipalities	Fuel poverty reduction, economic generation (jobs), revenue, carbon emissions reduction, energy security, regeneration, improving local infrastructure (e.g., relieving capacity constraints limiting economic development)	Limited capacity and expertise to drive projects forward, reputational risk, project development and capital funding, disruption during installation, monopoly supply, outside statutory duties
Institutional customers (hospitals)	Cost savings, energy security/reliability, capacity constraints, cost reduction, carbon emission reduction policies	Cost competitiveness (gas) and monopoly supply, mismatch between heat and power demand, reliability and transfer of control, disruption during installation. Lack of trust of developer
Industrial corporate customers	Cost savings, energy security/reliability, capacity constraints, cost reduction, outsourced energy, productivity	Cost competitiveness (gas) and monopoly supply, mismatch between heat and power demand, management capacity and reluctance to change, lack of understanding of technology, reliability, lengthy contracts. Lack of trust of developer
Commercial corporate customers	Cost savings, energy security/reliability, capacity constraints, cost reduction, rental space availability, carbon policy compliance, Corporate Social Responsibility	Cost competitiveness (gas) and monopoly supply, mismatch between heat and power demand, management capacity and reluctance to change, lack of understanding of technology, reliability, lengthy contracts and lack of certainty over future building use. Lack of trust of developer

Table 6.3 Continued…

Table 6.3 Continued…

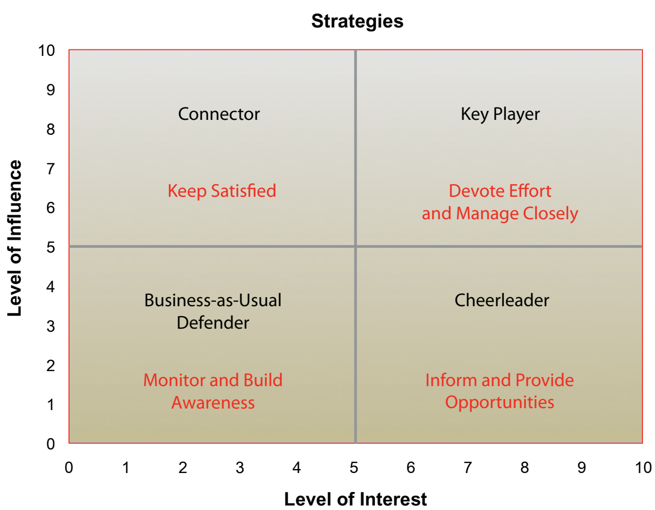
Building developers	Reduced capital costs by outsourcing energy systems to ESCo, cost-effective way of solving capacity constraints, increased space in developments, cheaper carbon policy compliance, Corporate Social Responsibility, meeting planning conditions	Time, due to lack of experience and understanding of technology, need to change a known and standardized development methodology, perception of higher capital costs, concern over salability due to monopoly supply, concern over high bills and bad press
Investors	Secure and regular revenues, proven technology	Development risk, policy change, stranded assets

Source: Adapted from Carbon Trust, H. Andrews Tipper, 2017.

6.3.3 Prioritize

In order to avoid spending a great deal of time and effort managing stakeholders, it is useful to categorize them based on the level of interest and degree of influence. The categories will help prioritize the stakeholders and guide the level of effort and specific targeted strategies to support the types of stakeholders. The grid shown in Figure 6.4 lists stakeholder categories prioritized by type and kind of effort.

FIGURE 6.4: STAKEHOLDER CATEGORIES PRIORITIZED BY TYPE AND KIND OF EFFORT



Source: IDEA.

6.3.4 Plan

The previous stages in the stakeholder engagement process will result in an understanding and analysis of stakeholder types, their motivations, and potential to promote or block the project as well as their specific interests and gaps in knowledge.

Having prioritized stakeholders according to their interest and influence, it is possible to create a plan of action to manage them.

Business-as-usual Defender

Stakeholders with a low level of interest and influence will benefit from being monitored and provided with information on the benefits of DE. Videos, industry white papers, government policy papers and case studies can help build increased awareness leading to project support.

Connector

Stakeholders with a low level of interest but a high degree of influence, such as mayors, economic development staff and urban planners, will need to be kept satisfied with regular flows of information and project status reports that are helpful in their work. It will enable them to connect the project with other parallel projects and champion synergies of objectives.

Key Player

It is important to devote effort and pay special attention to stakeholders with a high level of interest and a high degree of influence. Potential customers such as building owners expected to connect to the DE system as well as bankers and investors who want to ensure their investment is viable fall into this category. It is useful to understand their motivations and objectives and provide information on ways that the project can help them to achieve these objectives. It is critical to strive to clarify any misconceptions and provide information when it is needed to create a comfort level necessary to have them as allies rather than as adversaries.

Cheerleader

This group of stakeholders has a high level of interest but has a diffuse role in the degree of influence they may exert. Examples are the media and student groups. It is possible to leverage them as cheerleaders by providing them with opportunities to showcase the project and use its benefits to align with their own organizational, social and environmental goals

Plans should aim to provide the stakeholders with the type of information they need. A few examples of strategies are provided below:

- Monthly round-table discussions
- Information and feedback meetings every six months
- Project brochures and case studies
- Industry and government white papers
- Quarterly press meetings
- Tours of existing projects and best practice sites
- Educational workshops
- Webinars
- Videos
- Educational conferences, seminars and training such as those offered by IDEA, Euroheat & Power, Heatnet and Carbon Trust
- Regular meetings to touch base – in their offices
- Regular reporting
- Project website with info graphics and dashboards
- Project specific information such as:
  - project description and objectives
  - project site maps, size and makeup
  - project timeline
  - project cost and economic return
  - environmental impact
  - job creation

The plan should have detailed contact spreadsheet to track the engagement with stakeholders and a log of activities to help keep the information provided consistent, on track with project progress and streamlined.

6.3.5 Engage

This is the implementation stage of the stakeholder engagement process. It is an ongoing set of activities that continues through all stages of project development and may need adjustments and modifications to align with the project if necessary, so that stakeholders continue to be well-connected to the project and enable success.

SPOTLIGHT ON SUCCESS: DISTRICT ENERGY ST. PAUL

INFORMATION PEOPLE

Developed as a public-private partnership, District Energy St. Paul has worked closely with the City of Saint Paul, Saint Paul Port Authority, local businesses leaders, and civic partners to offer competitive energy solutions and cost-based rates that have played a critical role in development for the city. District Energy St Paul has become a showcase for energy efficiency through continued efforts to evolve, to reinvent, and to integrate sustainable solutions that have earned the operations a global reputation, including recognition from the United Nations Environment Programme.

They pay a great deal of attention to managing their many diverse stakeholders (Community Engagement, 2016) through newsletters, ongoing educational activities such as inviting the community to tour their systems as well as the use of art to raise awareness and increase interest in DE.

Photos by District Energy St. Paul.

6.3.6 Calibrate

Managing stakeholder is an ongoing process which benefits from a review of objectives as the project progresses.

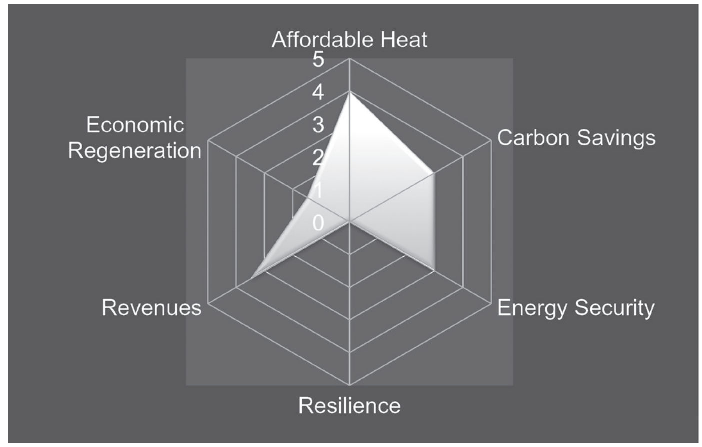
It is important to validate assumptions and engage diverse stakeholders in an exercise that explores the collective objectives of the group and the weight they place on them.

It is very useful to understand where the alignment is strong and where additional work and effort may be needed to bridge gaps.

Objectives setting

A useful tool for setting objectives is a spider diagram, also known as an Excel radar chart. Participants are given a set of likely objectives and each participant is asked to ascribe a value to each one. These are then collated, aggregated and represented as a spider diagram. This is particularly helpful in determining the collective attitude of the group. An example of an objective setting exercise to establish the key priorities for a DH scheme is shown in Figure 6.5. Details on how to use the tool are provided in Appendix B: Tools (Appendix B: Tools, 2016).

FIGURE 6.5: INTERACTIVE OBJECTIVE-SETTING TOOL



Source: BRE.

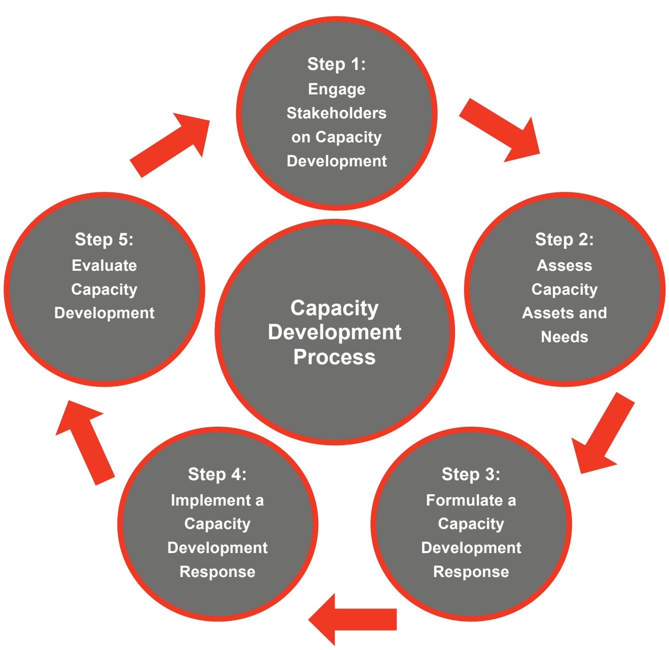
7 CAPACITY BUILDING

Organizations considering the development of a DE project involving a heat network may be concerned about their own capacity to develop, manage and operate such a system. While many of the conceptual tools necessary for these tasks are common to business management generally and the construction industry in particular, there are some areas which require specialist skills and knowledge. In this section we will consider these issues and offer suggestions on how to address such concerns.

7.1 Definition

There is a body of academic literature covering the capacity development of organizations. Very often studies and reports have been oriented toward particular fields or sectors. An early example was work undertaken from the 1970's onwards by the United Nations Development Program (UNDP), the World Bank and Oxfam International (Kaplan, 2000) focuses on the field of international development. Despite this long history there is little agreement on a generic definition. The UNDP has defined it as:

FIGURE 7.1: CAPACITY DEVELOPMENT PROCESS



Source: Adapted from UNDP, 2009.

"The process through which individuals, organizations and societies obtain, strengthen and maintain the capabilities to set and achieve their own development objectives over time" (UNDP, 2009).

7.2 Process

The UNDP approach to capacity building is illustrated in Figure 7.1. The process steps are:

1. Engage stakeholders on capacity development
2. Assess capacity assets and needs
3. Formulate a capacity development response
4. Implement the response
5. Evaluate capacity development

This methodology, designed for the field of international development, has been adapted for building of capacity within DE organizations.

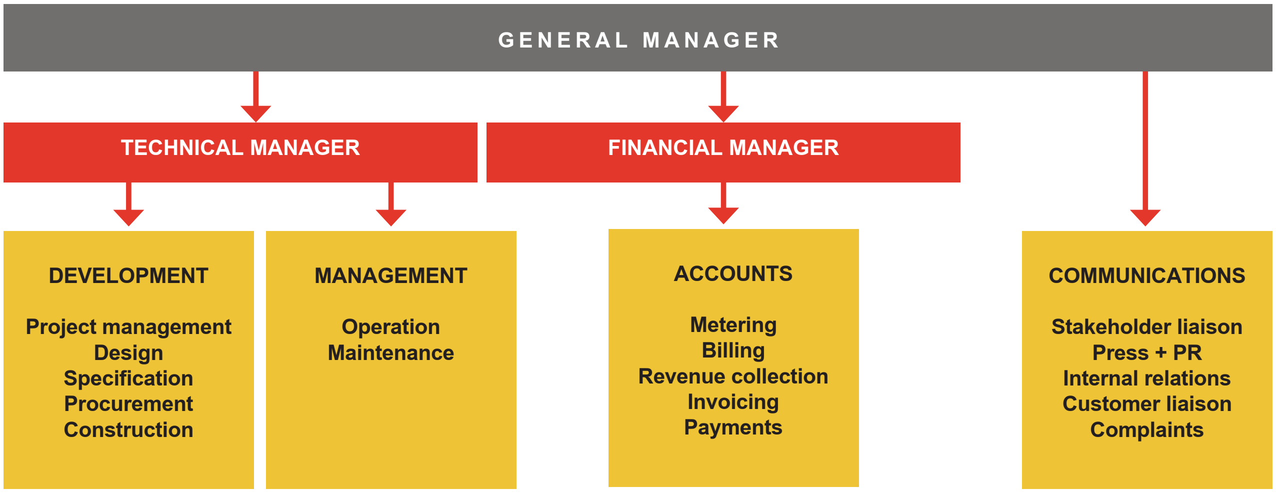
7.2.1 Engage Stakeholders on Capacity Development

This step refers to mapping out the position of the organization within its socio-economic environment. This will include the policy and regulatory framework as well as the commercial market in which it sits. A key aspect is defining and securing agreement on the organization's objectives. For example, a key stakeholder that will have a view on the objectives are the municipality within whose area the organization operates. It will be sensible to align the organization's objectives as closely with the strategic objectives of the municipality to reduce potential conflict and facilitate a collaborative relationship. Another key class of stakeholders will be investors. They will need to be comfortable with the organizations objectives. Very often mapping out this socio-economic environment will form a part of the organization's business plan.

7.2.2 Assess Tasks Required

In order to assess what capacity an organization has to develop, manage and operate a DE system it is necessary to understand what tasks need to be undertaken to do so. While some tasks will be general to the operation and management of any organization, some will be specific to the DE sector. Shown

FIGURE 7.2: SCHEMATIC OF TYPICAL FUNCTIONS AND TASKS



in Figure 7.2 is a schematic outlining typical functions and tasks for a DE project.

The following functional skills areas should be considered when building capacity:

- **General management** with overall responsibility for the operation and management of the organization. This post will be filled by a senior staffer with long management experience and qualified to degree or equivalent level. A technical background is an advantage but not essential. A key task for the general manager will be the recruitment of all the other members of staff. The board might establish a Policy & Operations (P&O) sub-group to work with and oversee the general manager on these activities. However, as the organization grows it may choose to employ a human resources manager to fulfil this role.
- **Operations staff** that have job qualifications related to the technology being used
- **Marketing personnel** to ensure steady growth of the network
- **Technical management** with responsibility for all technical matters including project development and ongoing maintenance. This staffer will be responsible for the specification and procurement of the design and construction of new projects. These will be contracted out along with project management but under the overall supervision of a Technical Manager. This post will be filled by an engineer qualified to a post graduate level and chartered engineer status.
- **Financial management** with overall responsibility for all financial matters including budget setting; monthly and annual accounts; cash flow forecasting; supervision of billing, revenue collection and bookkeeping. This post will be filled by an accountant qualified to degree level and chartered accountant status.
- **Procurement management** The senior management team should be responsible for the procurement of fuel and the sale of heat and electricity.
- **Project management** to manage project's technical design, specification, procurement of construction and installation.
- **Finance and accounting** staff for the day-to-day management of the finances including book keeping, issue and payment of invoices, metering, billing and revenue collection.
- **Communications staff** with responsibility for customer relations, complaints handling and external relations.
- **Legal services** to develop a suite of contracts to define the relationships between different parties involved in the project.

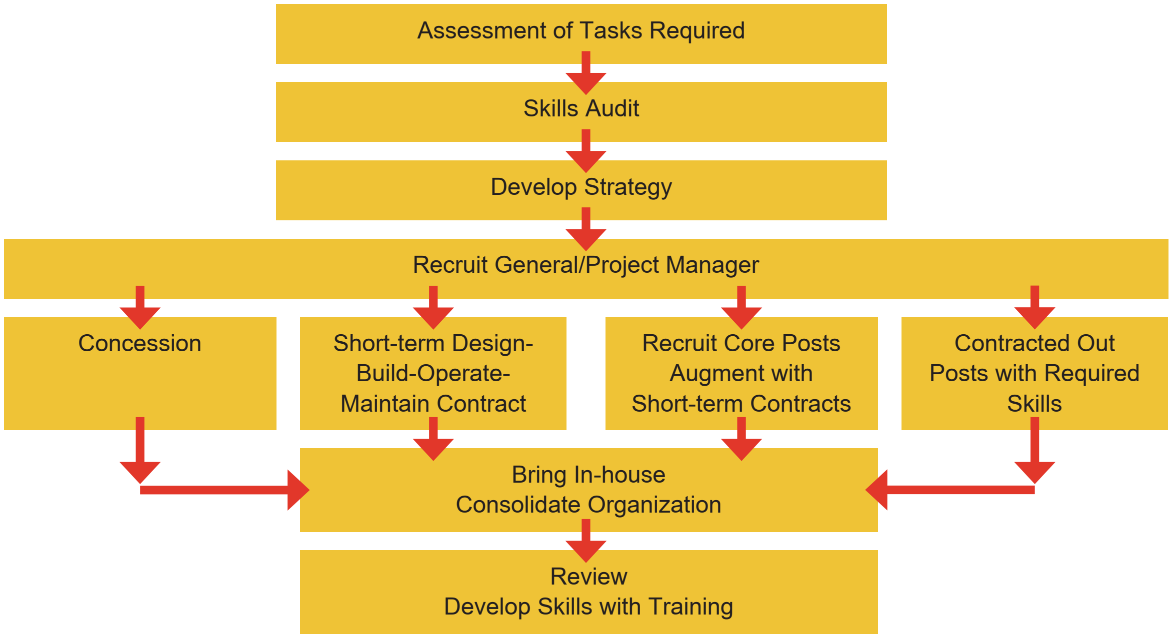
7.2.3 Assess Existing Skills Capacity

After defining the functions needed and the skills required to deliver them the next step is to undertake a ***skills audit*** of the organization to determine which or what is present and what will need to be acquired.

7.2.4 Formulate a Capacity Development Strategy

In this step, a strategy is developed to acquire the skills that are absent. A key task will be to develop a job description for the various roles. This will

FIGURE 7.3: SCHEMATIC SHOWING STEPS REQUIRED TO FORMULATE A CAPACITY DEVELOPMENT STRATEGY



form the basis for recruitment of staff with the requisite skills. See Figure 7.3 for steps required to formulate a capacity development strategy.

Frequently, projects do not have sufficient financial resources at the outset to acquire all the skills necessary for the roles to be filled. There are ways of addressing this challenge. The general or project manager drives this step of the process. It may be possible to initially add on the technical manager's responsibilities, if the individual also has engineering qualifications and experience. In the long term, there will likely be need for additional technical staff and a full-time technical manager can be recruited at that time.

Particular roles and activities can be contracted out in the short term until there is sufficient activity within the business to justify a full-time role when it can be brought in-house. For example, accounting firms can provide the necessary financial management on contract until there is sufficient activity and surplus finance available to bring it in-house.

Legal services are typically outsourced. Other services that are typically contracted out except in the largest companies are technical design and specification. This is a highly specialized area of expertise and is only required sporadically during the development of a heat network. Instead it is usually contracted out to specialist engineering consultancies that maintain this expertise and offer the service to a variety of clients. Individual clients therefore benefit from the designer's experience on other projects. As it can have a major impact on the technical and commercial success of the project procurement of design services must be undertaken with extreme care and due diligence. Track record should be robust and references checked. Furthermore, it is important to ensure that the key staff members involved in previous projects are still currently employed. Many engineering contractors offer design and build contracts (DB) as a combined package or design, build and operate (DBO) contracts as a package over a term of several years. Project proponents can use this approach to develop their projects and then take on the operation at the end of the contractual term and bring it in-house.

Certain pieces of equipment, such as CHP engines, need specialist maintenance skills. Typically, CHP manufacturers offer maintenance packages when selling their equipment. However, they will need to be monitored to ensure that they are fulfilling their contracts. There will be a need for a technical manager to provide such oversight.

Lastly, it may be that certain roles can be performed on a part-time basis or on short term contracts to cover bursts in activity.

7.2.5 Implement the Response Strategy

The capacity development response will typically combine a mixture of all these different approaches in different permutations according to the requirements of individual projects. A strategy or plan of how and when they will be deployed – and staff potentially recruited – according to the level of activity and available finance is generally included in the organization's business plan.

This step is the implementation of that strategy or plan. This may be done wholly internally or make use of a recruitment agency for particular roles.

7.2.6 Consolidation

Once the business is fully operational, has been running for several years and is producing financial surpluses, consideration should be given to consolidating the organization. Roles that have been contracted out could be brought in-house. This may be triggered by the assets being returned the owner at the conclusion of a DBO contract or concession term.

7.2.7 Re-Evaluate Capacity Development

The development of an organization's capacity and skills base needs to be constantly evaluated. The skills audit should be repeated from time to time. Additionally, the implementation strategy of plan should be flexible enough to cope with changing circumstances. Particular attention should be paid to staff members' workloads. Overload decreases organizational efficiency, depresses morale, can affect the health of the staff member and potentially lead to them departing from the organization.

Additionally, consideration should be given to the training requirements of staff. It is unlikely that new recruits will be a full fit with a specified role. Providing training can help individual staff members to fit their role or graft a new skill onto an existing member of staff. It can also help them grow and develop and become a more valuable member of the team.

8 ENABLING POLICIES

8.1 The Role of Policy

District Energy projects are impacted by both the nature and extent of national, regional and local policies that focus on energy, economic development, urban planning and environmental protection. Policy establishes the framework in which DE systems are deployed. There are often existing policy frameworks that directly and indirectly impose values on certain types of energy products, supply sources, infrastructure and energy consumption activities. Some countries and localities have chosen to implement policies that directly encourage DE, while others have developed policies to promote particular environmental goals that have indirect effects on DE system deployment.

Increasingly, national and municipal governments have recognized the significant need for early-stage support to stimulate DE projects. Activities that build a pipeline of projects, build institutional capacity, fund higher risk early-stage assessments, and that bring developers and communities together are all helpful in reducing real and perceived risks. When communities and developers understand that the policy framework is stable and supportive of DE, more projects can be pursued. When local, state and national policy is aligned and complementary, projects are more likely to be supported throughout their lifecycle.

Most of the policies that explicitly call out and support DE are local in their geography, and this section will explore a variety of these examples in several of our case study countries. However, there are good examples of policies on the national and regional level that also explicitly support DE and help motivate entire countries to consider DE on the local level. (See Table 8.1.) This section will explore some of the relevant and most impactful policies at the supra-national, national, state and local levels in all of the case study countries: Canada, Denmark, France, South Korea, Sweden, the United Kingdom and the United States.

TABLE 8.1: POLICIES BY NATIONAL, STATE/PROVINCIAL AND MUNICIPAL/COUNCIL LEVELS FOR SELECT COUNTRIES

COUNTRY	NATIONAL/STATE	MUNICIPAL/COUNCIL
CANADA	**Federal:** Establishes overarching emissions goals; no regulatory power **Provincial:** Specific emissions schemes and energy resource priorities	Establishes supportive policies and regulations for buildings
DENMARK	Establishes overarching emissions and energy goals; regulates DH prices; establishes policy that enables municipal power	Regulate development of infrastructure; can compel connection if desired; participation in local boards of DH companies
FRANCE	Establishes policy framework that supports DH; establishes carbon tax	Oversight of investment and rates
NETHERLANDS	Regulatory power over prices and customer connection costs	Oversight of new system development
SOUTH KOREA	Establishes broad regulatory framework for systems; one national company with public ownership owns most of South Korea's DH systems	Integrates heat plans with land use planning activities
SWEDEN	No regulatory power; establishes emissions and energy resource framework; leads oversight of price transparency	Lead tendering process and negotiate prices and investments
UNITED KINGDOM	Establishes low-carbon heat goals and policies; could exert regulatory power but does not	Lead tendering process and negotiate prices and investments
UNITED STATES	**Federal:** Establishes emissions goals but no direct regulatory power **State:** Establish energy resource goals; establish emissions valuation framework; no regulatory power over DH	Can require specific conditions be met in land use zones; typically, no regulatory power over thermal energy

8.2 Role of Political Framework

Each country discussed in this paper exhibits different levels of control over energy industries at different geographical levels, which can strongly influence the risk perceived by investors in DE as well as the degree to which local and regional policymakers consider the capabilities of DH.

8.2.1 North America

In the United States and Canada, broad national frameworks encourage certain energy resources, but the most impactful decisions around energy choices are made at the state and provincial level. DH is generally not regulated in most of North America, and so the ability to make investments and then receive guaranteed payback through consumer rates is limited. Thus, risk is something that must be mitigated locally by provinces, states and municipalities to encourage investments.

In the **United States**, where states' rights are strong, there is no broad national policy to promote energy supply efficiency goals and carbon reduction objectives. While some individual states have emissions goals and emissions frameworks within which to make decisions about energy resources, most still use whatever energy the market provides. Thus, DH systems are actively encouraged only by local governments, and tend to thrive in areas where the sheer size of a system supersedes typical utility planning activities, such as universities and hospital systems.

In **Canada**, some provinces, especially Ontario and British Columbia, have worked to actively encourage DE through the development of province-level policies explicitly establishing a regulatory framework. Energy regulation is largely done on the provincial level, but most provinces do not regulate DE. One exception is British Columbia, which does regulate DE systems unless the system is owned and operated by a municipality. In such cases, the municipal government is responsible for oversight and regulation of investments and consumer heat prices.

8.2.2 Europe

In **Europe**, strong European Union and national goals for emissions reductions and energy performance explicitly encourage DH and offer a framework for the valuation of emissions and energy efficiency benefits of DH. European Union funding for district heating-related research ensures that many of the universities are continuing to develop best practices in system development and that analyses of the costs and benefits of DH are regularly updated.

In most cases DH itself is regulated, and tariffs are subject to oversight of a regulatory body. In Europe the majority of governments are parliamentary in nature, and multiple parties frequently trade leadership positions. Thus, consensus policies are somewhat common, both at the national and local level. Additionally, most of the European countries that are profiled in this report have established binding goals for emissions related to climate change.

In **France**, a 2015 "energy transition" law further established the country's climate goals, increased its existing carbon tax, and assigned more resources to the development of heat networks throughout the country (Jean & Pelletier, 2016). The country has developed a national goal to expand DH, and regulatory decisions around new system development are left to regional and local governments. The national government supports the development of the systems, but local governments can make final determinations about the design and ownership structures.

In **Sweden**, national goals for energy and emissions mirror many of those in the EU, and establish the framework through which investments in DE national policy are viewed. However, DH is not regulated in Sweden, and the market is made up predominately of municipal systems, many of which have recently sold parts of the system to private owners. These systems were initially regulated locally, and were developed as natural monopolies. Today Sweden affords substantial negotiating power to both customers and providers of DE, preferring to encourage negotiated prices as opposed to regulated ones (District Heating Act (2008:263)). In 2013, a national effort to improve transparency in price setting helped to move the market to more fair pricing in lieu of regulation.

In **Denmark**, strong national goals around DH and CHP helped establish the robust DE market decades ago. National regulation of DE prices is coupled with local regulation and oversight of DE company activities. Local energy planning reflects aggressive national energy policy goals, though the role of DH and especially CHP in Denmark's energy future is currently under debate. Municipalities have ample power to implement policies and regulations in support of their local DH system, such as requiring connection of certain buildings.

In the **U.K.**, a national policy designed to encourage low-carbon heat was adopted in 2013, which has driven national programs and funding for early-stage feasibility work. As part of the policy, the national government clarified the role local governments should play in taking the lead on project development. National energy regulation activities could include DH but currently do not (Frontier Economics, 2015). Instead, local authorities wishing to encourage new investment typically tender for a specific type of service, and details of rate of return, etc., are worked out through negotiation. In this way, local councils have tremendous control over the market activities of DE companies.

In the **Netherlands**, tight national-level regulation of DH prices and strong input from the local governments help to encourage deployment of systems specifically addressing local challenges and opportunities while keeping rates low. Again, new system development is largely controlled by the local government, with maximum prices for energy and individual consumer connection set by a national consumer-focused agency (Authority for Consumers & Markets, 2013).

8.2.3 South Korea

In **South Korea**, there is a greater degree of alignment of national, state, city and municipal level policies, as well as a national regulatory framework for DH. Using an integrated energy supply approach enables South Korea to meet both thermal demand for heating and cooling and electricity demand through deployment of large-scale CHP while leveraging local energy resources such as landfill gas.

Local governments work within nationally established parameters, and a single company with substantial public ownership operates most DH systems in South Korea. Zones for DH development are identified, and there is broad coordination across the thermal and electricity sectors, which helps encourage deployment of CHP. After a single company is selected to serve a newly developed zone, the municipality then integrates the DH plans with its broader land use activities.

8.3 Heat Planning and Land Use Policies

District heating systems are inextricably linked with the physical space in which they sit. Buildings are the end users of DE systems, so land use policies that influence building development will indirectly influence DE opportunities. Land use policies can also directly influence DE deployment, though, by requiring that buildings in certain locations or with certain densities consider DE infrastructure.

8.3.1 Canada

Canadian provinces have largely supported DE within a broader effort to promote “community energy,” which includes building-scale energy efficiency as well as use of locally available energy resources through DE and CHP project deployment. One analysis found community energy plans in place in over 180 communities in Canada, which represents over half of the Canadian population (Bell, Robinson, Leach, Campbell, & Ratchford, 2015). Some provinces, such as Ontario, have set aside funding specifically to help communities develop these energy plans (Bell, Robinson, Leach, Campbell, & Ratchford, 2015). These plans can have direct impacts on municipal policies. For instance, in British Columbia a “solar hot water-ready” regulation is available for adoption by cities on a voluntary basis. The province offers guidance on policy implementation, and cities can choose to adopt the regulation, which requires that new single-family homes are built with the hydronic infrastructure to accept solar-based hot water in the future (Bell, Robinson, Leach, Campbell, & Ratchford, 2015). To date, 48 municipalities and towns have opted into this regulatory requirement (Queen’s Printer for Ontario, 1980).

British Columbia also has a long-standing requirement that municipalities undertake community-scale energy and emissions inventories, and provides support and guidance on what those inventories could look like. This helps municipalities and communities consider the energy choices that will most dramatically impact their greenhouse gas performance. Bill 27, which established the inventory requirements, also required local governments to establish local targets for greenhouse gas emissions (Rutherford, 2009).

Key Policy Documents

- Vancouver Neighborhood Energy Center guidance and framework (Crowe, Vancouver Neighborhood Energy Strategy and Energy Centre Guidelines, 2012)
- British Columbia’s Solar Hot Water Ready Regulation (Queen’s Printer, 2011)
- British Columbia’s full Community Energy & Emissions Inventory, which was established by Bill 27 (British Columbia, 2016)

8.3.2 Denmark

For decades Denmark has implemented policies that directly support DE. This has helped develop a substantial and mature DE industry. Every major city in Denmark has a well-developed DE system, and existing systems are still being expanded or adapted to respond to new fuel opportunities.

In the 1970s Denmark adopted several pieces of national legislation that officially established DH, especially DH based on CHP, as a critical component of the country's energy future. No new power plants were to be built unless they were CHP, and existing power plants were converted to CHP. These developments produced considerably more waste heat than had been previously available (Chittum & Østergaard, 2014). This surfeit of cheap waste heat helped drive the expansion of new DH systems.

At the same time, Denmark identified municipalities as the appropriate governmental entities to conduct heat planning activities and gave cities the clear authority to plan and oversee the development of DH networks. Municipalities undertook plans that identified existing waste heat resources, and identified how new developments and land use changes would potentially affect future demand for space heating. Municipalities then assessed which kinds of heat resources would best meet their needs, and determined the boundaries of new heat networks.

At the local level, municipalities have the authority to require connection of existing buildings to a DH system if they deem it appropriate to do so. Municipalities can require that new developments in certain areas connect to existing DH systems, or they can require that a new DH system be built to meet a newly developed building area. This authority indicates to the market that DH is a low-risk business for investment, since the demand for the heat product is secured (Chittum & Østergaard, 2014). Additionally, the national government has regularly developed technology catalogs for use by municipalities, to ensure all municipalities were making well-informed decisions with the most up-to-date information on performance and costs.

Key Policy Documents

- Electricity Supply Act of 1976 (Ministry of the Environment, 1976)
- Heat Supply Act of 1979 (Ministry of the Environment, 1980)

8.3.3 European Union

The European Parliament recently adopted the EU Strategy on Heating and Cooling, which strongly endorses the use of CHP and DH and cooling systems to provide energy- and emissions-efficient heating and cooling resources to a wide variety of dwellings across Europe (European Parliament, 2016). The overarching goal of the strategy is to de-carbonize all European buildings, which includes both extensive energy efficiency upgrades as well as continued promotion and development of de-carbonized electricity and heating and cooling. Utilization of waste heat, especially from industrial sources, is encouraged.

Key Policy Documents

- EU Strategy on Heating and Cooling (European Commission, 2016)

8.3.4 South Korea

The Korean government's Integrated Energy Supply Policy (IESP) provides significant support for CHP via urban planning policy to designate new developments as Integrated Energy Supply Areas (IESAs), thereby creating a captive market for DHC.

South Korea has dramatically reduced the risk associated with investing in new DE systems by stipulating that certain areas must include DH plans when they develop, and buildings must connect to those DH systems if they are in the designated area. The overarching law that establishes these development parameters is called the Integrated Energy Supply Act (Pales, 2013). DH system developers thus recognize these areas as providing guaranteed and reliable demand. The country develops an Integrated Energy Supply Master Plan every five years, which is where new specific areas are identified for connection.

The Ministry of Knowledge Economy (MKE) can designate an area as an IESA. After this designation, any construction plan must include the heat supply network, and all buildings and apartments on site are obliged to connect to an 'Integrated Energy Facility' (IEF) supplying district heating and cooling. Private companies bid for the right to supply the heat and electricity within an IESA, and the winner receives the exclusive right to do so. This law therefore creates a captive market for CHP and the provision of heat. It does not offer a direct financial incentive, but this is still an effective support for DHC and CHP, and drives activity in this market.

After a specific supplier is selected, the municipality itself has the responsibility for integrating heat planning within its land use planning activities, and for identifying existing waste heat streams (Pales, 2013).

The government also aims to increase the use of renewable energy in South Korea. CHP plays a key role in the country's extensive DH systems. DH companies building new CHP units are required to build renewable energy projects whether or not they are connected to those DH projects.

South Korea is continuously promoting the expansion of DE in consideration of energy efficiency and environmental problems. The second National Basic Energy Plan, announced by the government in 2014, outlines future energy policy direction, such as the realization of a low-carbon society, and calls for increased energy security, the rational use of energy and environment protection (International Energy Agency, 2016).

One of the six policy goals delineated in the Plan is aimed at increasing distributed energy generation from current levels of 5% to 15% by 2035, and to 35% in the long run. This goal supports construction of CHP plants in local regions. Other goals include applying the latest GHG reduction technologies to new power plants, promoting renewable energy, and improving energy efficiency by utilizing new technologies for heat production (Policies for a Sustainable Energy System - South Korea, 2014).

In 2008, the Prime Minister's Office issued the National Comprehensive Basic Plan for Climate Change Adaptation. After "expansion of DC system using district heat" was mentioned in this plan, South Korea's DC has expanded in the DH area. Also, South Korea's government has provided incentives for energy-efficient cogeneration such as an increase in sales prices from cogeneration and a reduction of fuel cost burden (Yoon, 2017).

In 2014, the Ministry of Trade, Industry and Energy (MOTIE) issued the Integrated Energy Supply Master Plan (MOTIE, Ministry of Trade, Industry & Energy, 2014). Many goals within the plan specifically support DE. These include expanding energy efficiency targets to gas and DH operators; promoting the distribution of DC and gas cooling, through direct subsidies and the promotion of DC systems for apartment buildings; treating DC as power load management equipment via technologies like ice thermal storage and gas cooling; developing DC supply plans; and expanding the DC potential market by promoting district cooling-ready technologies.

Key Policy Documents

- National Basic Energy Plan (International Energy Agency, 2016)
- Integrated Energy Supply Master Plan (MOTIE, Ministry of Trade, Industry & Energy, 2014)

8.3.5 United Kingdom

The UK developed a heat-specific energy policy guidance document for England and Wales in 2013 called the Low-Carbon Heating Strategy. This and supporting documents establish a national plan for low-carbon heating, and lay out the government's priorities and plans for neighborhood-scale DH solutions. These efforts clearly identify early-stage support for DH networks as an important way to help stimulate early market development, bring down costs, and build out supply chains (U.K. Department of Energy and Climate Change, 2013). To administer this early-stage support, the government formed the Heat Networks Delivery Unit (HNDU), which offers direct assistance to localities interested in developing and implementing district-scale solutions.

The HNDU has administered a total of £11 million in grants to localities working on early stage development of new or expanded heat networks. Over 118 different local authorities in England and Wales have received these grants, which were explicitly designed to support the UK's policy to encourage locally-based heat networks. This program has been critical in supporting the riskier aspects of DE development, such as feasibility assessments, heat mapping, and energy master planning (UK.gov, 2015). Localities receive direct grants, but they also receive technical assistance during the early stages of their project development.

To keep the momentum moving forward on the early-stage work funded by HNDU, new funds will be made available for techno-economic modeling. Over the course of five years, beginning in 2016, the UK government will commit £328 million in capital funding to DH networks. The program is called the Heat Networks Investment Project (HNIP) and will first begin with a pilot program framework that is expected to be smaller in scope than the eventual final HNIP program (called the "full scheme"). A public consultation was made available, and the comments on the consultation have now been published. The project will begin by offering communities up to a 67% cost share of the cost of feasibility studies (Department for Business, 2017). The final HNIP scheme will likely channel a significant capital boost to DH projects throughout England and Wales. The opportunities identified in the initial HNDU-funded activities will have the opportunity to move to full commercialization.

Separately, the Scottish Government published a Heat Policy Statement (2016) on its intentions to de-carbonize heat. Although DE is subsumed in a broader framework of energy efficiency, the Heat Policy Statement includes a target of 1.5 TWh of heat demand to be delivered via heat networks, and 40,000 homes connected by 2020. To support this ambition municipalities will be provided with support to develop a strategic approach to DH and financial support will be available through the Scottish Energy Efficiency Program (SEEP) and the Low Carbon Infrastructure Transition Program (LCITP).

Finally, in London, the Greater London Authority (GLA) adopted official policy in support of decentralized heating and cooling networks and identification of existing heat resources to meet current heat needs. The London Plan, the GLA's spatial development plan, has developed a three-tier energy hierarchy. New building developments must:

- Be lean (reduce demand for energy)
- Be clean (supply energy efficiently)
- Be green (provide much of the residual load from renewable sources)

District heat networks are specifically prioritized as a means of supplying heat efficiently.

The GLA has a goal of meeting 25% of its heating and power needs with local, decentralized energy systems, including DE, by 2025.

Key Policy Documents

- London decentralized energy policies (Greater London Authority, 2016)
- Scottish Heat Generation Statement (The Scottish Government, 2015)
- UK Heat Networks Delivery Unit services (UK.gov, 2015)
- UK Heat Network Investment Project consultation (U.K. Department of Energy and Climate Change, 2016)
- UK's The Future of Heating: A strategic framework for low carbon heat in the UK

2012 and 2013 documents (U.K. Department of Energy and Climate Change, 2013)

8.3.6 United States

One of the important roles cities can play is ensuring that DE is fairly assessed compared to other

8.3.7 SPOTLIGHT ON SUCCESS: VANCOUVER

Vancouver skyline and mountains, facing north. Photo by Spencer Martin, Creative Commons.

The City of Vancouver has broadly endorsed DE in its Neighborhood Energy Strategy, which is designed to help the city meet its climate and energy goals. The city issued guidelines for the development of neighborhood-scale energy centers, as well as for the development of business structures and the setting of rates. The city has jurisdiction over the buying and selling of thermal energy, and has oversight over most aspects of the development of neighborhood energy centers, which will typically be DE solutions (Crowe, Vancouver Neighborhood Energy Strategy and Energy Centre Guidelines, 2012).

Vancouver municipal regulations stipulate that major developments over two acres in size must consider the feasibility of onsite energy generation using low-carbon resources. Additionally, developments in denser areas must include buildings that are "district energy-ready," with hydronic infrastructure, so that they could potentially connect to a newly developed DE system in the future (Integral Group, 2014).

alternatives when new buildings are developed. In Cambridge, Massachusetts, the City Council adopted a zoning ordinance – Cambridge's Zoning Ordinance 1355 (City of Cambridge, 2013) – for a 26-acre area in a highly desirable commercial and educational hub. As a condition of building in the area, the ordinance specifically requires developers of new developments in the zone to assess the feasibility of onsite energy generation, including CHP that might offer power or heat to nearby buildings. The ordinance further requires all commercial buildings to assess the feasibility of connecting to a steam-based DH system that already serves the area.

Key Policy Documents

- Cambridge's Zoning Ordinance 1355 (City of Cambridge, 2013)

8.4 Greenhouse Gas Reduction Goals

8.4.1 European Union

The European Union has a long history of binding greenhouse gas and energy goals that its member states must help meet. This has established a strong foundation for DE, especially recently, as the EU has increasingly recognized the important role DE will play in meeting these goals. EU member states are required to meet their own state-specific goals. Taken together, these goals comprise the EU's official goals, which include a 20% reduction in greenhouse gases by 2020, relative to 1990 levels, and a 40% reduction in greenhouse gases by 2030, relative to 1990 levels. These goals have helped shape the goals of member countries, and the EU has simultaneously encouraged DE as part of its greenhouse gas policy objectives as noted in the previous section.

Key Policy Documents

- EU greenhouse gas goals (European Commission, 2014)

8.4.2 United Kingdom

The United Kingdom has a binding CO_2 reduction target of 80% by 2050, relative to 1990 levels. This target was established in 2008 as part of the Climate Change Act. Importantly, this goal is the only legislative carbon target in the world. The UK established an advisory committee – the Climate Change Committee – to develop official guidance to the government on how to reach the goal. The committee establishes carbon budgets for different tranches of time, which, when taken together, will target the 2050 goal (Committee on Climate Change, 2015). The most recent carbon budget, the 5th, establishes CO_2 emissions goals through 2032. These budgets were not initially very supportive of DH due to concerns over the prevalence of fossil gas-based CHP in current heat networks. Recently, with the recognition of local waste heat opportunities, the committee has become more supportive of DH and its important role in meeting established carbon budgets. The 5th budget estimates that highly efficient DH systems could serve 18% of the UK's total heating needs by 2050, which would be a significant rise from the current 2% of heating demand that is currently met by DH today (UK Department of Energy and Climate Change, 2016).

Key Policy Documents

- UK Climate Change Act (Crown Copyright, 2008)
- UK 5th Carbon Budget (Committee on Climate Change, 2015)

8.4.3 Denmark

Denmark is a world leader in establishing aggressive energy and environmental goals, which have historically helped push the country toward acquisition of low-emission energy resources faster than almost any other country. Today the country has an audacious goal of a 100% renewable energy economy, across all sectors, by 2050. In order to meet its goal, renewable DH will likely play an important role.

The Danish national government issues estimates of carbon prices attributable to various types of energy resources every year. Low, medium, and high estimates of price enable potential investors to conduct sensitivity analyses on DH projects. Table 8.2 shows the low, medium, and high estimates of future carbon price approved for use in cost-benefit analyses by the Danish government. The establishment of accepted price estimates helps ensure all potential project developers are assessing the benefits of a new project through the same lens.

Key Policy Documents

- Danish national energy and emissions goals (Danish Energy Agency, 2016)

TABLE 8.2: FORECASTED ANNUAL CARBON PRICES IN DENMARK, IN DANISH KRONER/TON CO_2 EMISSIONS

YEAR	LOW	MIDDLE	HIGH
2016	43	57	65
2017	43	59	65
2018	43	61	72
2019	43	63	84
2020	43	66	102
2021	43	70	123
2022	43	73	147
2023	43	77	157
2024	43	82	166
2025	43	86	175
2026	45	90	183
2027	47	94	191
2028	49	98	199
2029	50	102	206
2030	52	105	213
2031	54	110	222
2032	57	114	231
2033	59	118	240
2034	61	122	248
2035	62	126	255

Source: Center for Klima og Energiøkonomi, 2016. Translated from Danish.

8.4.4 Canada

At the national level, Canada has set a goal of reducing greenhouse gas emissions 30% by 2030, relative to 2005 levels (International Energy Agency, 2015). Specific targets for certain industries have been developed, but the costs associated with emitting greenhouse gases are heavily influenced by provincial climate policies. The most-populated provinces in Canada have all adopted policy mechanisms that assess a cost to emitting greenhouse gases. Some are taxes, some are cap-and-trade schemes, but all are designed to attach a price signal to emitting CO_2, among other gases. Critically, the national government is poised to adopt a nationwide CO_2 tax designed to ramp up to $50 CAD by 2022 (Ljunggren, 2016). The federal government has said that all provinces need to instigate a carbon price by 2018 or else the national government will implement one for them (Campion-Smith, 2016). This would bring the provinces that do not currently have a CO_2 price signal into alignment with those that do.

8.4.5 United States

In general, DE systems in the United States have been deployed in spite of a lack of enabling policies or policies that explicitly encourage reduced greenhouse gas emissions. Most US policies that are directly supportive of increased DE have been developed and administered at the state or city level. A national goal to reduce greenhouse gas emissions by 26-28% by 2025, relative to 2005, has driven the development of sector-specific emissions reduction efforts. A national rule establishing state goals for reduced CO_2 from electric power plants (called the Clean Power Plan) will likely establish a value and quasi-market for CO_2 emissions for the first time in the US, beginning in 2022. The US Supreme Court has issued a stay of implementation of the Clean Power Plan. The plan is not currently in force during this judicial activity, but many states are developing their compliance plans regardless, in anticipation of an enforceable rule in place in the near future. As states work to develop their plans to comply with the Clean Power Plan, the emissions benefits of CHP and DE will likely be viewed as beneficial for states looking to satisfy their state-specific emissions targets.

Key Policy Documents

- The Clean Power Plan (United States Environmental Protection Agency, 2015)

8.4.6 South Korea

South Korea deploys many top-down policies that establish strong support for DE. South Korea has a country-wide cap-and-trade scheme for CO_2, which complements other existing policies that encourage reduced energy use, increased energy security and increased use of renewable energy resources.

South Korea has finalized its 2030 target of reducing GHG emissions by 37% from business-as-usual (BAU) levels, higher than its earlier plan for a 15-30% cut. The country's emissions are projected to reach 850.6 million metric tons of carbon dioxide equivalent by 2030 based on BAU levels. This is equivalent to limiting GHG emissions in 2030 to 536 $MtCO_2e$ (81% above 1990 emission levels) excluding land-use, land-use change and forestry (LULUCF). In June 2010, the GHG Inventory and Research Center of Korea was established under the Ministry of Environment to manage GHG emission information in a comprehensive and systematic manner. It is in charge

8.4.7 SPOTLIGHT ON SUCCESS: AARHUS

RISK INFORMATION

Photo by Aarhus Kommune.

Aarhus had set itself a city-wide goal of being CO_2-neutral by 2030. In support of this stated future need, AffaldVarme Aarhus analyzed several scenarios to determine the investments that would be needed to prepare the CHP systems to utilize various biomass resources. The cost-benefit assessments undertaken included a cost of CO_2 emissions, which was based on a forecast price developed by the Danish government and updated annually. Various alternatives were considered and the city prioritized the solutions that would yield the greatest CO_2 reductions as well as the greatest overall economic benefits.

Table 8.3 reflects the analysis conducted for several scenarios to meet Aarhus' long-term heating needs. While the initial economic benefit of wood pellets appeared to outweigh that of the straw-fired CHP, there were concerns about maintaining a reliable supply of wood pellets considering a growing global demand for the resource. Thus, both projects were identified as attractive if pursued concurrently as a way to further mitigate risk by relying on a variety of resources (AffaldVarme Århus, 2010).

TABLE 8.3: COMPARISON OF ANNUAL COST/BENEFITS FOR PROPOSED NEW HEAT RESOURCES IN AARHUS

HEAT RESOURCE	TOTAL NET BENEFIT (Million Danish Kroner)	FIXED COSTS	CO_2 REDUCTION FROM HEAT ('000 metric tons)
Wood pellets	303	500	332
Straw-fired CHP	207	1000	123
Wind-based heat pump	116	1050	75

Source: Center for Klima og Energiøkonomi, 2016. Translated from Danish.

of setting GHG reduction goals for each sector and industry and managing statistical data.

As part of the International Carbon Action Partnership, South Korea launched its Korea Emissions Trading Scheme (KETS), the first country-wide cap-and-trade program in operation in East Asia, in January 2015. The KETS covers approximately 525 of the country's largest emitters, which account for 67.7% of national GHG emissions. The KETS covers direct emissions of six Kyoto gases as well as indirect emissions from electricity consumption. The KETS will play an essential role in meeting Korea's 2030 Intended Nationally Determined Contribution (INDC) target of 37% below BAU emissions. In its first year of operation trade under the KETS has been limited. However, 2015 has seen a steady flow of credits from national offset projects. This country-wide cap-and-trade scheme for CO_2 complements other existing policies that encourage reduced energy use, increased energy security and increased use of renewable energy resources (International Carbon Action Partnership, 2007).

8.5 Other Energy Efficiency and Renewable Energy Goals

8.5.1 European Union

As part of the EU's directive on energy efficiency, which established the above energy efficiency goal, all member states were required to undertake an evaluation of DH, DC and CHP potential by the end of 2015 (European Commission, 2013). This marked the first time the EU had embarked on a comprehensive detailed assessment of the potential of these technologies to help meet the climate and energy goals. To date, 25 member countries have submitted their evaluations of CHP and DH potential. Additional EU policies that support DE include a goal of having 20% of all energy be supplied by renewable resources by 2020, and an overall 20% increase in energy efficiency over 1990 levels by 2020.

Key Policy Documents

- EU Directive on Energy Efficiency (European Commission, 2013)
- National assessments of CHP and DH potential are publicly available (European Commission, 2016)

8.5.2 United States

State-level policy has historically been more impactful on the energy markets in the US than national policy. There are few district energy-specific policies in the US, but there are many policies that directly support CHP, including CHP-based DE. Most US states have developed an energy efficiency resource standard (EERS) and/or a renewable energy portfolio standard (RPS). These EERS and RPS goals typically set a percentage of energy to be supplied by energy efficiency or renewable energy, respectively, by a certain year. Regulated utilities in each state then acquire energy efficiency and renewable energy resources to meet their specific targets. In most states with an EERS, CHP, including CHP-based DE systems, will qualify as an energy efficiency resource. And in most states with an RPS, biomass or biogas-based district systems and CHP will also qualify as renewable energy resources. However, only a small number of states have specific programs that explicitly support the deployment of CHP or DE.

In Massachusetts, for instance, the alternative energy portfolio standard (APS) explicitly credits CHP project outputs and renewable-based thermal production as APS resources. Utilities can use APS resource credits to satisfy a requirement that they meet 5% of all electricity sales with APS resources by 2020. In Oregon, a recent state bill – S.B. 1547 – establishes the thermal output of a biomass or biogas-fueled system as eligible for credit within the state's established RPS. Other states include CHP and CHP-based DE as eligible within their EERS regulations and goals, including California, New York, Maryland and others.

In Colorado, the Fort Collins Zero Energy District (FortZED, 2016) secured funding from the federal government to engage in very specific city-level research and testing of district-scale energy solutions that would help reduce electric peak loads. The city-level policy establishes a goal of being a net-zero-energy city using locally sourced energy resources. This goal has supported DE, using the broad target of net-zero energy as a fundamental driver.

Key Policy Documents

- Massachusetts' updated Alternative Energy Portfolio Standard (Commonwealth of Massachusetts, 2009)
- Oregon S.B. 1547 (78th Oregon Legislative Assembly, 2016)
- Colorado's FortZED project (FortZED, 2016)

8.6 Policies that Mitigate Investment Risk

Well-designed policies, especially at the local level, can often be effective risk-reduction measures. Policies can reduce project risk for all stakeholders and signal to the private sector that a project is supported or endorsed at various governmental levels. This is a very important role that local jurisdictions are particularly well-positioned to play.

Local policymakers can identify specific geographies that are well-suited to DE, or they can support analysis that can in turn identify those geographies. By clearly articulating which geographic areas are well-suited to district systems, local policies can reduce perceived risk by developers of district systems. Developers understand that certain areas are priority areas for a city or town, and can reasonably expect proposed DE projects to be considered on equal ground with other alternatives.

To further reduce risk, local policies can pair targeted areas with certainties around potential customer connection. For instance, cities may identify target areas for DH systems and then stipulate that land and building developers must build buildings that are "district energy-ready," with hydronic heating systems and appropriate building connections. Cities can also require that a building be connected to a district system, provided it meets some set of criteria. These types of requirements can offer a guaranteed customer base and a guaranteed demand, which dramatically reduces DE system project risk. Cities are able to link direct and indirect incentives to such policies as well, to further entice developer interest. For instance, in some cases a city may stipulate that new buildings must be made district energy-ready, but that increased density could be allowed above and beyond what the existing zoning might allow.

The riskiest activities in DE system development are typically those that happen earlier in a project's lifecycle. Initial screening and feasibility studies are risky activities to fund, since such studies may identify DE as a poor solution for a given area. Regardless of the outcome of a study, the consulting entity that produces the study must be paid.

Many DE projects never move beyond the initial concept stage, then, because no party is ready to spend money on a feasibility study that may in fact find that DE is not an appropriate solution for a given area. This is where local policies that ease or otherwise support early-stage screening and feasibility assessments are so critical. National programs can also support this type of early-stage project analysis, and some of these programs are discussed in the next section.

City leaders are also often not well-educated about DE because they have never worked with a DE system. This is why policies and programs that offer early-stage technical assistance can also dramatically reduce the risk of a project, by leveraging an ever-growing knowledge base around DE, and helping cities and local leaders avoid starting from scratch. Local leaders can take advantage of external support and technical knowledge, and DE developers or other third-party stakeholders do not have to spend as much time educating policymakers on the function and expectations of DE systems. When all stakeholders believe that local leaders are knowledgeable about DE and view it as an appropriate long-term energy solution for a given location, project risk declines.

8.6.1 Denmark

With so many Danish cities reliant on the DH industry, the municipal credit union, KommuneKredit, offers cities low-interest loans when cities provide a Kommune Garanti to a DE project, which is an underwriting of a specific loan. In this way, DE developers benefit from a significantly reduced capital costs for their major investments (Chittum & Østergaard, 2014).

Developers of Danish DH systems see little risk and little uncertainty in investing in system development. The national government and local governments all use the same cost-benefit schemes to assess which projects should move forward, and the CO_2 reduction benefits of district-scale solutions are considered for every project. European and Danish goals for energy and CO_2 emissions reductions have also established a framework in which the energy and CO_2 benefits of DE systems are continually

TABLE 8.4: DANISH EMISSION COEFFICIENTS FOR SELECTED DH RESOURCES

FUEL	PLANT TYPE	CO_2 g/GJ	CH_4 g/GJ	N_2O g/GJ	SO_2 g/GJ	NOx g/GJ	PM 2.5 g/GJ
CENTRAL POWER PLANTS AND CHP							
Natural gas	Steam turbine	57	1	1	0.4	55	0.1
Coal	Steam turbine	94.2	0.9	0.8	8	26	2.1
Fuel oil	Steam turbine	79.5	0.8	0.3	100	138	2.5
Wood	Steam turbine	0	3.1	0.8	1.9	81	4.82
LOCAL CHP							
Natural gas	Gas turbine	57	1.7	1	0.4	48	0.05
Natural gas	Motor	57	481	0.6	0.5	135	0.16
Straw	Steam turbine	0	0.5	1.1	49	125	1.11
Wood	Steam turbine	0	3.1	0.8	1.9	81	4.82
Waste	Steam turbine	37	0.3	1.2	8.3	102	0.29
Biogas	Motor	0	434	1.6	19.2	202	0.21

Source: Center for Klima og Energiøkonomi, 2016. Translated from Danish.

valued and are expected to be valued in the future. This offers more certainty to developers as they plan around integrating existing and future heating resources. Additionally, Danish building codes explicitly recognize the increased efficiency of district-scale systems, and account for the more efficient energy use (Bush, Hawkey, & Webb, 2016). Table 8.4 shows typical emissions values for selected DH fuel sources. [insert table 8.4].

The national cost-benefit framework is updated annually and establishes set emissions values for various types of DH resources, such that they may be easily compared to alternative scenarios.

Key Policy Documents

- Danish KommuneKredit credit union (Kommunekredit, 2014)

8.6.2 France

The city of Paris has identified DE as a key strategy to reaching climate-related emissions goals. The latest Climate Action Plan further develops this ambition, and the city has supported the identification of certain areas as right for DE. In designated zones, the city can enforce an obligation to connect. The city has identified this "network" approach as the best way to integrate renewable and low-carbon resources as they are identified and become available.

Key Policy Documents

- 2012 Paris Climate Action Plan (Mairie de Paris, 2012)

8.6.3 The Netherlands

Dutch cities that aim to encourage DE deployment and the development of buildings that are connected to district systems can implement requirements to connect to the district systems. In Rotterdam, the city has identified specific targeted areas for DE deployment, and can stipulate that connection is required in those areas. This greatly reduces the risk associated with investing in DE infrastructure (United Nations Environment Programme [UNEP], 2015).

8.6.4 United States

The federal government also offers a loan guarantee program that is designed to underwrite the risk of loans for DE projects, as well as other capital intensive energy projects. The federal government had made available up to $8 billion total in loan guarantees for qualifying projects.

Key Policy Documents

- US Loan Guarantee Program details (US Department of Energy, 2015)

8.7 Resiliency and Climate Change Adaptation Policies

8.7.1 United States

One of the primary drivers of DE in the US is concerns about the reliability and resiliency of energy infrastructure during weather catastrophes. Cities that were affected by Superstorm Sandy in 2012 have recently developed policies that encourage critical facilities such as hospitals and wastewater treatment plants to consider CHP-based DE systems when upgrading existing facilities or building new ones. For instance, the New Jersey Energy Resilience Bank offers direct grants and financing for projects, including DE and CHP that improve the energy resiliency of critical facilities.

In Connecticut, the city of Stamford adopted Energy Improvement District enabling legislation, which allows businesses to join together voluntarily to form an entity that would own and operate energy resources, including DE, and issue bonds to pay for the construction of the equipment. The Energy Improvement District ordinance was developed in part to support the deployment of more resilient and reliable energy resources. In several US states, including Texas and Louisiana, government-owned facilities deemed "critical" – such as medical and first responder facilities – must conduct feasibility assessments for CHP whenever building a new facility or significantly renovating an existing facility. Since many of these facilities include multiple buildings that would be excellent candidates for DE, consideration of CHP, which offers a thermal supply, could drive consideration of DE for economic purposes.

Key Policy Documents

- New Jersey Energy Resilience Bank (New Jersey Economic Development Authority, 2016)
- Connecticut Energy Improvement District Ordinance (City of Stamford, 2007)
- Texas H.B. 1831, An Act Relating to Disaster Preparedness and Emergency Management (Legislature of the State of Texas, 2009)

8.7.2 SPOTLIGHT ON SUCCESS: UNITED STATES

INFORMATION

In New York State, the devastating effects of Superstorm Sandy led the governor and state energy policymakers to establish a well-funded effort to fund early stage assessment of DE systems designed to improve facility resiliency and reliability. Called NY Prize, the program explicitly aims to encourage the consideration and deployment of microgrids, or DE systems with significant electric components. Projects are encouraged to be able to fully island from the grid. To encourage this, the cost-benefit framework developed by the program and used in individual project feasibility studies ascribes specific monetary benefit to staying online when the grid goes down, and shedding non-critical loads in the event of emergencies.

Key Policy Documents

- NY Prize program (New York State Energy Research and Development Authority, 2016)

8.8 Policies that Address Additional Barriers

8.8.1 Canada

For Canadian cities, direct investment in DE infrastructure or development of a special-purpose vehicle (SPV) designed to invest on behalf of the city has not always been legally allowed. In Ontario, a provincial law was passed to allow cities to make investments in energy infrastructure and recover costs. This legislation paved the way for the restructuring of Toronto's existing not-for-profit DE corporation into a for-profit entity held by shareholders representing local interests.

Canada has developed reliable funding mechanisms to help overcome the major investment hurdles inherent in DE. The Green Municipal Fund, administered by the Canadian Federation of Municipalities, is a revolving fund that can cover the cost of the higher-risk activities present in early stages of project development, such as feasibility assessments. The fund, which is designed to support municipal-led activities, can also offer direct financing of capital projects, at up to $10 million per loan, to overcome capital constraints.

Canada has also established the Gas Tax Fund, a permanent fund for municipal infrastructure projects which distributes funding to each province and territory based on population. The fund distributes a total of $2 billion CAD each year, and is designed to grow each year at 2% a year. Provinces and territories then determine how to utilize those funds, and projects can include community energy projects such as DE (Government of Canada, 2016).

Key Policy Documents

- Green Municipal Fund (Federation of Canadian Municipalities, 2017)
- Gas Tax Fund agreements (Canada, 2016)

8.8.2 United States

Other smaller policies and programs have encouraged DE as well, though never in a comprehensive manner. In New Jersey, a detail of the 2009 Public Law defines "contiguous property" as two properties that, though they may be separated by a public street, are buying thermal energy from each other. This supports DE because it enables electric infrastructure that might be part of the DE system to serve nearby buildings. Without the law, electric infrastructure would typically be restricted from crossing streets due to the franchise arrangements held by local electric utilities.

Key Policy Documents

- New Jersey Public Law 2009, Chapter 240 (Senate and General Assembly of the State of New Jersey, 2010)

8.8.3 SPOTLIGHT ON SUCCESS: TORONTO

Photo by Enwave Toronto.

Ontario amended its Municipal Act for the City of Toronto to allow the city to make energy-related capital investments on targeted private property and use "alternative methods" to collect payment for those investments from the private entities (Community Energy Association, 2013). This arrangement allows the city to invest in DE infrastructure on behalf of a private development, or several developments, and recoup the expenses in a way that respond to the private entities' risk and return requirements. Investments that do not touch certain buildings can still ask those buildings to pay for the investments if those buildings benefit from the investments. This allows the city to take on some of the major capital expenses associated with DE that private developers are sometimes hesitant to make.

Key Policy Documents

- Toronto District Heating Corporation Act, 1980 (Queen's Printer for Ontario, 1980)

8.9 Strategies for Success: Considerations in Designing Policies

8.9.1 Avoiding Unintended Consequences

Most energy and environmental policies do not explicitly call out the role of thermal energy networks. This makes it confusing for project champions and investors to understand how thermal energy systems' environmental and energy performances will be viewed and assessed. For instance, policies that compare source fuel and emissions to some standard business-as-usual will likely penalize DE systems by not taking into account the increased efficiency inherent in a DE system.

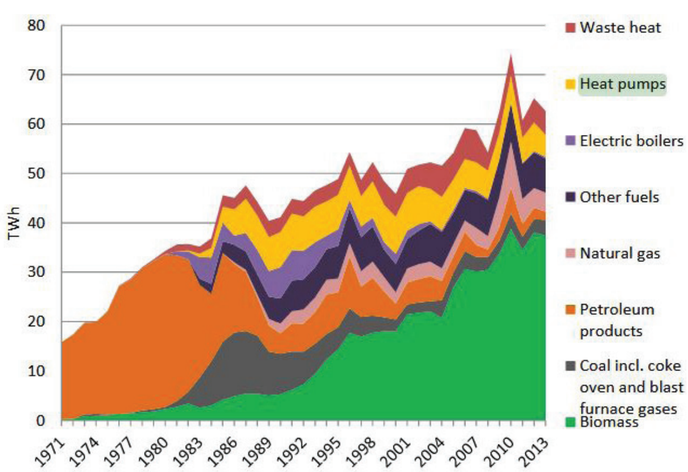
District heating is often a cost-effective climate change mitigation and adaptation strategy. However, some energy and environmental policies discourage DE by not fully accounting for its efficiency and emissions benefits relative to what the emissions of business-as-usual energy usage would be. These policies do not treat all energy resources on a level playing field, and may inadvertently reduce DE deployment or create situations where environmental goals are experienced as obstacles by DE developers. For instance, countries that express their energy or environmental goals as primarily renewable electricity goals may overlook cost-effective renewable-fueled heating resources such as DE. Heat pump technology, for instance, may be most efficient and most cost-effective when implemented on a large scale and paired with a DH distribution network. Policies that explicitly promote building-scale heat pumps may not be maximizing the cost-effectiveness and emissions reduction capabilities of the technology. It is critical to ensure that all types of resources, at all scales, are sufficiently considered and compared when making decisions about future energy resources.

District energy schemes can take advantage of economies of scale and fully utilize available renewable resources, such as geothermal wells, in a manner that building-by-building energy solutions cannot. Therefore, policies that aim to reduce the energy use or emissions of buildings should take full account of whether district-scale energy solutions are offering effective energy and emissions reductions. One example of a family of policies that have matured over time to better reflect the potential of DE to offer energy and emissions benefits is city and state requirements that certain buildings be built to LEED (Leadership in Energy & Environmental Design) standards. LEED initially focused primarily on the on-site energy use of a building, and consideration of the economies of scale or renewable resources that might be best leveraged by a district-scale energy solution were not adequately valued within LEED itself or policies that called for LEED building standards.

As LEED standards better reflected the known performance of DE systems and the ability to integrate renewable resources, policies that required LEED-rated buildings also matured. Of the 40 points possible for basic LEED certification, 18 are available in the Optimize Energy Performance category, which gives credit for the improved energy efficiency of a building compared to business-as-usual energy consumption, through the lens of energy costs. The Performance Excellence in Electricity Renewal (PEER) rating process, which works in concert with LEED, is currently developing an alternative compliance pathway (ACP) for DE systems under LEED, which should better reflect district energy's superior energy performance over business-as-usual energy use (Goff & Yan, 2017).

Policies need to be carefully crafted to ensure that as wide a variety of options as possible are considered when choosing an optimal energy solution. Policies can be crafted to clearly delineate how the energy used and emissions produced by DH networks should be measured and valued. Examples of such energy and environmental policies are discussed below.

FIGURE 8.1: SHARE OF HEATING SUPPLIED BY RENEWABLE RESOURCES IN SWEDEN



Data source: Swedish Energy Agency, 2015.

8.9.2 Supporting Renewable Resources

When policies are in place to support DE as a tool to deploy the most cost-effective and emissions-efficient resources, renewable energy resources benefit. In Denmark, the share of renewable energy comprising district heat has grown from 35% to 46% between 2009 and 2013 (Euroheat & Power, 2015). A similar story can be seen in Sweden, in Figure 8.1, below. DE is often a highly effective way to meet energy needs while using renewable resources, but policies must be in place that adequately value effective emissions reductions. Such policies can help take full advantage of existing renewable opportunities in the heat sector, including solar thermal, biomass, biogas, and the use of existing waste heat resources. Additionally, planning DH systems alongside other thermal and electric systems can ensure that the optimal infrastructure is in place to best leverage existing and potential future resources, including a wide variety of renewable resources (Connolly, Vad Mathiesen, & Lund, 2015). The flexibility inherent in district-scale systems that include both electric and thermal generation and storage capabilities are well-suited to a future energy system dominated by a wide variety of renewable resources.

Many policies in place separate renewable energy goals from efficiency goals, yielding a situation where a DE system, which could most efficiently take advantage of existing renewable resources, might not compare favorably to proposed solutions that offer building-scale renewable resources. This is because many policies promoting renewable energy have targets that are expressed as a share of electricity sales that must be renewable, which completely ignores opportunities in the thermal realm. This is unfortunate, because district-scale solutions are often more cost-effective ways to integrate renewable resources, and will typically displace both less efficient electricity resources and less efficient thermal resources. Policies that more holistically assess energy opportunities and offer benefits based on overall improved energy and emissions efficiency are more likely to encourage DE solutions.

9 CONCLUSIONS AND KEY MESSAGES

The changing global energy landscape faces a variety of challenges in providing the energy infrastructure needed to meet the electricity, heating and cooling needs of an energy-driven world. A great deal of attention has been paid to addressing the challenges on the electricity side of the energy infrastructure, but the thermal side does not get the attention it deserves.

Heating and cooling solutions deployed at a scale larger than an individual building and the creation of thermal grids akin to the electric grid hold a great deal of potential in meeting many challenges including:

- Meeting demand from emerging economies that are also dealing with the challenge of fuel poverty and lack of energy infrastructure
- Grappling with the round-the clock demands and energy intensity levels of various sectors such as hospitals, emergency response and data centers
- Supporting urban growth through a resilient energy infrastructure that can weather outages
- De-carbonizing the energy infrastructure to meet climate action goals

District energy systems make up the backbone of the efficient, reliable and resilient infrastructure that supports the heating and cooling in many cities, communities, hospitals, airports and campuses.

Underlying the success of these systems and the critical role they play in supporting education, research, commerce and industry and vibrant city life are creative solutions that leverage local resources, innovative technologies, integrate renewables and incorporate efficiency through good system design, construction, optimization and operation by well-trained staff and operators

Even more critical to the success, however, is ensuring economic viability, sustainable business models for service delivery and appropriate governance to attract end-users and financing for new system deployment, expansion of existing systems to meet growing load demands or renewal of assets that have reached the end of their useful lives.

Key message: District energy systems are long-lived and provide many valuable benefits. The success of many systems across the globe has been based on their ability to combine the technical, financial and governance dimensions to lead a project from conception to delivery of service. The ability to leverage trends, define drivers and objectives while balancing built landscape with the energy, social and financial landscapes is critical. Engaging in community-level energy planning provides useful decision-making information to key stakeholders

Good technical design must be combined with a viable business model and strong governance to move a project from concept to delivery and to further manage it through its lifecycle of stages that include renewal, modernization and even a sale.

Managing stakeholders and providing the right types of skills are essential activities that reap large rewards and reduce risk.

Policies at the local, state, provincial and national levels that enable DE have been instrumental in also moving economic, environmental and social objectives forward.

9.1 Trends Affecting District Energy

Major changes in the way cities, campuses, and community projects are being developed have ushered in a period of intense energy resource experimentation and innovation. The lenses through which communities, institutions, urban planners, developers, building owners and the financial community think about their energy resources have changed. Below we identify some of the major political, economic, social and technological trends influencing DE development:

- Resiliency goals and critical facilities requirements
- 4th generation DE and hot water conversions
- Net-zero goals embedded in development
- Changing electric mix
- Nodal and smaller system development
- Thermal and electric grid integration
- Integration of renewable resources
- Smart cities
- Real estate development and financing trends
- Constantly evolving political landscape on energy and climate

Key message: A local project gains visibility and support when it leverages political, economic, social and technological trends.

9.2 District Energy Drivers

District energy systems are driven by local considerations and specific objectives that address a variety of local needs and challenges and often contribute to national resource efficiency and the meeting of environmental targets.

9.2.1 Economic Drivers

Revenue Generation

District energy systems can frequently provide significant revenue generation opportunities for the cities or entities that own or host them. Such systems offer a reliable new source of income while meeting other needs, which can drive the development of new projects.

Strategic restructuring

In the face of limited capital availability facing a system owner, operation and maintenance can be strategically restructured to leverage third-party resource.

Increasing Local Economic Competitiveness

By keeping energy rates low and stable for residents, reducing overall energy consumption due to added efficiency, and proving long-term price assurance on energy rates, DE offers cities a great opportunity to meet energy needs while driving economic development and attracting enterprise.

Boosting Value of Existing Resources

District energy systems, through load diversity and aggregation, provide the necessary scale that makes it feasible to take advantage of local and renewable fuel resources, something that is not viable at a building level to meet heating and cooling needs.

9.2.2 Environmental Drivers

The expectation of environmental benefits drives DE system development because of two main characteristics of DE systems: their increased efficiency and their ability to integrate renewable energy resources, including low- and no-carbon local resources such as waste heat. DE systems help meet GHG goals and stimulate growth of renewable energy source such as geothermal.

9.2.3 Social Drivers

District energy resources offer broader benefits to society that frequently drive investment. District systems can be highly resilient in the face of natural and other disasters, and they can also directly address and mitigate fuel poverty. Addressing both of these issues can significantly strengthen communities.

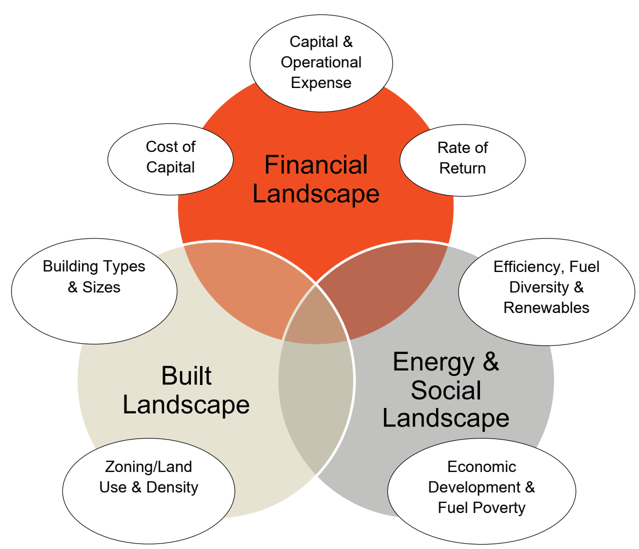
9.2.4 Political Drivers and Constraints

Political leaders across the political spectrum typically approach new development projects and social campaigns with a desire to reduce the risk exposure of their constituents and organizations. A well-designed policy framework at state/province as well as federal and national level can reduce risk for project development. At the same time, local leaders and citizens desire to make the decisions that affect their local infrastructure and livelihoods, including the energy infrastructure that serves their homes, offices, hospitals and educational institutions. This is why local efforts to regain control and ownership of utility infrastructure have blossomed in the past decade.

9.2.5 Striving for Balance

District energy systems address multiple challenges and take advantage of multiple opportunities, which vary tremendously from place to place. Each of

FIGURE 9.1: BALANCING MULTIPLE LANDSCAPES



Source: IDEA.

the drivers or constraints outlined above drive projects around the world to different extents, depending on what is most interesting, attractive and compelling to the involved stakeholders. The goal is to balance the built landscape with the energy, social and financial landscapes. (See Figure 9.1.)

Key message: A DE system need not have all drivers in place. In some cases, a single driver may be so strong that its existence essentially mitigates the need for any other drivers. And in other cases, while one driver may be the initial element that starts the process, others may eventually supersede and supplant the original ones.

It is important that a constant discussion of these drivers, and their evolving nature, continue throughout project development, and leaders regularly reassess which issues are viewed as most critical to stakeholders.

9.3 Community-Based Energy Planning for Successful Projects

Until recently, for a majority of property owners, businesses, and local governments, energy has been little more than a utility and a bill to pay. Similarly, land-use planners and property developers have not needed to be concerned about the energy requirements of tenants, residents, and building owners.

Municipal, city and state leaders faced with growing economic, social and sustainability challenges are increasingly interested in local energy production. They aim to provide a robust, efficient and resilient energy infrastructure to support a place that is attractive to live and work in as well as inviting for business, industry and research enterprises to locate.

Communities grappling with resiliency after storms and flooding are deploying community energy electric microgrids that are aimed at "keeping the lights on" through disruptions caused by weather or human error. CHP enables the microgrids to "island" from the grid during an outage and provide power to the community until the grid returns to normal.

Availability of resilient thermal energy supplements the "lights on" objective with equally important keeping the "heating and cooling" on objectives.

Thermal DE networks are essential to "keeping the heat and cooling on" and also serve to provide aggregate thermal loads that help make CHP viable.

The following key activities are common to successful community energy projects:

- Developing community energy plans
- Exploring thermal community energy opportunities
- Exploring renewable energy sources
- Leveraging related and supporting plans
- Building a pipeline of projects to support the community energy plans

Key message: Communities should invest in creating community energy plans that build upon existing community development planning, climate action plans and energy studies to provide a framework and guidance for project development.

9.4 Business Models and Structures of Governance

The underlying technology of DE is well understood, yet many well-intentioned projects do not complete the journey from concept to service. Occasionally existing systems face the challenge of retaining customers in the face of competition from other building based thermal sources.

The choice of business model will also be influenced by the stage of the system in its lifecycle. Public models that fit the early stage of concept development may benefit from moving into the hybrid types of models to leverage private engagement as they enter the operations and maintenance, modernization and renewal stages. Sometimes private business models may have to change to public models to support specific objectives.

A business model that works to support a successful project is characterized by the appropriate balance between risk, financing and control.

Key message: There is no one business model that is the best. The level of control, risk, the investment required, ownership and management structures and expected rates of return define the choice of business models and governance structures.

9.4.1 Risk Allocation and Public-Private Sector Roles

It is necessary to allocate risk to the appropriate public or private partner. The following table shows generic delivery structures representing a variety of public-private sector roles and some ways to allocate risk along the public-private spectrum.

9.4.2 Migrating Between Business Models

The selection of a particular model does not lock the project into that model in perpetuity. Business

TABLE 9.1: GENERIC DELIVERY STRUCTURES AND ROLES WITH RISK ALLOCATION

	OPTION	DESCRIPTION	RISK ALLOCATION	MUNICIPAL/COUNCIL
Public	1	Entirely public sector led, funded, developed, operated and owned	Public sector retains all risk	Public sector procures contracts for equipment purchase only. Procurement could be direct, or via a publicly owned arm's-length entity
	2	Public sector led: entirely publicly funded, greater use of private sector contractors	Private sector assumes design & construction risk, and possibly operational risk	Public sector procures turnkey asset delivery contract(s), possibly with maintenance and/or operation options
	3	Public sector led, private sector invests/takes risk in some elements of the project	Private sector takes risks for discrete elements (e.g., generation assets)	As 2, with increased private sector operational risk, and payment or investment at risk
	4	Joint venture: public sector & private sector partners take equity stakes in a special purpose vehicle	Risks shared through joint participation in JV vehicle / regulated by shareholders' agreement	Joint venture: both parties investing and taking risk
	5	Public funding to incentivize private sector activity	Public sector support only to economically unviable elements	Public sector makes capital contribution and/ or offers heat/power off-take contracts
	6	Private sector ownership with public sector providing a guarantee for parts of project	Public sector underpins key project risks	Public sector guarantees demand or takes credit risk
	7	Private sector ownership with public sector facilitating by granting land interests	Private sector takes all risk beyond early development stages	Public sector makes site available and grants lease/license/wayleaves
Private	8	Total private sector owned project	Private sector carries all risks	No or minimal public sector role (e.g., planning policy / stakeholder engagement

Source: Adapted from Scottish Futures Trust Guidance on Delivery Structures for Heat Networks, March 2015.

models may need to evolve over time to suit the need of the time. A system that may have started as a public non-profit system may over time be operated as a hybrid public-private concession. Municipalities can buy out private companies or take an equity stake in order to increase their strategic control. Conversely, municipalities can develop projects as publicly owned ventures and, once well-established and costs and revenues are stabilized, sell them on to private sector investors or energy companies.

During the development phase projects are considered high risk and consequently debt capital is priced accordingly. Once they have stabilized their costs and revenues they become low risk and can therefore flip to lower-cost capital. An example is Wick Energy which was developed using equity funding and then sold out to traditional investors.

Another example is Enwave Toronto, where the investment made in the early development stage by OMERS and the Toronto City Council de-risked the project during its vulnerable development phase. In the sales and acquisition stage the de-risked system with a good track record of performance was worth considerably more than the investment made. Brookfield Asset Management paid $480 million CAD to acquire Enwave District in 2012. The profit made by the Toronto City Council on the sale of its 43% stake in Enwave to Brookfield for $168 million CAD was the largest windfall the council had ever received.

Table 9.2 shows the migration of business models from case studies in this report.

TABLE 9.2: MIGRATION OF BUSINESS MODELS FROM CASE STUDIES

		PUBLIC			HYBRID			PRIVATE
Case	Migration path	Internal Department	Social	SPV	Concession	Joint Venture	SPV	Private Utility
Aberdeen, UK:	Arm’s-length not-for-profit		•					
Aarhus, Denmark:	Municipally owned & run	•						
Birmingham, UK:	Run as a concession				•			
Norman, USA:	Initially owned and operated by the university. Currently owned by university with private concessionaire for operations and maintenance				•			
Paris, France:	City owned system with Engie as Concessionaire				•			
Phoenix, USA:	Private DE Utility							•
Rotterdam, Netherlands:	Joint venture					•		
Sangam, South Korea:	KDHC is an SPV owned by public entities Korea Electric Power Company, Seoul Metropolitan City government, Korea Energy Management Corporation			•				
Stockholm, Sweden:	Fortum Varme AB is a JV formed by Finnish energy company Fortum, and the City of Stockholm					•		
Toronto, Canada:	For major investments operated as SPV with two public shareholders;			•				
	Now run as a private DE utility							•
Vancouver, Canada:	Run as municipal utility subject to public oversight board	•						
Wick, UK:	Started as public social;		•					
	Moved to public SPV;			•				
	Currently private							•

9.5 District Energy Lifecycle and Strategies for Success

Securing a viable future for DE entails that systems deliver value, meet objectives, attract positive attention and stand out as best practice sites.

Systems that fail at any point during their journey through the system lifecycle impose a cost on stakeholders and have a negative impact on the brand of DE.

District energy systems by nature have a lengthy trajectory from concept to realization and then continue to be in service for up to fifty years or more often experiencing phases of expansion, renewal, modernization and even changes in ownership.

9.5.1 Stages of the Lifecycle

Concept

Municipalities, cities and towns as well as campuses, businesses and industry engage in setting sustainability, economic development and urban development objectives. Planning staff, neighborhood groups and experts develop climate action plans, transportation studies, energy maps and campus utility master plans. The development of new greenfield districts or the rejuvenation of brownfield sites offer early stage opportunities to explore DE as a possible solution. At this stage, an early concept of the envisioned systems is developed.

Feasibility

At this stage, the potential district is identified and the objectives are defined. The project scope and scale, and phasing of the development timeline, are outlined, with the intent of pursuing technical and economic study of various options to determine viability of project scope and economics.

Design Build

This stage is where in-depth attention is paid to the technical aspects of the system. The selected option is designed and engineered, systems components are procured and the DE system is built and installed.

Operations and Maintenance

This stage can span decades and requires knowledge of the system and how best to operate and optimize performance.

Expansion

During the long life of DE systems, especially in campus, hospital and research end–use sectors, it is necessary to expand the capacity of the system to meet the added loads from growth.

Renewal

District energy systems have long useful lives. Mature and aging systems require infusion of capital for replacing end-of-life assets. Renewal is a stage where aging assets are reviewed for needed replacement.

Modernization

As technology offerings evolve and systems mature, opportunities to modernize and improve the design for increased efficiency by converting from steam to hot water systems, changing to biomass fuels, adding CHP and solar thermal, adding thermal energy storage and DC, and integrating renewable resources into the thermal grid become available.

Sale & Acquisition

Systems that are established and in operation can change ownership. The sale may be between two private parties, from public to private, private to public, or private to private.

These categories of stages are distinct but do not necessarily flow in a linear fashion – sometimes expansion needs require new feasibility assessments and the build-out of new components.

9.5.2 Managing Success at Every Stage

Each project stage has different risk and financial needs and requires stage specific information and tools for decision-makers.

As projects move from pre-concept to full feasibility analysis to design, the various ways in which the risk and information are shared, the money to fund the project is identified and deployed, and the people and stakeholders are motivated to support and work toward project milestones are fundamental to whether the project succeeds or fails.

For a project to successfully navigate through the different stages, project leaders need to maintain momentum and enable all participants to work toward project objectives.

Key message: Paying attention to the risks for each stage in the lifecycle while managing stakeholder objectives with limited resources can be challenging. It requires careful planning, information gathering, and strong money management. It is invaluable to have good project teams who will leverage best practices, and rely on useful technical and project resources available through a variety of organizations that support DE.

9.6 Stakeholder Engagement

Projects, initiatives and organizations all benefit from support they receive from stakeholders. While technical and economic feasibility and governance are necessary ingredients for success, the role played by stakeholders can determine the success or failure of projects. It is therefore important to understanding the objectives and concerns of key stakeholders and endeavors to align project objectives with stakeholder interests. It is better to have stakeholders as allies than adversaries. DE projects and systems by nature benefit and affect many groups and are influenced by many constituents.

Stakeholders approach projects with a variety of motivations and barriers.

Listening should be at the heart of any stakeholder engagement. This will enable you to understand what each stakeholder needs and how you can address their needs through your project. Understanding their barriers will help to move stakeholders from being potential adversaries to being allies.

Key message: Stakeholder engagement is a continuous process which benefits from recognizing the type of stakeholder, what they need and targeting communication and engagement strategies accordingly.

9.7 Capacity Building

Specific skills and roles needed in the DE sector and approaches to capacity building are explored in detail in Chapter 7. Organizations need to assess the level of in-house capacity available. It may become necessary to outsource some roles and activities in the short term until there is sufficient activity within the business to justify a full-time role when it can be brought in-house.

The development of an organization's capacity and skills base needs to be constantly evaluated.

Additionally, consideration should be given to the training requirements of staff. It is unlikely that new recruits will be a full fit with a specified role. Or that role may evolve and change. Providing training can help the individual staff member to fit their role or graft a new skill onto an existing member of staff. It can also help them grow and develop and become a more valuable member of the team.

Key message: Appropriate staffing is critical and must be acquired or developed. The extensive body of knowledge available through reports, conferences, workshops and webinars and educational videos is a valuable resource for not just staff but the diverse stakeholders engaged in decision-making.

9.8 Enabling Policies

District Energy projects are impacted by both the nature and extent of national, regional, and local policies that focus on energy, economic development, urban planning, and environmental protection. Policy establishes the framework in which DE systems are deployed.

Some countries and localities have chosen to implement policies that directly encourage DE, while others have developed policies to promote particular environmental goals that have indirect effects on DE system deployment.

Increasingly, national and municipal governments have recognized the significant need for early-stage support to stimulate DE projects. Activities that build a pipeline of projects, build institutional capacity, fund higher risk early-stage assessments, and that bring developers and communities together are all helpful in reducing real and perceived risks. When communities and developers understand that the policy framework is stable and supportive of DE, more projects can be pursued.

Chapter 8 brings into focus the following types of enabling policies in Canada, Denmark, France, the European Union South Korea, Sweden, United Kingdom and the United States:

- Heat planning and land use policies
- Greenhouse gas reduction goals
- Other energy efficiency and renewable energy goals
- Policies that mitigate investment Risk
- Resiliency and climate change adaptation policies

Key message: While it is helpful to have local, state, provincial and national policies align, often local objectives and policies have been key to the success of DE projects.

Figures

Tables

Abbreviations

ADE	Association of Decentralized Energy
BAU	Business-as-usual
BDEC	Birmingham District Energy Company
CAD	Canadian dollars
CAPEX	Capital expenditure
CCHP	Combined cooling, heat and power
CEP	Community energy plan
CHP	Combined heat and power
CPCU	Paris Urban Heating Company
DBFO	Design, build, finance, and operate
DC	District cooling
DE	District energy
DH	District heating
DEAL	District Energy Aberdeen Ltd.
DERA	Danish Energy Regulatory Authority
DEMaP	Decentralized Energy Master Planning (United Kingdom)
DKK	Danish Krone, currency of Denmark
ELENA	European Local Energy Assistance
EfL	Energy for London
ESCO	Energy service company
EU	European Union
Gcal/h	Gigacalories per hour
GHG	Greenhouse gases
GLA	Greater London Authority
GW	Gigawatt
GWh	Gigawatt-Hour
HNDU	Heat networks delivery unit
HNIP	Heat networks investment project
IDEA	International District Energy Association
IEA	International Energy Agency
INDC	Intended nationally determined contribution
IRR	Internal rate of return
KDHC	Korea District Heating Corporation
KEMCO	Korea Energy Management Corporation
KEPCO	Korea Electric Power Company
KETS	Korea Emissions Trading Scheme
kW	Kilowatt

kWh	Kilowatt-hour
lbs/hr	Pounds per hour
LDA	London Development Agency
LEED	Leadership in Energy & Environmental Design
LFG	Landfill gas
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
LULUCF	Land-use, land-use change and forestry
MKE	Ministry of Knowledge Economy
MW	Megawatt
MWe	Megawatt-electric
MWh	Megawatt-hour
NEU	Neighborhood energy utility
NGO	Non-governmental organization
NOX	Nitrogen oxide
NPV	Net present value
OMERS	Ontario Municipal Employees Retirement Savings System
OPEX	Operational expenditure
OU	The University of Oklahoma
PNE	Paris North East
PUE	Power usage effectiveness
PV	Photovoltaic
ROI	Return on investment
RPS	Renewable portfolio standard (South Korea)
SEFC	Southeast False Creek
SEK	Swedish Krona
SICUDEF	Syndicat mixte de Chauffage Urbain de la région de la Défense
SPV	Special purpose vehicle
SRF	Solid recovered fuel
TDHC	Toronto District Heating Corporation
TES	Thermal energy storage
TWh	Terawatt-hours
UK	United Kingdom
UNEP	United Nations Environment Programme
WACC	Weighted average cost of capital
WtE	Waste-to-energy

Glossary

absorption chillers: chillers that use heat to drive the refrigeration cycle and produce chilled water.

anchor load: a heat or cooling demand that is significantly large, predictable and (often) nearly continuous. Used to help initiate initial district energy development due to long-term guarantee of demand. Many are publicly owned buildings and can include hospitals, government buildings, leisure centers, stadiums and data centers. A large thermal energy load which could connect and potentially provide early income to a **district energy** project.

arms-length body: an entity established by a public organization to deliver services on its behalf but which is wholly independent of the host organization.

articles of association: a document that outlines a company's operations and structure.

base load: see demand load.

BOOM see **DBOOM**

Btu (British thermal unit): the amount of heat required to raise the temperature of one pound of liquid water by 1° Fahrenheit. **MMBtu** refers to one million Btus.

capital expenditure (CAPEX): upfront costs that bring a project to market. For a district energy system, these include development costs, pipes and network, thermal plant and storage.

Climate Action Plan: a document produced by an institution or community that identifies ways to reduce carbon dioxide emissions in accordance with a predetermined timeline for achieving carbon neutrality.

cogeneration: another term for CHP.

combined cooling, heat and power (CCHP) or tri-generation plant: a power plant that is capable of utilizing excess heat produced in power production for an external process such as district heating, but that can also use heat to produce cooling for an external process such as district cooling if needed.

combined heat and power (CHP) plant: a power plant that is capable of utilizing excess heat produced in power production for an external process such as district heating.

combined heat and power (CHP): the concurrent production of electricity or mechanical power and useful thermal energy (heating and/or cooling) from a single source of fuel. A CHP plant captures heat that is typically exhausted as waste and repurposes it for additional uses.

company limited by guarantee: a guarantee company has no share capital or shareholders. Instead it has members who undertake to contribute a nominal amount toward any shortfall in the company's assets to settle its debts in the event of its being wound up.

company limited by shares: limited by shares means that the liability of the shareholders to creditors of the company is limited to the capital originally invested, i.e. the nominal value of the shares and any premium paid in return for the issue of the **shares** by the company. A limited company may be "private" or "public."

DBFO (design, build, finance, and operate): a form of project financing in which a private entity finances, designs, constructs, and operates an energy facility for a customer.

DBOOM (design, build, own, operate, and maintain): a procurement method in which a private entity designs, installs, owns, operates, and maintains an energy facility for a customer, who then purchases the energy from the private company. A **BOOM (build, own, operate, and maintain**) methodology is a similar alternative.

Delta T: the temperature differential between thermal energy supply and return.

demand load: the amount of energy consumers demand in any building or development. **Base load** refers to the pre-existing load for a given area or the load to be met by any system under consideration. The period of highest level and rate of energy consumption over a defined period, usually one hour, is called the **peak load**.

development-based land-value capture(DB–LVC): capturing the land-value increase as land is urbanized to finance infrastructure investment.

discount rate: the interest rate used in discounted cashflow analysis to determine the present value of future cash flows. The discount rate takes into account the time value of money as well as the risk and uncertainty of future cash flows.

district cooling (DC): The system by which cold water is pumped through pipes around a "district" to meet cooling demand, replacing air conditioning and building-level chillers. Cold water is produced at large centralized energy centers in a more efficient process than decentralized cooling production.

district cooling: the production of chilled water at a central plant for distribution through insulated pipes to multiple buildings for air conditioning.

district energy network: a system of insulated pipes for distributing heat in the form of steam or hot water, or cooling in the form of chilled water generated in a central plant to supply thermal energy to multiple buildings.

district energy/ district energy systems: the provision of thermal energy at a district level through district heating and/or district cooling.

district energy: the production of thermal energy (heating or cooling) at a central plant or plants and distributing the steam, hot water, and/or chilled water to local buildings through a network of insulated pipes.

district heating (DH): the system by which hot water or steam is pumped through pipes around a "district" to meet heat demand. Heat is produced at large centralized energy centers in a more efficient process than decentralized heat production.

district heating: the production of steam or hot water at a central plant for distribution through insulated pipes to multiple buildings for space heating, hot water use, or other purposes.

electric chiller: an electricity-driven compression chiller that can produce cooling.

energy map: a map showing opportunities and constraints for clean and renewable energy projects across a given area. This will incorporate thermal demand data typically presented in a heat map.

energy mapping: mapping of a city's local heating or cooling demand in order to understand current and future energy use, infrastructure, emissions and available resources. Mapping can also incorporate land-use and infrastructure planning in order to best plan district energy systems.

exergy: the potential for useful mechanical work. High-exergy fuels include coal, biofuels and natural gas. Low-exergy energy sources include low-temperature waste heat from industry.

feasibility study: a study that is used to assess the economic and technical viability of a project.

free cooling: the utilization of low temperature sources such as aquifers, rivers, lakes and seas to provide cooling to district cooling networks.

geothermal energy: capturing the internal heat of the earth to provide heat for power or heating. Due to the large-scale nature of geothermal, it is often used for heat provision with district heating.

heat map: a map showing locations where heat demand is sufficient to support **district heating**. Often included as part of an **energy map**.

hurdle rate: the minimum rate that a company expects to earn when investing in a project. Also referred to as a company's required rate of return or target rate. In order for a project to be accepted, its internal rate of return must equal or exceed the hurdle rate.

internal Rate of Return (IRR): the discount rate that makes the net present value of all cash flows from a particular project equal to zero. The higher the IRR of a project, the more desirable it is for investment.

load diversity: different energy consumers use their energy at different times of day. These are **load profiles**. A variety of different l**oad profiles** will provide load diversity.

load profile: load variation shown on a graph over 24 hours.

local authority/municipality: a unit of administration within government such as a municipality.

master plan: also known as a comprehensive plan, a diagram or plan showing how a site or area can be developed or regenerated. Terms such as development brief or design framework are often used. A master plan often establishes a three-dimensional framework of buildings and spaces as well as determining the distribution of uses. Energy would be one element of a master plan.

Microgrid: a local electric system or combined electric and thermal system that: (1) includes retail load and the ability to provide energy and energy management services needed to meet a significant proportion of the included load on a non-emergency basis; (2) is capable of operating either in parallel or in isolation from the electrical grid; and (3) when operating in parallel, can provide some combination of energy, capacity, ancillary or related services to the grid. A microgrid can be as simple as a cogeneration facility behind a single meter with an isolation breaker, but sophisticated microgrids often serve larger facilities or campuses and will increasingly serve multiple customers.

mixed-use zoning: an urban planning tool that encourages different building-use types to be developed in proximity. Such zoning is useful for district energy because the load is more varied, and hence smoother.

memorandum of understanding (MOU): a document that describes an agreement between parties and outlines an intended common line of action.

net present value (NPV): the difference between present values of cash inflows and the present value of cash outflows. Present value is calculated using a discount rate.

networks expand and link together to meet demand growth.

nodal development: The initial development of district energy in segregated “nodes” within a city, which consist of small networks. These nodes can then be interconnected in the future.

nodal network: a network that develops gradually as smaller **district energy**

net present value (NPV): the discounted value of an investment’s cash inflows minus the discounted value of its cash outflows. To be profitable, an investment should have a net present value greater than zero.

operational expenditure (OPEX): the running costs of a project after initial development and construction. For a district energy system, these include: fuel, operation, maintenance, local and state taxes, electricity, insurance, water, chemicals, service contracts for primary equipment and management of projects.

peak load: see **demand load.**

prime mover: the machine that provides the **base load** in a **district energy** system, typically an engine or turbine.

public private partnership (PPP): a joint venture where the private sector partner agrees to provide a service to a public sector organization.

rate/tariff: a rate is the calculated price that a customer must pay. For regulated systems the rate must be submitted to the regulating body before it is approved as a Tariff that can be charged to a customer. As a noun the two are sometimes used interchangeably to mean the price to the customer.

refrigeration ton (RT), or ton of refrigeration (TR): a unit of power, approximately equivalent to 3.51 kW, used to describe the heat-extraction capacity of cooling equipment.

refrigeration ton-hour (RTH): a unit of cooling energy, approximately equivalent to 3.51 kWh, that refers to one TR of cooling capacity producing cooling for one hour.

return on investment (ROI): a financial metric that is dependent on both a project’s Internal Rate of Return (IRR) and its Weighted Average Cost of Capital (WACC), and that indicates the profits that a project will receive.

revolving fund (RLF): a financing mechanism often initiated from public funds to support strategic investments without necessitating direct public ownership. The fund helps bring projects to completion and then may exit projects to recapitalize the fund so that it can be redeployed to other projects. The fund that issues loans to projects on an ongoing basis as previous loans are successfully repaid.

ring-fenced budget: a practice of earmarking the budget for a specific purpose

ring-main: a circular spine of distribution pipe for a thermal network. This allows thermal energy to be pumped in both directions if required and typically captures thermal energy from a variety of sources along the route. Both features increase network resilience.

return on investment (ROI): a metric used to determine a company’s benefit resulting from an investment of some resource, generally represented as a percentage. ROI = (Net profit / cost of investment) x 100.

Renewable Portfolio Standard (RPS): a policy requiring electric utilities to deliver a certain amount of electricity from renewable energy sources by a specific date.

solar thermal: a renewable energy technology that produces useful heat from the energy of the sun. Large-scale solar thermal can be connected into district heat networks.

special purpose vehicle (SPV): a separate entity created to take ownership and responsibility for an energy project’s development and ongoing operation, separating risk and liability from the project sponsor(s).

Thermal energy storage (TES): a process in which thermal energy is produced and stored for later use. The storage tank is connected to the district energy network to allow surplus production of heating or cooling to be stored and utilized in the future and allow the shifting of thermal energy production to times when non-peak power is available.

waste heat: any heat source that is not normally utilized to its full potential, as it typically requires infrastructure to connect it (e.g., waste heat from power stations, steel mills, transport and incinerators).

waste-to-energy (WTE) or waste incineration: burning of municipal solid waste to reduce waste going to landfill and also to produce useful energy for electricity and/or heat generation. The heat produced can be fed into a district energy network.

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Annex XI Final Report
Governance Models and Strategic Decision-Making Processes for Deploying Thermal Grids

Appendix A: Case studies

Twelve case studies have been compiled to provide diverse examples of business models, financing strategies and governance structures for district energy systems in Canada, Denmark, France, South Korea, Sweden, UK and USA. They highlight the drivers and objectives behind each system's development and growth and provide a summary of the journey of the system over time. Each example showcases the strategies for success as well as lessons learned.

Case 1: Public Internal Department

AffaldVarme Aarhus, Aarhus, Denmark

Financing cost-effective CO_2-neutral heat sources

The new Lisbjerg biomass-fueled CHP plant. Photo by Aarhus Kommune.

SYSTEM AT A GLANCE

Capacity:	**DH: 3.2 million MWh**
Network length:	**130 km**
Customers served:	**315,000**
Equipment:	**waste incineration plant, hot water loop, backup boilers, CHP system**
Fuel:	**coal, oil, biomass, waste heat**
Use of thermal energy:	**space heating, water heating**

SYSTEM DESCRIPTION

AffaldVarme Aarhus is a municipal-owned and -operated district heating system that serves 315,000 customers in the Danish town of Aarhus. Its heat is largely derived from an oil- and coal-fueled CHP system as well as local waste incineration activities. Recently the company began construction of a new CHP generator in Lisbjerg adjacent to the waste incinerator that will burn straw and other biomass resources. That new generator began providing the system with heat in fall 2016. The plant will eventually supply about 20% of the system's total heat, with the waste incineration plant providing an additional 20%. The Lisbjerg CHP plant at full build-out will supply about 37 MW of power to the grid and the equivalent of 77 MW of heat. Another 50% of the remaining heat is supplied by the Studstrup Power Plant, a 700 MW CHP plant owned by DONG Energy. Studstrup recently completed a 1.3 billion DKK conversion process that allows one of its units to burn wood pellets instead of coal. Other units are currently capable of co-firing straw with oil.

DRIVERS AND OBJECTIVES

- Aarhus's main driver was its established goal of being CO_2-neutral by 2030, requiring Aarhus to address the fuel sources of its CHP system, which has been powered by oil and coal for years
- City goals included a desire to keep district heating rates low, since the municipality is encouraging economic growth and wishes to use low heating rates as a tool to attract new companies
- Because the CHP plant that provides most of the heat to the city is privately owned, the city had an overarching objective to develop a long-term plan that encouraged DONG Energy to make investments that are in the interest of the city and its citizens

FINANCING AND GOVERNANCE

Financing

The existing Studstrup CHP plant is owned by DONG Energy, the former national energy company that is now partly owned by the national government. A newly developed financing model approved by the national energy regulatory body, the Danish Energy Regulatory Authority (DERA), resulted in investment for an updated CHP plant that was biomass-ready. This model was developed in conjunction with both AffaldVarme Aarhus and DONG Energy, and presented to the national regulatory body for approval (Energitilsynet, 2012). Half of the investment in the service life extension for the unit to make it biomass-ready was borne by AffaldVarme Aarhus (DONG, 2012).

The investments required to upgrade the plant to use wood pellets were estimated to be 1 billion DKK, and DERA approved the arrangement after determining that the upgrade would maintain low and stable energy prices for customers (Energitilsynet, 2012). The arrangement had to be structured in a manner that encouraged DONG Energy to make the long-term investments necessary to upgrade the targeted units. AffaldVarme Aarhus covered 80% of the costs associated with the biomass conversion, and DONG took on 20% of the costs associated with service life extension (Sekretariatet for Energitilsynet, 2012).

Governance

Cities are responsible for their own district heating planning activities and coordinate closely with each other and DERA. In 2010 the Aarhus city council approved a plan to make necessary investments in the district heating system toward the goal of being CO_2-neutral. As DH companies in Denmark are typically run as not-for-profits, DERA pays close attention to the impact of new investments on consumers.

Cities ask their district heating companies to present ideas to serve heat to new developments, and in Aarhus the city and the district heating company work together to develop climate and energy-related goals. In this way the goals and priorities of the district heating company complement those of the city at large. The city council approved the AffaldVarme Aarhus investment in the Lisbjerg CHP plant.

National policies have established 2030 as the last year that district heating facilities can burn oil and coal. Such facilities are thus planning on a full replacement of those resources over the next 13 years. Because this policy is well-established and understood to be not subject to changing political whims, an investment in a biomass-based system was seen as the least risky investment the company could make.

STRATEGIES FOR SUCCESS

RISK

- Municipalities have the ability to compel connection of buildings to the district heating system, so the heating company was able to approve investments with the expectation that the number of customers would grow
- The city of Aarhus has understood the business needs of DONG Energy and has sponsored the regulatory requests necessary to economically incentivize DONG to invest in full biofuel powering of Studstrup's Unit 3

INFORMATION

- The Aarhus City Council adopted a climate plan outlining three clear scenarios for making the district heating CO_2-neutral by 2030, thus offering clear guidance to the private sector about what the city would be willing to support in the long term

MONEY

- Major investments necessary for the new CHP system were approved by city leaders, thus giving confidence that the district heating company could make the investments with full faith that the investments could be recouped through customer rates
- DONG Energy invested their own money in the upgrade of boiler Unit 3 of Studstrup because they had full support by the DERA that their investments were necessary and would be reflected in future rates. They also understood that AffaldVarme Aarhus was taking on the bulk of the risk associated with the biomass conversion

PEOPLE

- The city of Aarhus and DONG Energy have worked very closely to align goals related to CO_2 emission reductions

JOURNEY

City established public district heating company as arm of city government with involvement of regional heat plants including incineration plant and electric generator

→

The system grew to heat 95% of the homes in Aarhus and expanded to incorporate several nearby towns into one integrated system

→

New environmental goals drove city to lead new effort to work directly with private sector heat suppliers to obtain the heat supply they needed and develop new business models regarding investment

LESSONS LEARNED

- The establishment of clearly articulated environmental goals that will be aggressively pursued lays the foundation for groundbreaking conversations with external partners (e.g., DONG Energy)
- Once established, a local district heating company can use its respected brand to further deploy district energy beyond the municipal borders

Case 2: Public Internal Department

Southeast False Creek, Vancouver, Canada

Establishment of a new, transparent utility

Stacks that also serve as public art in Southeast False Creek. Photo by David Dodge, Green Energy Futures, Creative Commons NC.

SYSTEM AT A GLANCE

Capacity:	**DH: 3 MW**
Network length:	**4.7 km**
Buildings served:	**22**
Equipment:	**electric heat pump, energy transfer stations, backup boilers**
Fuel:	**electricity, latent heat from sewer, natural gas for backup boilers**
Use of thermal energy:	**space heating, domestic hot water**

SYSTEM DESCRIPTION

The Southeast False Creek (SEFC) district heating system was designed around capturing and utilizing waste heat from sewage as the main energy source. This unique system makes productive use of the heat present in the city's sewer system, which is recovered and then boosted in temperature via two electric-driven heat pumps to supply space and water heating to over 4,300 residential units. SEFC is the first raw sewage heat recovery plant in North America (Baber & Damecour, 2008).

It was developed by the city government as an explicit strategy to meet carbon dioxide reduction goals. The city continues to own and operate it today as the Neighborhood Energy Utility (NEU), with its own franchise agreement for the area it serves.

Hot water is supplied at 65° C in the summer and 95° C in the winter. The use of an existing heat resource yields a greenhouse gas emissions profile that is 70% less than a business-as-usual heating scheme (Preservation Green Lab, 2010; UNEP, 2015).

DRIVERS AND OBJECTIVES

- Reduce greenhouse gas emissions
- Provide heating services that are economically competitive with electric and natural gas-based alternatives
- Demonstrate commercial viability early on in the system's lifespan
- Exhibit full transparency in setting of customer rates
- Demonstrate to developers that connecting to a district system would be trouble-free
- Provide substantial guidance to builders when they are designing buildings that will connect to the system

FINANCING AND GOVERNANCE

Financing

The SEFC system functions as a typical utility recovering fixed and variable costs through customer rates. Often first adopters are faced with bearing the high up-front capital costs. In SEFC, however, to avoid this impact on first adopters, a rate structure that gradually covers first capital costs over time with a slowly escalating fixed charge was set in place. When the first capital costs were incurred, the city was able to leverage its high credit rating and finance 100% of the initial investment. It used an internal city capital projects fund, a loan from the federal Gas Tax Fund and a loan from the Federation of Canadian

Municipalities Green Fund to make the initial investments.

Customer rates are based on customer class, and distinct fixed and variable charges are implemented based on class. Energy charges are assessed on a building-by-building basis and building owners are then free to recoup those charges as they see fit, using metered data or proxies such as floor area (Ostergaard, 2012). Having regulated rates gives the utility significant certainty around revenues. The utility is currently allowed to earn a healthy 10% return on equity.

Rates are currently structured so that 57% of a customer's bill is based on fixed costs and the remaining 43% is variable. This ratio is subject to change as the utility's finances are reassessed annually. The total costs for the system were levelized through rates over 25 years, and annual operating shortfalls can be covered by reserve funds set aside for rate stabilization (Ostergaard, 2012). The initial annual operating shortfalls were significant due to the high up-front capital costs, and the city uses its rate stabilization fund as a kind of credit line for these kinds of initial capital projects (Crowe, 2013). The rate stabilization fund was financed by the Capital Financing Fund, which is the utility-wide capital fund. Thus, the costs of providing a rate stabilization fund were included in the initial assessment of overall system costs.

Governance

The system is subject to continued oversight from an independent expert review panel that continually assesses whether city ownership still makes sense and whether the structure is best serving customers and the city (Ostergaard, 2012).

The City Council has full oversight over the utility. It annually reviews and re-sets rates if necessary (Ostergaard, 2012), paying particular attention to what customers are paying, how that compares to alternatives and whether the utility can continue to justify necessary investments. The council must approve all system expansions and participates in a comprehensive rate review every five years (Crowe, 2013). The council can urge the utility, via ratemaking, to prioritize certain outcomes. For instance, a recent assessment of utility rates asked the utility to consider how to structure rates in a manner that more directly emphasized energy conservation. The council and review panel can consider whether the efforts to recover more of the system's costs later in its lifespan are being fairly recovered from customers. At present the council has approved a rate schedule that is predicated on recovering all the under-recovered costs by 2025 (Baber, 2015).

The fully public nature of the system means that finances are very transparent, and regulators are able to address financial challenges and approve rate changes in a manner that is also highly transparent.

STRATEGIES FOR SUCCESS

RISK

- Adopted a tariff structure that reduces risk for earlier adopters by spreading fixed costs over a long period of time and that covers initial shortfalls with a fund separate from rate-based revenues
- The city approved a bylaw requiring connection to the district system when developing within the established utility franchise area, thus ensuring that a critical mass of connected load could be reached

INFORMATION

- Studied appropriate rate structure and project staging
- The city has leveraged learnings from SEFC to encourage and pursue more neighborhood-scale sewer heat recovery projects

MONEY

- City leveraged its strong credit rating to acquire low-interest financing to fully fund the initial capital investments

PEOPLE

- Vancouver City Council has full oversight of utility and regularly assesses rates and business structure

JOURNEY

City identified greenfield development for environmental performance during planning stages, and district energy was seen as a critical component	City leveraged its strong financial rating to obtain full financing; business model requires connection to district energy utility	Maturation of neighborhood energy utility yields regular assessment of rates and comfort with business model for future deployment; public oversight maintained

LESSONS LEARNED

- When exploring a new resource, such as heat from a sewer, bring in experts who can identify potential concerns early on. For example, too much heat extraction from the sewer system could negatively affect the operation of the sewers
- If GHG reduction is the primary goal of the project, design a rate scheme that directly incorporates GHG performance as a desired metric and valued benefit
- Tightly control rate schedule and undertake frequent assessments to ensure rates are tracking with costs and meeting societal goals, such as avoiding an undue burden for early adopters

Case 3: Public Social

Aberdeen Heat & Power Co., Aberdeen, UK

A not-for-profit approach to addressing fuel poverty

Aberdeen skyline;
Seaton CHP Energy Centre (inset).
Photo by Michael King.

SYSTEM AT A GLANCE

Capacity:	**DH: 15 MW; CHP: 4.5 MW**
Network length:	**14.4 km**
Buildings served:	**50**
Equipment:	**gas-fired reciprocating CHP engines, gas boilers**
Fuel:	**natural gas**
Use of thermal energy:	**space heating, domestic hot water, CHP-generated electricity sold via private wire arrangement and exported to the power grid**

SYSTEM DESCRIPTION

In 1999 Aberdeen City Council adopted an Affordable Warmth Strategy to tackle fuel poverty in the city. In part this strategy determined that investment in its own housing stock should be focused on its least thermally efficient properties. An evaluation using energy rating software concluded that their 59 high rise blocks of flats were the least energy-efficient. Most of these blocks lacked external cladding and the flats were heated with electrical night storage heaters. Residents were under-heating their homes due to the high cost of electricity.

The council commissioned a study to identify the technical solution best able to deliver low-cost heating to residents. The study concluded that this goal could best be achieved with water-based communal heating systems connected to combined heat and power (CHP). While the council could afford to install this technology in one cluster of blocks it could only do so at the rate of one project every 12 years due to capital constraints.

Commercial energy services companies could access third-party investment to accelerate deployment but the returns required would result in high heating charges to the residents – undermining the objective of reducing fuel poverty. The council established an arm's-length not-for-profit company limited by guarantee based on member ownership and entered into a 48-year framework agreement with the company providing it with exclusivity in delivering district heat and CHP projects in council-owned property. This term was deemed sufficient to retrofit all 59 blocks.

Using a blended financing arrangement, the company has now completed a total of five projects serving approximately 2,600 flats and 14 public buildings. Each project is developed as a stand-alone project connecting several buildings into a 'heat island' or 'heat node.' But these are embedded in a broader strategic approach that will see heat islands connect to each other and link together to form a ring main around the city with a series of plant rooms containing a range of technologies and fuel sources. This will improve the robustness of the network and provide resilience and energy security as well as the ability to hedge between the prices of different fuels.

The broader strategic approach is flexible enough to adapt to arising opportunities. For example, the council is intending to replace social housing units demolished as part of a road re-alignment. A cost comparison exercise determined that it would be more cost-effective to spend £1 million to extend the heat network to connect the new housing units than to install individual gas boilers after factoring in maintenance, depreciation and term replacement costs. Additionally, the council has accessed a £1 million central government grant from the Scottish Energy Efficiency Program to densify the heat network by connecting the major institutional and cultural buildings within a defined area of the city center.

DRIVERS AND OBJECTIVES

- Address fuel poverty through the provision of affordable heat
- Reduce carbon emissions
- Develop skills and employment in the local economy
- Secure external financing for refurbishment of the council's housing stock
- Benefit citizens by reducing carbon emissions and heating costs

FINANCING AND GOVERNANCE

Financing

For the first project serving 289 flats 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 over a ten-year term. Based on the security provided by this contract the company was able to secure a £1 million capital loan from a commercial bank to deliver the project. At that point, the government-funded Community Energy Program became available and the company was able to spread the loan finance over a further two projects, blending it with grants from government and utility energy efficiency programs as well as council funds otherwise intended for refurbishing the heating systems within their stock. The company has taken on £1 million of additional commercial debt to finance additional generating capacity to meet expanding demand.

As a not-for-profit, surpluses generated by the company are re-invested in the business. Revenues from electricity sales and non-residential heat sales are used to hold down heat charges for residential customers. Charges are set to cover costs and ensure that they do not exceed the accepted definition of affordable warmth: 10% of disposable income for the poorest household type (a single pensioner on welfare). The company has been able to reduce heating costs for householders by 40%.

Governance

An arm's-length not-for-profit company was formed as a company limited by guarantee based on membership. As a community-owned company established by the council, it can be considered a public/social entity. Residents and other community members nominate board directors, with two seats reserved for the elected councillors. The company is structured into task-orientated sub-groups that report to the full board. At first, all activities were contracted out to specialist providers. These have progressively been brought in-house to be undertaken by an expanding number of employed staff.

EU procurement legislation precludes the company from making energy sales to private customers because the 48-year framework agreement is considered to be 'state aid.' Therefore, Aberdeen Heat & Power has established a wholly owned for-profit company - District Energy Aberdeen Ltd. (DEAL) - that buys heat from the parent company and retails it to privately owned buildings. Profits generated by DEAL are returned to the parent company as dividends.

STRATEGIES FOR SUCCESS

RISK

- Risk is reduced as the budget for the district energy non-profit is wholly separate from that of the city council. This ensures that the city does not have to absorb losses from the district system
- 48-year framework agreement reduces demand risk
- Specialist activities (design, construction) are outsourced
- Flexible approach allows network extension to adapt to opportunities

- Information on phased deployment enables a strategy to build the district's ring main network as a staged development
- Heat islands or nodes are able to be developed as stand-alone projects
- Close working relationship with council's refurbishment and regeneration programs is helpful

- Not-for-profit company can accept lower return on capital
- Framework agreement provides security to commercial lenders
- Can access public and private sources, allowing blended funding

- Board of local people enables decisions close to delivery impact
- Seats reserved for councillors maintains close links with council
- Activities were contracted out until skills developed in-house

JOURNEY

Council establishes arm's-length not-for-profit company and sets out clear objectives → Not-for-profit company's focused management and ring-fenced budget allows rapid network expansion → Not-for-profit company establishes wholly owned for-profit subsidiary to retail to commercial customers

LESSONS LEARNED

- Achieved key objectives of affordable warmth and carbon reductions
- Evaluated technical and financial options available to achieve objectives
- While limited capital constrains council ability to achieve objective itself, it is able to contribute to the project by providing demand guarantees instead
- Not-for-profit arm's-length company provides focused management and de-coupling from the council budget
- Required skills need to be contracted out until company grows sufficiently to bring them in-house
- Flexibility to respond to opportunities helps to achieve rapid network expansion

Case 4: Public-Private Concession

Paris District Heating & Cooling, Paris, France

Moving climate action through urban district energy networks

Louvre Museum. Photo by Creative Commons.

SYSTEM AT A GLANCE

Capacity:	**DH: 2000 MW; DC: 330 MW; CHP: 250 MW**
Network length:	**DH: 475 km; DC: 73 km**
Customers served:	**DH: 600**
Equipment:	**gas turbine, heat recovery steam generators, electric centrifugal chillers, steam turbine chiller, gas boilers**
Fuel:	**municipal waste electricity, natural gas, 'free cooling,' geothermal**
Use of thermal energy:	**space heating, process steam, space cooling, grid power**

SYSTEM DESCRIPTION

The city of Paris boasts both district heating and cooling networks that have served the city for several decades and continue to keep step with the objectives of the city and its population.

In 1927, the city looked to DH to reduce air pollution from coal consumption. Today the expanded system boasts over 50% renewable fuel sources and delivers affordable heat to social housing (UNEP, 2015).

DH is provided by CPCU (Paris Urban Heating Company), which as a private company obtained its first concession from Paris in 1927 to produce and deliver steam to public buildings.

A DH network of over 450 km serves Paris and 12 municipalities in its metropolitan area. Most Parisian monuments – including its 21 hospitals, the Louvre museum, 50% of its public buildings and 50% of the social housing – are connected to DH. By avoiding more than 1,000 building chillers and cooling towers on rooftops in the center of historic Paris, the iconic aesthetic of the city is maintained.

CPCU has eight power production sites, two of which are CHP plants, while three are waste-to-energy (WtE) plants. Half of the steam used by CPCU comes from these WtE plants, which provide the base load of the network, with boilers meeting peak demand.

The WtE plants, owned by Sytcom, the metropolitan agency for household waste, treat non-recyclable household waste from over 5 million inhabitants in 84 municipalities and prevent the release of around 900,000 tons of CO_2 annually. Steam from the combustion process is used to generate electricity, a small part of which is used by the plants, with the majority being sold to EDF to supply the electricity grid. The heat is sold to CPCU.

The main steam network serves space heating needs as well as industrial processes including laundry, cooking, sterilization, humidification and food processing. CPCU has 19 hot water loops that serve smaller neighborhoods by converting steam to hot water via a heat exchanger. CPCU has also installed 100 MW of geothermal DH networks to increase the share of renewables in the energy mix.

District cooling is provided by CLIMESPACE, a subsidiary of ENGIE that has been a concession holder with the city of Paris since 1991 to develop and operate the Paris district cooling system – the largest cooling scheme in Europe.

CLIMESPACE has 10 production sites. At three of the largest production sites – totaling 148 MW in capacity – the DC network makes use of the 'free cooling' by using cold water from the River Seine to pre-cool water before it enters electric chillers, thereby reducing electricity consumption, cost and CO_2 emissions while improving efficiency (ClimateSolutions, 2015).

The network circulates mainly via the sewers of Paris. This limits the need for earthmoving at street level and minimizes the impact of the concession holder's work on the urban environment.

The control room of the DC network maximizes the use of this 'free cooling' and uses the three production sites as the base load supply to meet 75% of the network's cooling demand, resulting in the use of 35% less electricity than typical cooling in buildings. The other production sites on the network that meet peak cooling demand have highly efficient electric chillers with cooling towers. In addition, the network also has three thermal energy storage tanks for cold water storage that can instantly provide more cooling to the network and help shift the electricity demand during periods of peak demand.

A separate DC network operated by SUC (a subsidiary of Dalkia) supplies the chilled water via a 10 km network to cool over 1.5 sq m of office space including La Défense, Europe's largest business district, in the west region of Paris. SUC is a public utility with a concession from the Défense region urban heating syndicate (Syndicat mixte de Chauffage Urbain de la région de la Défense or SICUDEF) for the production and distribution of cooling in the towns of Courbevoie and Puteaux, along the River Seine.

DRIVERS AND OBJECTIVES

The 2007 (Mairie de Paris Plan Climat Énergie de Paris, 2007) and 2012 (Mairie de Paris Plan Climat Énergie de Paris, 2012) Paris Climate Protection Plans have played a key role in providing an impetus to growth in district energy through several focused actions:

- CPCU had set a target to increase the share of renewables from 49% to 60% by 2012. In its capacity as granting authority, the city of Paris asked CPCU to attain this 60% rate rapidly and aim for 75% of renewable energies by 2020, mainly by tapping the potential for geothermal energy. Meeting the renewable energy mix targets allows it to apply a reduced national sales tax (VAT) rate of 5.5%, instead of 19.6%
- Priority to be given to connecting buildings to CPCU's district heating network
- Required CPCU to install individual meters to promote better energy management in connected buildings
- Revised regulations concerning majority rules for buildings held in co-ownership (in particular for cost-effective work and connections to a collective heating system) to facilitate loans and investment decisions. The majority of Parisian buildings are co-owned, and work on common objectives – where substantial energy savings can be made – must be approved by the co-owners' associations
- Joint development zones (ZAC) have been used to transform declining urban areas and experiment with new forms of city blocks and prescribe connection to the district heating networks. The plan advocated legislative power for regional authorities to reach beyond national frameworks to prescribe connection to the district heating network in non-ZAC areas
- Recommended a detailed geothermal study to help CPCU identify areas of growth and development
- Advocated studying the possibility for new zones with mandatory connections when the energy mix of the DH system is more than 50% renewable or recovered energy
- Required a heating master plan from CPCU requiring new developments to explore interconnecting heat networks to increase baseload across networks and to pool investment
- Recommended exploration of combining energy distribution and production efforts to pool investment and production costs and reduce energy prices for Paris consumers
- Advocated the development of a DC network as a possible solution in areas that already contain large numbers of cooling towers at stand-alone plants, which can represent a health hazard

FINANCING AND GOVERNANCE

Financing

Paris has utilized the concession type of public-private partnership for its DH and district cooling infrastructure development and operation concessionaires – CPCU, Climespace and SUC.

CPCU is a public-private joint venture with 33% owned by the city of Paris, 64% by ENGIE and 2% traded publicly. The 90-year CPCU concession initiated with CPCU in 1927 provides Paris with an annual dividend of €2 million and an annual concession fee of €7 million.

In 2011 the European Commission authorized France, under EU state aid rules, to provide a €26 million direct grant for the construction of a DH network in the North-East of Paris (Europa, 2011). The aid will be granted to CPCU, a subsidiary of ENGIE and the current holder of the DH concession in Paris. The new network will displace conventional electric resistance heating and save 65,000 tons of CO_2 emissions between 2011 and 2024 and help meet EU2020 environmental objectives. The aid was deemed appropriate in view of the €170 million invested in the network.

The concession that was due to expire on December 31, 2017 was extended by seven years until 2024, in order to allow it to recoup the total investment of €170 million in the network. The French authorities committed to tender the concession anew in 2024 or operate it directly.

Climespace operates under a 30-year concession contract from the city of Paris, initiated in 1991 and ending in 2021 when it will be renegotiated. Climespace is 100% owned and financed by ENGIE (formerly GDF Suez). Climespace provides annual revenue to the city of approximately €1 million per year.

In 2008 CPCU and Climespace worked as partners to develop a geothermal plant in PNE (Paris North East) that combines the two systems to simultaneously produce both steam and cold water. This unique plant features a new concept whereby production for both cooling and heating is derived from geothermal energy and seasonal thermal energy storage.

Governance

The combination of city ownership and the use of a concession model have allowed Paris to maintain a high degree of control over district heating and cooling development, while also benefiting from the efficiency improvements and capital investment contributed by the private sector.

The concession contract specifies tariffs that Climespace can charge to its customers. These tariffs vary depending on time-of-use and the size of the energy transfer station that a building requires. An annual concession review enables the city to manage the multiple objectives in partnership with the concessionaire.

The contract has undergone several amendments including environmental management. CPCU is required to develop a multi-year program of environmental initiatives and describe its implementation in an annual report. The contract also stipulates that CPCU absorb all of the steam generated by the incineration of household waste, within the limits of its operating requirements. The concession contract sets a maximum price for the heat delivered, indexed against the share of renewable heat generated to promote their share in the energy mix. The city can also require a special low price for those in social housing.

The production facilities – except the three WtE plants and the DH network – are owned by the city of Paris, while CPCU operates and maintains the system and serves the customer. The city nominates four of the 10 board directors.

STRATEGIES FOR SUCCESS

RISK

- DE enables meeting renewable energy targets
- DC eliminates cooling towers to maintain the aesthetics of Paris
- City conducts annual concession review

INFORMATION

- Paris Climate Action Plans provided guidance for DH & DC
- Efficient use of city waste and ‘free cooling’ from the River Seine
- Paris geothermal study provides guidance on resources for DH & DC
- Concessionaire provides global best practices in DH and DC

- City gets annual concession fee and a dividend from equity in CPCU – adding revenue and reducing operation and maintenance costs
- Reduced VAT is available for concessionaire using renewables
- CPCU gets low-cost capital from city
- City can leverage private capital from ENGIE

- City of Paris has representatives on boards of concessionaires for governance
- Employees of the concessionaire provide state-of-the-art expertise

JOURNEY

Started with objectives to reduce air pollution, serve social housing and maintain aesthetic of building rooftops → Expanded district heating and cooling networks while leveraging diverse renewable fuel sources → Met environmental objectives through substantial use of renewables. Now planning connected networks

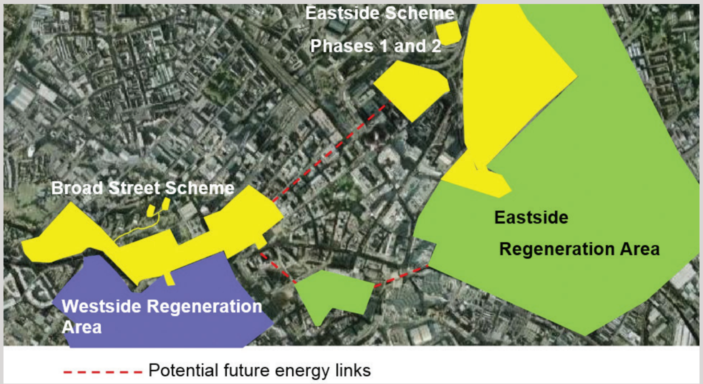
LESSONS LEARNED

- It is possible to meet social and environmental objectives while delivering economic value
- The well-designed concession contract and governance model have made it possible for Paris to leverage private sector expertise while providing public sector low-cost capital
- It was useful to have early-stage guidance from the city on objectives
- Cities are able to use renewable resources such as 'free cooling' from the River Seine and city waste through the scale of operations made possible by district energy
- Rather than rely on just national and EU plans and policies, Paris has undertaken several initiatives such as the 2007 and 2012 Paris Climate Protection Plans and Paris geothermal study to explore the city's geothermal heating potential and requiring a heating master plan from CPCU for new developments to explore interconnecting heat networks to increase baseload across networks and pool investment

Case 5: Public-Private Concession

Birmingham District Energy, Birmingham, UK

Developing a city center heat network



Map of Broad Street and Eastside district energy systems.
Photo by Cofely District Energy.

SYSTEM AT A GLANCE

Capacity:	**DH: 7.3 MW; DC: 4.9 MW; CHP: 7.5 MW**
Buildings served:	**16**
Equipment:	**4 gas reciprocating engines, gas boilers, absorption chillers**
Fuel:	**natural gas**
Use of thermal energy:	**space heating, space cooling**

SYSTEM DESCRIPTION

Plans for developing Birmingham's city center arena, conference center, commercial and retail facilities provided an opportunity for engineering staff at the Birmingham City Council to install gas-fired CHP to support a heat network. However, the council was unwilling to provide direct investment. It had a culture of obtaining services from the private sector with an emphasis on short-term cost competitiveness. However, passing on the financial risk of high upfront costs meant less control on network expansions decisions. The availability of grants from a new central government program led to a partnership in 2003 with Aston University and Birmingham Children's Hospital to tender a contract for a 25-year concession to develop a heat network serving several buildings in the city center. For this project the city appointed Utilicom, a French company later acquired by GDF Suez, re-branded as Cofely District Energy and now known as ENGIE. The company established a wholly owned special purpose vehicle, Birmingham District Energy Company (BDEC). The project has been developed as two separate heat networks – Broad Street and Eastside. A 25-year energy services agreement for Broad Street was signed in 2006 and for Eastside in 2008-09.

The trigeneration project supplies heat, chilled water and electricity via a private wire network to the buildings connected with a total of four plant rooms housing a total capacity of 7.5 MWe CHP with 7.3 MWt of gas-fired boilers. The chilled water is generated by 4.9 MW absorption chillers using the heat from the CHP engines.

The Broad Street network commenced in 2007 with a plant room built at the International Convention Centre. This supplies heat, chilled water and electricity to several large buildings in the business district including the Town Hall, Council House, Hyatt Regency Hotel, International Convention Centre, National Indoor Arena (housing a supplementary plant room with a 600 kW CHP engine), Repertory Theatre, and Paradise Circus leisure and retail complex. In 2010 this network was extended to connect the Cambridge and Crescent Towers residential blocks owned by Birmingham City Council, thanks to a grant from the government's Low Carbon Infrastructure Programme.

The Eastside Network is being developed in two phases, one centered around Aston University and the second around the Children's Hospital. Other connected buildings include the council's Lancaster Circus offices, the council's Woodcock St. administration block, the Magistrates Court, the Masshouse residential development, and a 656-unit student accommodation block. In 2014 the Eastside Network was extended to connect the redeveloped New Street Railway Station and the major retail complex above it. The station connection will make it possible for the two heat networks to connect, previously prohibited because the building's footprint acted as a barrier between them.

DRIVERS AND OBJECTIVES

- Reduce carbon emissions
- Reduce energy costs
- Address fuel poverty for Cambridge and Crescent Towers
- Minimize investment by City Council

FINANCING AND GOVERNANCE

Financing

The project benefited from a £700,000 grant from the government's Community Energy Program. The remainder of the £1.86 million project was financed by Cofely District Energy (previously GDF Suez, now ENGIE) under a 25-year design, build, finance and operate contract/concession under which the partnering tendering organizations, the city council, Aston University and the Children's Hospital agreed to buy energy from the company for the life of the concession. Energy charges are benchmarked to the market but with an efficiency driver built in. In 2009 an additional grant of £1.5 million from the government's Low Carbon Infrastructure Program allowed the connection of the Cambridge and Crescent Towers.

Governance

BDEC is a wholly-owned subsidiary of ENGIE. All directors are ENGIE employees. The project was initiated by the council, which also tendered the concession contract. The assets return to the council at contract end, so it can be considered a public-private entity. Under the concession contract BDEC established three networks with 7.5 MW CHP capacity serving 10 major buildings with heat, cooling and power; BDEC assumes all development, retail risk and control over network development. Further extensions must meet ENGIE's investment criteria. The council cannot determine the investment strategy, and its ambition for future expansion must be pursued through contractual negotiation. Tight definition of the contract precluded third-party heat suppliers accessing the network and potentially undercutting the agreed pricing structure.

STRATEGIES FOR SUCCESS

RISK

- Risk-averse Council decided to do a full risk transfer to BDEC
- Council priced risk into a long-term concession contract

INFORMATION

- Council learned from experience of DH and CHP at Stechford, East Birmingham
- Engineers linked goals of sustainable growth into long-term concessionary contract
- Feasibility study conducted in 2003
- Based on a visit to a project in Southampton operated by private company Utilicom (now ENGIE), the Council granted it a concession to own and operate the CHP/DH network

MONEY

- Steady long-term return on investment for ENGIE
- Contract is benchmarked to market prices with efficiency driver
- Grants made available from government programs

PEOPLE

- BDEC board has all ENGIE employees
- Investment decisions are made according to ENGIE criteria
- Council cannot determine investment strategy
- Council needs for network expansion must be pursued through contractual negotiation

JOURNEY

Developed early technical understanding and feasibility → Overcame risk aversion and lack of investment through long-term contract → While covering investment risk the contract limits network expansion and requires negotiation

LESSONS LEARNED

- Council unwilling to take on risk due to a culture of external competitively tendered services for short-term benefit
- Transferring risk through a long-term contract enabled investment by BDEC
- Risk transfer creates constraints on the pace of network expansion as the contract does not allow the council to determine investment strategy
- Develop a good understanding of technical possibilities

Case 6: Public-Private Concession

University of Oklahoma, Norman, USA

College campus leverages private sector resources

Ellison Hall, University of Oklahoma. Photo by Creative Commons.

SYSTEM AT A GLANCE

Capacity:	**DH: 53 MW (180,000 lb/hr); DC: 35 MW (10,000 tons); CHP: 15 MW**
Network length:	**11.3 km (7 miles)**
Buildings served:	**150**
Students:	**30,000**
Equipment:	**gas turbine, heat recovery steam generators, electric centrifugal chillers, steam turbine chiller, gas boilers**
Fuel:	**electricity, natural gas**
Use of thermal energy:	**space heating and cooling, campus process steam, campus power**

SYSTEM DESCRIPTION

The University of Oklahoma (OU) is a research university located in Norman, Oklahoma. Until 2006, the north and south sides of campus were served by two chilled water plants. The boiler plant, built in 1948, housed natural gas-fired boilers with a capacity of 295,000 lb/hr serving steam-driven chillers and condensing turbines generating 16 MW of power and a backpressure turbine distributing steam and hot water to campus buildings.

With limitations in cooling tower capacity and ages of chillers and boilers ranging from 40 to 60 years, the utility infrastructure struggled to provide reliable service to both ends of campus.

Considering the anticipated campus growth and the aging asset fleet, the university chose to enhance its long-term capabilities rather than undertake short-term improvements. A $60 million project was initiated in 2008 to create a new Utility Plant 4 (UP4) with four 2,500-ton chillers and space for three future units; two 7.5 MW combustion turbines with heat recovery steam generators; a redundant 60,000-lb/hr water-tube steam boiler; and seven cooling tower cells (three for the future chillers). The UP4 plant is run baseloaded, with the older plant providing additional campus electricity. CWP1 serves campus chilled-water loads in excess of UP4 capacity.

The current utilities infrastructure serves 11 million sq ft using a 7-mile network of pipe in tunnels. The CHP system is designed to generate reliable and cost-effective electricity and much-needed generation redundancy to facilitate maintenance on steam turbine generators. It also provides reliable and efficient steam to serve summer campus heating loads, allowing the larger power plant boilers to be shut down for service. The CHP system reduces regional carbon dioxide emissions by an estimated 25,000 metric tons per year, a reduction of 15%. The project provides lifecycle savings of $15 million over 30 years.

With reduced public financial resources, and burdened with aging and inefficient utility infrastructure, the university's Board of Regents solicited bids for the management, operation, maintenance, renewal and reconstruction of its multi-utility system. In 2010 Corix Utilities (Oklahoma) Inc., a subsidiary of Corix Infrastructure Inc. of Vancouver, B.C., was selected by OU to purchase a 50-year concession to invest in and design, build, operate and maintain the steam, electrical, natural gas, chilled-water, potable water and waste water systems (Corix, 2012).

DRIVERS AND OBJECTIVES

- Improve reliability of service and renew aging campus utility infrastructure
- Harness funds for academic projects by monetizing utility system assets
- Focus on academic mission
- Reduce GHG emissions

FINANCING AND GOVERNANCE

Financing

The Board of Regents authorized a nationwide solicitation to seek alternative private financing and monetization of utility assets to enable reallocation of public funds to the academic and research missions of OU. Corix Utilities (Oklahoma) Inc. was selected by OU to purchase a 50-year concession to invest in and design, build, operate and maintain the steam, electrical, natural gas, chilled water, potable water and waste water systems. The initial acquisition price was $118 million and the total 50-year capital investment is estimated at over $600 million. The concession agreement is structured to mirror regulated utilities in Oklahoma and uses cost-of-service-based annual rates.

Governance

The concession agreement allows OU to continue to own all utility infrastructure assets while Corix Utilities is responsible for day-to-day operations and maintenance and the funding of all future utility renewal and capital improvements. As part of the transition, Corix retained the incumbent employees from OU. Fuel, electricity and water procurement continues to be done by OU.

Corix prepares a cost-of-service study in preparation for rate setting every year in coordination with OU procurement and finance staff. A university-appointed independent “regulator” with an industry and legal background reviews the annual cost-of-service study and approves the pass-thru rate for the utility services for OU. The Board of Regents and the university facilities and capital planning and projects staff work in partnership with Corix to plan future master planning and upgrades to utility systems.

STRATEGIES FOR SUCCESS

RISK

- Update aging infrastructure unable to reliably serve campus peaks and future growth
- Avoid increased debt leading to lower bond rating for campus
- Explore third-party capital for infrastructure renewal and modernization

INFORMATION

- Developed campus master plan with new, efficient CHP and chiller capacity
- Collected information on cost of third-party operations and service management
- Concessionaires implement best practices in operations and maintenance

MONEY

- Concession provides steady long-term return on investment for Corix
- Cost-of-service study ensures fair rate-setting
- Concession agreement serves the university’s capital needs for infrastructure

PEOPLE

- Board of Regents and utility administrators are very engaged
- Corix retained OU staff with institutional knowledge
- Independent regulator provides review of cost-of-service study to set rates
- Corix is able to build on positive affiliation with OU

JOURNEY

University central plant started producing steam and electricity in 1948	Until 2006, University funded system expansion and added cooling to keep up with campus growth	Diminished availability of funds led OU to award private concession to operate and maintain systems and address renewal of its aging infrastructure

LESSONS LEARNED

- US public research universities had the foresight in the past to invest in reliable and efficient campus energy infrastructure
- Campus growth and energy demands require ongoing capital infusion to expand the energy infrastructure
- Aging systems need modernization and funds to maintain and operate
- Funds in academic institutions are increasingly less available for non-academic purposes
- A private concession to operate and maintain the systems provides relief to scarce public funds and leverages expertise and best practices from the private sector

Case 7: Public-Private Joint Venture

Rotterdam District Heating, Rotterdam, Netherlands

Leveraging extensive waste heat resources

Rotterdam as seen from the Euromast tower. Photo by Mlefter.

SYSTEM AT A GLANCE

Capacity:	**DH: 1.4 million MWh (5,100 TJ)**
Network length:	**26 km**
Buildings served:	**150,000 residential dwellings**
Equipment:	**waste heat recovery, hot water loops, hot water storage tank**
Fuel:	**waste heat**
Use of thermal energy:	**space heating**

SYSTEM DESCRIPTION

Rotterdam's district heating system, Warmtebedrijf Rotterdam, repurposes a substantial amount of waste heat, primarily from industrial activities on the harbor and the local waste incinerator. Other heat sources include a local sewage plant and data center (Warmtebedrijf Rotterdam, 2015). The incinerator, AVR, is the largest waste-to-power plant in Europe, supplying electricity and steam to local users (AVR, 2016b). The fuel sources include both household and industrial waste streams from as far away as Italy and Ireland, which ship waste to the AVR via barge (AVR, 2016a). A separate biomass generator located at AVR utilizes local waste wood.

Warmtebedrijf Rotterdam, primarily owned by the municipality of Rotterdam, is focused on creating a waste heat chain between the port and the residential part of Rotterdam. A 26 km pipe network called the New Heatway and two heat distribution companies – Eneco for the north part of town and Nuon for the south part – enable sustainable use of industrial waste heat to warm up Rotterdam households. A public-private initiative, the New Heatway's initiators and shareholders include the Province of South Holland, the Municipality of Rotterdam, Woonbron housing corporation and E.On, the Netherlands' largest energy provider. Design, development and maintenance of the New Heatway is the responsibility of Visser & Smit Hanab, a private company.

A recently developed 'heat hub' includes a 5,000 cu m hot water storage tank that can supply the system for one to three days in cases of loss of supply (Warmtebedrijf Rotterdam, 2015). The tank is charged when there is excess supply on the system and discharged when there is high demand (Warmtebedrijf Rotterdam, 2015). Supply temperatures for the whole system are 98°-120° C, while return temperatures are 50°-70° C (Warmtebedrijf Rotterdam, 2015).

DRIVERS AND OBJECTIVES

Rotterdam's district heating system has its roots in the rebuilding after the devastation of World War II (Keeton, 2014). Since then, the city has continued to identify DH opportunities and has effectively leveraged the waste heat of the active port area (Keeton, 2014). The DH opportunities presented by these waste heat resources were identified in the Rotterdam Climate Initiative, which had direct involvement by the Port of Rotterdam, a major source of those waste heat resources. When efforts to structure a new DH system with substantial private sector investment fell through, the city had to restructure its project to address the economic realities presented by the Great Recession.

The investment in the New Heatway and other recent system upgrades was driven largely by interests in reducing carbon emissions, improving air quality and leveraging the cost-effective heat resources available locally (Keeton, 2014; UNEP, 2015). The system has also helped improve the energy efficiency of Rotterdam's industrial sector, offering economic benefits to the city and region (Warmtebedrijf Rotterdam, 2015). The investment in Eneco's 16.8 km Pipeline North, which comprises a portion of the New Heatway by connecting the AVR incinerator to the Eneco distribution system, was driven in large part by the need to replace the supply of heat that would be lost when a nearby CHP plant completed its planned shut-down (Port of Rotterdam, 2013).

To meet an increased demand for thermal products, the AVR incinerator is working to increase its thermal output and decrease its electric output. Hot water will supply the DH system, while a separate steam supply will serve industrial facilities with high-temperature process steam (AVR, 2016a).

FINANCING AND GOVERNANCE

Financing

Warmtebedrijf Rotterdam was founded in 2010 as a joint venture between the Municipality of Rotterdam and E.ON Benelux. The city of Rotterdam invested €38 million in Warmtebedrijf Rotterdam. The city also underwrote a €149.5 million bank loan and sought the involvement and investment of the private utility company E.On. The city benefited significantly from a €27 million grant from the national government of the Netherlands that was meant to ascribe monetary value to the social benefits of the CO_2 and NOx reductions (UNEP, 2015).

The investment in the new district heating company was structured as an equity investment by the city, which gave Warmtebedrijf Rotterdam the confidence to make all the investments necessary to complete the entire connection and affirm that it was a public service utility.

Warmtebedrijf Rotterdam has two components:

- Warmtebedrijf Exploitatie N.V., which is focused primarily on customer-facing activities, such as managing contracts, business development, and final dispatch of heat and electricity. The main partners of Warmtebedrijf Exploitatie N.V. are the municipality of Rotterdam and E.ON, Benelux.
- Warmtebedrijf Infra NV, which takes on the debt for major infrastructure projects (Warmtebedrijf Rotterdam, 2015). The main partners of Warmtebedrijf Exploitatie N.V. are the municipality of Rotterdam and E.ON, Benelux.

These two components of Warmtebedrijf Rotterdam operate under a 30-year user agreement, which includes payment from Warmtebedrijf Exploitatie NV to Warmtebedrijf Infra NV for use of its transmission pipes. Warmtebedrijf Infra NV then uses those payments to help cover its investment and maintenance costs.

Governance

The city used its authority to help secure the necessary demand to make the systems economically viable. As part of their concession arrangements, Eneco and Nuon must purchase wholesale heat from Warmtebedrijf Rotterdam. The city requires connection of new buildings in targeted zones that coincide with the established concession areas served by Eneco and Nuon. Thus, the two distribution companies have been able to invest in additional network upgrades because of their exclusive concessions and the reliable heat supply of Warmtebedrijf Rotterdam. Additionally, Eneco's and Nuon's rates and profits are heavily regulated, and rates to customers must be lower than what the business-as-usual alternative would be (UNEP, 2015). Warmtebedrijf Rotterdam-supplied heat is distributed to end users via the heat networks of Eneco and Nuon, which have both been granted exclusive concessions by Warmtebedrijf Rotterdam to serve two different areas of the city.

The city also worked directly with potential large consumers, such as housing developments and building developers, to obtain their commitment to connection in already developed areas (UNEP, 2015).

STRATEGIES FOR SUCCESS

RISK

- City recognized hesitation to invest during recession and made significant equity investment to reduce risk for other parties
- Flexible business model has enabled growth and use of industrial waste
- Required connection ensures distribution companies can expect investments to be paid for over time

INFORMATION

- Regular outreach to existing and future consumers to understand their specific heat needs
- Well-established goal of 50% carbon emission reductions by 2025

MONEY

- Major equity stake provided by city when economic conditions required it
- Significant investment in network upgrades made by two companies that have concessions

PEOPLE

- Members of Rotterdam Climate Initiative instrumental in sustainability objectives
- Port of Rotterdam significantly involved in plans and business structure, including partial ownership of Warmtebedrijf Rotterdam

JOURNEY

City recognized initial plan to take advantage of waste heat resources was not viable; had to reconsider role of local government in system development

→

City took lead in establishing new organization with business model conducive to making needed near-term investments to reduce risk

→

City leadership and early investment stimulated new investment by private sector, aided by de-risking activities such as requiring connection to network

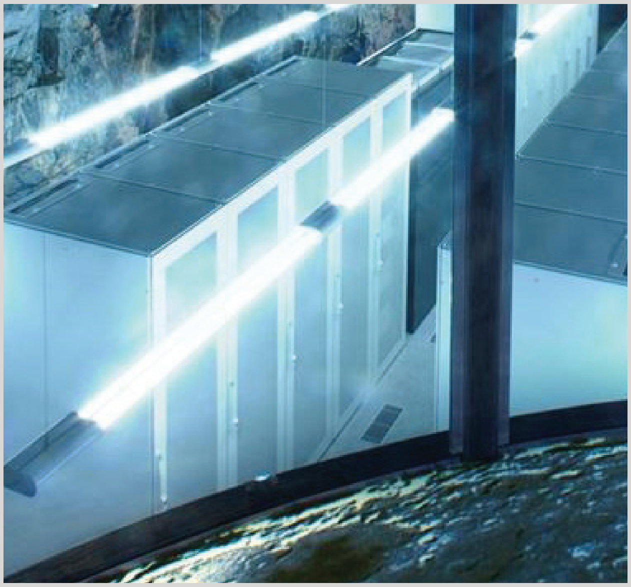
LESSONS LEARNED

- Multi-partner business models can be complex
- Be willing to completely reconsider plans when major changes have affected the economic or political context
- Business and environmental needs can be simultaneously addressed with creative solutions, but only with effective communication and cooperation among all major stakeholders

Case 8: Public-Private Joint Venture & "Prosumer"

Fortum Värme & Bahnhof Data Center, Stockholm, Sweden

Open district heating: embracing the consumer as producer



Pionen Data Center. Photo by Fortum.

SYSTEM AT A GLANCE

Capacity:	**DH: 3,891 MW; DC: 350 MW**
Network length	
Fortum Värme:	**DH: 2,400 km; DC: 294 km**
Customers served:	**DHC: 9,500**
Equipment:	**heat pumps, fans (at Pionen)**
Energy sources:	**natural gas, seawater 'free cooling'**
Use of thermal energy:	**space heating and cooling**

SYSTEM DESCRIPTION

Fortum Värme AB is a joint venture district heating and cooling company formed by the Finnish energy company Fortum and the city of Stockholm in the early 1990s. It is the leading supplier of district energy in the Stockholm area, with 10,000 district heating and cooling industrial and household customers. In Stockholm, district cooling is mainly based on using 'free cooling' from the Baltic Sea. Frigid water at 6° C (43° F), drawn from 100 ft below the surface of the sea, absorbs the heat from malls, office buildings and data centers. Today, Stockholm has over 2,400 km of heating pipe and 294 km of chilled-water pipe (Fortum, 2013).

In 2012, Fortum Värme developed a new business model called Open District Heating™, with the city of Stockholm, Bahnhof, Coop, ICA, Stiftelsen Stora Sköndal and Hemköp. This innovative solution turns data center waste heat energy into a DH energy source in Sweden and provides an opportunity for data center cooling customers to create a revenue source by selling heat that is a byproduct of the cooling. Data centers have minimal heating needs and can profit from surplus heat sales. This model is also referred to as a "prosumer" model. A growing number of data centers are redirecting the heat from their hot aisles to nearby homes, offices, greenhouses and even swimming pools. The ability to re-use excess heat from servers is being built into new data centers, helping to improve the energy efficiency profile of these facilities. Having a large DH network makes Stockholm an ideal location for data centers aiming to be net-zero.

An example of the "prosumer" model is the Pionen data center owned and operated by Internet company Bahnhof. Located in a nuclear bomb shelter built 30 m underground in the side of a mountain, it houses over 8,000 servers. The data center cooling plant includes two heat pumps connected in series, with a total cooling output of 694 kW and a heat output of 975 kW. During normal operation the plant supplies around 600 kW of excess heat to the DH system at a delivery temperature of 68° C. The heat pump design enables them to be directly connected to the DH network, whose local pumping capacity can absorb the additional pressure drop (IEA Insight Series, 2016). The heat generated by the servers is harnessed to provide heating to hundreds of apartments because Pionen is located in one of Sweden's most densely populated areas, in Södermalm in Stockholm.

DRIVERS AND OBJECTIVES

- Heat recovery from data centers is an important part of Fortum Värme's work toward reaching 100% renewable or recovered fuels for making district heating in Stockholm
- Increase usage of local biofuels and waste (Fortum, 2015)
- Reuse data center energy as heating source (Carrier, 2014)
- Contribute to green building design for data center (Carrier, 2014)
- Eliminate the use of existing cooling towers, thus avoiding the occasional production of 'fog' at street level (Carrier, 2014)
- Achieve a power usage effectiveness (PUE) score for the data center below 1.0 by accounting for the hot water produced from the waste heat in the PUE calculation (Carrier, 2014)
- Reduce CO_2 emissions (Carrier, 2014). January 2016 was cold, with temperatures down to -20° C. Fortum Heat manufacturing plants in the Stockholm area were all in use. By recycling more than 1,000 MWh of waste heat, open DH helped reduce oil use by about 195 tons by avoiding peak production (Fortum, 2016)

FINANCING AND GOVERNANCE

Financing

Bahnhof has invested a total of $522,000 (Swedish Krona [SEK] 3.4 million) in the new Pionen cooling plant, including heat pumps, pipe installation, hot tapping, electrical work, control equipment, construction and insulation. Payback times are estimated to be in the range of three to five years. Fortum Värme has invested $200,000 (SEK 1.3 million) in the new supply pipeline from Bahnhof's plant to the DH network (IEA Insight Series, 2016).

Fortum Värme borrowing is done through public loan programs as well as long-term bilateral loans from the European Investment Bank and the Nordic Investment Bank. In addition to medium-term notes and short-term commercial paper, it also has access to an open-ended long-term loan commitment which serves as a revolving credit line (Fortum, 2015).

The green bond concept was developed in 2007-2008 by SEB, a Swedish financial group for corporate customers, institutions and private individuals, and the World Bank as a response to increased investor demand for engagement in climate-related opportunities. It is an investment vehicle that integrates the fiduciary element of fixed income products with climate mitigation and adaptation awareness, giving mainstream investors access to climate-related investment opportunities.

In May 2015, Fortum Värme issued its first 2,500 million SEK green bond in a dual tranche with six- and seven-year maturities. This funding aligns with the goal of moving to standalone funding after 2016 (Climate Bonds, 2015).

All of the 2,500 million SEK proceeds have been utilized, with 2,254 million SEK allocated to new projects and 246 million SEK to refinancing of older projects meeting the following criteria of the green bond framework. Some examples include:

- Investments in distribution systems that enable change in operations, or help end users connect to DH, thereby reducing local fossil fuel use
- District cooling (new production or connecting customer to grid) helps achieve a higher coefficient of performance (COP)
- New capacity in WtE solutions or change of energy source in existing production in order to reduce primary energy usage in society (Climate Bonds, 2015)

Governance

Fortum Värme has a strong link to the city of Stockholm. The joint venture business entity consists of Fortum Corp., owning 90.1% of the shares and 50.1% of the votes; and the city of Stockholm owning 9.9% of the shares and 49.9% of the votes; plus preference shares which gives it access to 50% of the company's profits and also has subscription rights that, if exercised, would bring the city of Stockholm's ownership to 50%.

In summer 2014, Stockholms Stadshus AB acquired the city's share in Fortum Värme Holding. Stockholms Stadshus AB is owned by the city of Stockholm and serves as a unifying function for most of the city's limited liability companies. Stockholm City Council has delegated the governance, planning and operational follow-up to the board of directors of Stockholms Stadshus AB to ensure that Fortum Värme implements the City Council's owner directives and achieves set targets, as well as ensuring the optimal utilization of financial resources (Stadhus-AB Stockholm, 2014).

In January 2016, under the terms of a renewed shareholder agreement, the ownership became 50/50. Owners have also agreed that Fortum Värme should have standalone financing without support from the owners. Therefore, a number of bonds have been issued in the past year. All financial transactions are carried out under defined risk mandates within limits established by the board (Fortum, 2014).

STRATEGIES FOR SUCCESS

RISK

- Meet Sweden's renewable energy targets and EU 2020 environmental objective
- Reduce economic impact of Swedish carbon tax
- Manage limited public financial resources

INFORMATION

- Aim to meet Swedish Integrated Climate and Energy Policy objectives by 2020 (IEA Insight Series, 2016)
- Eliminate the use of the existing cooling towers and thus avoid the occasional production of 'fog' at street level
- Utilize 'free cooling' from the Baltic Sea

MONEY

- City of Stockholm has 50% ownership
- Tax-exempt Green Bonds Framework support for investments in distribution systems that enable connecting end users with DH, thereby reducing local fossil use (Fortum Green Bonds, 2015)
- European Investment Bank, provided medium-term note and revolving credit facility
- Sweden instituted a CO_2 tax in 1991 (World Bank, 2015). Its effect on fossil fuel consumption has been especially noteworthy in terms of DH – which faces the full CO_2 tax – where the use of biomass input has increased from 25% in 1990 to nearly 70% in 2012

PEOPLE

- Stockholm City Council has delegated the governance, planning and operational follow-up to the Board of Directors of Stockholm's Stadshus AB
- Fortum has the ability to leverage best practices and has needed skills and capabilities

JOURNEY

Developed joint venture company to leverage 'free cooling' from the Baltic Sea and meet carbon objectives

→ City of Stockholm reduced its financial role and encouraged greater private financing

→ Fortum developed Open District Heating™, an innovative "prosumer" business model to engage customers and reuse waste heat

LESSONS LEARNED

- Supportive national energy policy can benefit the development of strategies like 'free cooling' from the Baltic Sea
- Maintaining a longstanding relationship with the city of Stockholm helps leverage public funds and reduce initial capital risk
- Working with potential customers helps build innovative prosumer business models, simultaneously meeting economic and environmental objectives

Case 9: Public-Private Special Purpose Vehicle

Sangam District Heating and Cooling, Sangam, South Korea

Miracle on the Han River: raising a city with district heating

Sangam Integrated District Heating Plant. Photo by Taeyoon Yoon.

SYSTEM AT A GLANCE

Capacity:	**DH: 278 MWh (240 Gcal/h); DC: 180 MWh (160 Gcal/h); CHP: 4 MW**
Buildings served:	**163**
Equipment:	**LFG and SRF boilers, LNG peak load boiler, absorption chillers**
Fuel:	**SRF, LFG, LNG**
Use of thermal energy:	**space heating and cooling**

SYSTEM DESCRIPTION

Located to the west of central Seoul, the Sangam-dong neighborhood spans the northern banks of the Han River. It is home to the iconic Daegu Stadium, a World Cup host venue. Sangam is also known for Digital Media City, a high-tech city centered on Digital Media Street for broadcasting, movies, games, music, e-learning and related industries.

The Sangam area was originally a massive landfill where Seoul had dumped its municipal household and industrial solid waste. After closing that landfill in the early 1990s, Seoul installed gas extracting pipes and incineration facilities to recover 240,000 cu m of landfill gas (LFG) per year.

Based on a long-term contract with Seoul, the Korea District Heating Corp. (KDHC) built an integrated energy supply facility to add an incinerator with 34 Gcal/h capacity to process 200 tons of municipal solid waste per day into solid recovered fuel (SRF). LFG from the landfill and SRF from the incinerator fire the baseload boilers while peak loads are served via liquid natural gas (LNG) peak load boilers. In addition, the Sangam system supplements its heating supply via pipelines connected to the nearby KDHC CHP facility. Cooling is provided by absorption chillers.

Sangam is Korea's first district-type community energy system (CES) to be constructed by KDHC in the Sangam housing development zone and the first to use LFG for DH in Korea. The CES business generates heat from small-scale heating resources and supplies electricity to certain clusters of buildings (KDHC, 2009). It also supplies over 150 Gcal/h of cooling to 35 customers in Sangam using a combination of absorption chillers, turbo refrigerators and ice storage systems (KDHC Tzu-LangTan, 2016).

Nationally, KDHC supplies district energy to over 2,000 commercial buildings and 1.3 million households in its franchise area, representing a 55-60% national market share. The backbone of its distribution system is the Seoul Metropolitan District heating pipeline network consisting of 3,830 km of supply and return pipes. The district heating division provides cogeneration plants and massive-scale heat generation to supply apartments, businesses and commercial buildings. The district cooling division uses surplus heat from the cogeneration plants and alternative electric energy resources to supply hot or chilled water. The community energy system division generates heat from small-scale heating resources and supplies electricity to groups of buildings such as in Sangam.

The company also sells electricity to Korea Electric Power Corp. through the Korea Power Exchange.

DRIVERS AND OBJECTIVES

The Integrated Energy Support Act of 1991, amended in 2010 and 2014 (MOTIE, Ministry of Trade, Industry & Energy, 2014), which called for the development of a master plan for integrated energy (heat or heat and electricity) supply, helped drive district heating. Developments with at least 5,000 households, or larger than 600,000 sq m, would be designated as integrated energy supply zones, with the government competitively selecting a DH supply company for the zone.

The South Korean Renewable Portfolio Standard (RPS), introduced in 2012 (KEMCO,2012) by the Ministry of Knowledge Economy (MKE), stipulated that KDHC obtain a percentage of its energy from renewable sources, initially 2% in 2012 and rising to 10% by 2022.

In Korea, where urban land is scarce, the RPS was the key driver of WtE in Sangam as the volume of non-recyclable waste was reduced by 95-96% through combustion to generate SRF for use in boilers. WtE and LFG producers involved in the RPS receive renewable energy certificates (RECs).

In addition, the Sangam development and KDHC helped meet a key objective of an eco-friendly ‘Green Seoul’ by using large quantities of LFG from the landfill (thus reducing the pressure on landfill capacity) and reducing 62,000 tons of GHG emissions annually along with avoiding the risk of gas spills. Seoul transformed the landfill area into an eco-friendly residential area by building parks and modern WtE facilities. The anxiety of residents about the presence of LFG, possible spills and poor air quality were mitigated by the benefits the system provides. Because the cost of operating a SRF plant is less than the cost of incinerating trash, and since the waste is treated utilizing environmentally friendly processes, there are far fewer concerns about NIMBY (not in my backyard) issues from local residents.

FINANCING AND GOVERNANCE

Financing

The long-term contract with the Seoul Metropolitan Government enabled KDHC to utilize waste fuels and operate the WtE facilities. Seoul derives revenues of $5.5 million annually from the sale of waste fuels to KDHC. The government invested $138 million in the LFG project, used mainly for pipelines to extract the LFG gas and building facilities to dispose of sewage sludge and leachate. KDHC invested around $150 million in the pipelines to connect the nearby CHP plant to secure heat supply to the Sangam area and extend the Seoul metropolitan district heating network.

KDHC manages its projects via debt and equity financing. In January 2010 KDHC raised $125 million by listing 25% of its stock to finance the building of four new CHP facilities ranging from 99 MW to 515 MW installed capacity and to extend district heating services into new areas in and around Seoul. By December 2015, KDHC had revenues of $1.8 billion.

Governance

KDHC was founded in 1985 as a public enterprise for the purpose of promoting energy conservation and improving living standards through the efficient use of district heating. The Korean government remains KDHC’s largest shareholder, owning a 34.6% stake, while state-owned Korea Electric Power Company (KEPCO) holds 19.6%. Other shareholders are government-owned Korea Energy Management Corp. (KEMCO), the Seoul metropolitan government, employees and the general public. Shareholders can make revisions to the company’s articles of incorporation, decide on the appointment of directors and approve the settlement of accounts at the general shareholders’ meeting.

STRATEGIES FOR SUCCESS

RISK

- The ability of the government to designate integrated energy supply zones reduces the risk for DH supply providers like KDHC that can count on a revenue base and potential growth
- KDHC can reduce its risk for additional investments in the DH infrastructure by leveraging connections to the Seoul metropolitan district heating network

INFORMATION

- The Integrated Energy Support Act provides valuable information on planned DH supply zones and helps with longer-term planning of DH companies
- The South Korean RPS enables the use of local resources to reduce waste

MONEY

- The role of large public sector shareholders in KDHC enhanced its ability to raise money in the private markets
- The government-funded extraction of LFG from the Sangam landfill created a unique opportunity for KDHC to help meet environmental and economic objectives
- Continued investment to extend the metropolitan network allows KDHC to optimize capital investment to serve new customers

PEOPLE

- The partnership among residents of Sangam, the Seoul metropolitan government and KDHC was critcal in avoiding NIMBY issues and using local resources to provide DH services

JOURNEY

Multiple public entities formed an enterprise (KDHC) for the purpose of saving energy and improving living standards by providing efficient district heating to 1.3 million homes →	Seoul government invested in LFG pipeline project to make the massive Sangam landfill available as a LFG resource for DH →	Seoul metropolitan district heating network continued to expand. Designating DH zones helped reduce risk for DH suppliers

LESSONS LEARNED

- The Integrated Energy Support Act provided valuable information on designated planned DH supply zones, de-risks customer connection uncertainties and helps with longer-term planning of DH companies
- The South Korean RPS enabled the use of local resources to reduce waste
- Leveraging LFG resource in Sangam helped meet environmental goals
- The long-term contract with the Seoul Metropolitan Government enabled KDHC to utilize waste fuels and operate the WtE facilities
- Use of CHP to meet heating and electricity needs was made possible by public sector energy efficiency and electricity supply partners KEPCO and KEMCO

Case 10: Private Utility

NRG Phoenix, Phoenix, USA

Leveraging ice storage for customer savings

Chase Field, home of the Arizona Diamondbacks and location of a chiller plant. Photo by NRG.

SYSTEM AT A GLANCE

Capacity:	**DC: 141 MW (40,000 tons)**
Network length:	**6.4 km (4 miles)**
Buildings served:	**34**
Equipment:	**17 chillers, two ice storage units, chilled water pipe**
Fuel:	**electricity**
Use of thermal energy:	**space cooling**

SYSTEM DESCRIPTION

The Arizona Diamondbacks, a Major League Baseball team, played 80 home games in the Chase Field stadium each year. Cooling for these popular events was provided initially by 8,000 tons of peak chiller capacity. During an energy audit performed in 1999, it was determined that while the ballpark was operating at peak efficiencies, the majority of its 8,000 tons of installed chiller capacity remained unused as capacity was only tapped for the Diamondbacks' 80 home games each year. During that same time period, Northwind Phoenix was completing a study to determine the feasibility of developing a district cooling system for downtown Phoenix. The Diamondbacks and Northwind could immediately see the benefits of building a district cooling plant that combined the under-utilized 8,000 tons of cooling capacity at Chase Field with a new ice-storage chilled-water facility to handle peak event loads.

The current system, owned by NRG Phoenix, produces and distributes chilled water to hotels, Chase Field, the Phoenix Convention Center, government buildings, biomedical research facilities and other customers. The system alleviates stress on the electric grid by using nighttime power to make ice in giant steel coils, which is stored and used for daytime cooling needs. Ice melts during the day and chilled water enters the district cooling system at 34° F (1° C) (Perfette, 2009). This approach can eliminate as much as 10 MW of electric demand from the grid, freeing up capacity for other needs and reducing the need to tap costlier, often dirtier, peak electric resources.

DRIVERS AND OBJECTIVES

- The system's initial objective was to serve the baseball stadium using the ice chillers already in place at that location. Eventually the system linked together additional chiller plants within the downtown Phoenix area (Lodge, 2007), building capacity in the system as customer demand grew (Berry, 2008).
- The city of Phoenix leverages the district system as a business development tool because its cooling costs are less than comparable individual building-scale cooling solutions.
- The primary driver of the NRG system has always been economics. As an example, the city of Phoenix, which has several buildings connected to cooling network, has saved millions of dollars by

avoiding considerable up-front capital costs and continued operation and maintenance costs of building-scale cooling solutions (O'Grady, 2010).

FINANCING AND GOVERNANCE

Financing

The Phoenix district cooling system has always operated as a nonregulated, private, for-profit company, able to make investments in response to market demand. Customers typically reduce their energy consumption by about 13% after connecting to the system (NRG, 2016a), so it is not surprising that NRG continues to enjoy increased demand for its cooling services today.

While the company initially considered Phoenix to be its sole operating area, it soon began building and operating CHP and chiller/heating plants well outside the downtown Phoenix core, including in Tucson and as far away as California (Lodge, 2007). In 2006 Northwind brought a new chiller plant online, located at the Phoenix Convention Center and offering a much-needed boost in the system's capacity. The company has followed a typical growth strategy by investing in new assets as opportunities are identified.

In 2010, APS Energy Services sold Northwind to NRG as part of a broader strategy to refocus its business holdings. NRG, on the other hand, was looking to expand its alternative energy business offerings in the southwest U.S. region (O'Grady, 2010).

Today the NRG system continues to see its demand grow, and the reliability of the cooling services it provides has been a driver for growing customer interest. Maricopa County, which surrounds the NRG Phoenix system, identified the reliability of the district cooling system as a reason they chose to connect the new county sheriff's office to the NRG system in 2014. The costs the county avoided by designing a building that did not need onsite chillers helped drive the decision to connect (NRG, 2016b).

Governance

The Phoenix district cooling system has always been a for-profit entity. It is not subject to energy regulations and so it does not need to satisfy an externally developed cost-benefit analysis when making decisions about new investments. The city does not offer any incentives to NRG, nor does it get involved in system planning or operations.

When the system is operating at full capacity during the day, about 10 MW of peak-time electric demand is mitigated, reducing congestion on the grid. However, these benefits are not currently monetized by NRG because there is no regulatory framework in which to value the benefits.

STRATEGIES FOR SUCCESS

RISK

- The company has systematically identified and connected to major anchor tenants, some of which have also functioned as hosts for major system components, such as Chase Field. In this way the system has been built around major guaranteed loads, reducing risk for all stakeholders
- NRG Phoenix has expanded beyond Phoenix, identifying complementary business and technical opportunities that can leverage the company's technical and managerial strengths

INFORMATION

- NRG regularly reaches out to area developers to help them understand the costs and benefits of connection, with a particular emphasis on the high system reliability

MONEY

- The system began operation as a subsidiary of the larger power utility, using internal capital to make investments in new business arms

PEOPLE

- NRG maintains a strong relationship with the developer community, and the city continues to help market the system as a strategic business asset for companies wishing to expand or relocate in the Phoenix area

JOURNEY

Existing ice chillers served one customer (the baseball stadium); owners were reconsidering how to maximize existing assets

Private owner made investments in existing assets to enable increased capacity; system grew organically, adding capacity as demand grew

System sold when original parent company decided to refocus its business; acquired by company with history of successful district energy operation

LESSONS LEARNED

- Grow in a nodal fashion and work on connecting nodes later
- Maintain close ties with real estate sector to continually understand their energy needs and better predict market demand for energy services
- Identify additional benefits to neighborhood and region, e.g., peak electric demand reduction, and incorporate into business development and stakeholder engagement

Case 11: Private Utility

Enwave Toronto, Toronto, Canada

Urban waters keeping Toronto cool

Intake pipes being deployed in Lake Ontario. Photo by Enwave Toronto.

SYSTEM AT A GLANCE

Capacity:	**DC: 11 MW (75,000 tons)**
Network length:	**10.6 km**
Buildings served:	**140**
Equipment:	**chilled-water loop, heat exchangers**
Fuel:	**deep lake water, electricity, natural gas for steam-driven chillers**
Use of thermal energy:	**space cooling**

SYSTEM DESCRIPTION

In Toronto's downtown core, 40 million sq ft spread across 140 buildings are cooled by a closed-loop district cooling system that uses the cold water lying at the bottom of Lake Ontario as its cooling source. In the winter, as the air cools the lake surface, the denser and cooler water sinks to the bottom, where it stays close to 4° C all year, even as the top of the lake warms a bit during the summer. Underwater pipes in this deep lake water cooling system – the world's largest – bring cool water from the lake to a series of heat exchangers which connect to a separate loop that cools the connected buildings. By using this naturally occurring resource, the system avoids 90%, or 61 MW, of electrical demand that would otherwise be required to cool each building separately.

DRIVERS AND OBJECTIVES

Toronto has been served by a DE system since the 1970s, when the city's DH services were originally provided by a city-owned non-profit entity, the Toronto District Heating Corporation (TDHC). TDHC was initially developed to serve the needs of government and institutional buildings but faced challenges when trying to raise new capital to finance necessary investments to meet the growing needs of the city (Enwave Energy Corp., 2016). These challenges included a requirement that the city approve all major business deals, which stifled innovation with bureaucratic processes when trying to take advantage of new business opportunities. The company and its leadership identified an important objective as developing a new business structure that would allow it to have the freedom and flexibility to more adroitly respond to market opportunities. A new company, Enwave, was born.

Enwave's new business structure allowed it to take full advantage of a new resource opportunity that emerged as the city was assessing its drinking water needs. As the city considered the role of Lake Ontario as its future drinking water supply, the idea that deep water from the lake could be used as a cooling resource for Toronto was gaining more traction. Though the idea of using lake water for cooling had initially been considered as far back as 1982, it was not until 1998 that an environmental assessment for the project was finalized, and it would not be until 2003 that the first pipes for the system were laid on the bed of Lake Ontario (Fotinos, 2007; Preservation Green Lab, 2010).

FINANCING AND GOVERNANCE

Financing

Enwave's previous iteration, TDHC, was chaired by Dennis Fotinos, who was also a city council member at the time. TDHC's initial investors and shareholders were the Province of Ontario, the University of Toronto, several hospitals and the city of Toronto. Fotinos and other leaders recognized that the company had to change its business structure and attract outside capital if it was to make the investments necessary to bring the deep lake water cooling concept to fruition. Natural Resources Canada, a department of the Canadian government, financed much of the engineering assessments to better understand the cooling potential of lake water, which helped establish that the concept was viable (Fotinos, 2007). Around that same time, the head of the Ontario Municipal Employees Retirement Savings System (OMERS) pension fund noted in a public speech that the fund was having difficulty identifying infrastructure projects that were ripe for investment (Spears, 2013). OMERS learned of the opportunity for investing in a restructured TDHC at exactly the time it was looking for such an investment.

TDHC was restructured as the private corporation Enwave in 2000, with the city of Toronto owning a 43% stake in the company and OMERS owning the remaining 57%. The new business structure gave the company the flexibility to make the major capital investments necessary to fully realize the deep lake water cooling objective. The cooling project was officially launched in 2004, financed in part by public and private bonds that were secured via customer letters of intent (Preservation Green Lab, 2010).

In 2011, facing a potential citywide budget shortfall, the Toronto City Council decided to put Enwave up for sale. The city and the pension fund decided to sell 100% of their shares and sought external assistance from Scotiabank to help facilitate the sale. In 2012 the asset management firm Brookfield Asset Management Inc. purchased Enwave for about $480 million CAD, with proceeds divided among the two shareholders based on their percentage of investment. The city of Toronto collected about $168 million CAD in the sale, which represented about $100 million CAD more than its initial investment in 2000, a sale price that was on the high end of what the city had expected to receive (Grant, 2012). Additionally, throughout the city's ownership, it collected about $1 million CAD annually from Enwave in shareholder dividends and fees for the use of its water infrastructure (C40 Cities, 2011).

Governance

Throughout its history, Enwave has worked in close partnership with the city of Toronto. As TDHC, the company was overseen entirely by the city and other shareholders, all of whom were focused on the public good: the university, the province and area hospitals (Enwave Energy Corp., 2016). When it became Enwave, the company could take a more aggressive approach to investments but was still subject to public oversight. The city of Toronto and OMERS appointed Enwave's board of directors (Fotinos, 2007). However, Enwave did not have to seek full city approval for its investments; rather, only the appointed directors would weigh in on such matters. The Toronto City Council had to approve the sale of Enwave to Brookfield and consider whether the terms were beneficial to the city. With the purchase by Brookfield, however, the city no longer has direct control over the operations and investments of the company.

STRATEGIES FOR SUCCESS

RISK

- Recognized limitations of existing business structure
- Needed to make investments in potable water infrastructure
- Developed business structure that always included city representation
- Identified investment partners that could take larger risks but still keep interests of city in mind

INFORMATION

- Conducted technical assessments of lake water for district cooling
- Municipal familiarity with business model allowed city to understand merits and operation of system

MONEY

- Government funding helped initial studies and assessments
- New business structure provided a match for the investment needs of pension fund
- Business/tariff structure provided stability and viability for private investment

PEOPLE

- Toronto City Council had representation of district energy company leadership
- Municipal employee pension fund valued the stability of long-term infrastructure investments
- City of Toronto assessed changes in business structure to benefit its citizens and investors

JOURNEY

Public not-for-profit initially developed to provide low-cost heating to residents; limitations of business model hindered expansion → Developed special-purpose business model to allow greater flexibility and financial risk-taking while retaining public oversight → Completed sale of system to private company, yielding significant revenue for the city

LESSONS LEARNED

- Ensure national and provincial/state regulations allow for development of ideal business model
- Identify mutually beneficial infrastructure projects across city departments which can greatly reduce costs and resistance by enlarging the group of interested stakeholders
- Work with potential customers early so that when letters of intent are required, they already fully understand the concept

Case 12: Private Utility

Wick District Heating, Wick, UK

A journey through ownerships

Aerial view of Wick-Caithness County town. Photo by Government of Scotland.

SYSTEM AT A GLANCE

Capacity:	**DH: 3.5 MW**
Network length:	**10 km (6.2 miles)**
Buildings served:	**270+, public buildings, whiskey distillery**
Equipment:	**biomass boilers**
Fuel:	**biomass**
Use of thermal energy:	**space heating, DHW, industrial process steam; electricity (in future)**

SYSTEM DESCRIPTION

Wick is a Scottish town at the northernmost tip of mainland Britain. It is not connected to the national natural gas grid. Residents rely on costly oil and LPG from a public network to heat their homes and buildings. In 2003 the local municipality, Highland Council, received funding support from the Scottish government to undertake heat mapping in the town and assess wood fuel availability in the local region. This identified clusters of heat demand and plentiful wood fuel resources. Another government-funded study in 2004 detailed the design of a heat network connecting a whiskey distillery, adjacent 270 social housing units, public buildings and the regional hospital. Caithness Heat & Power was established as a not-for-profit company between Inverhouse Distillery, Highland Council and Pultneytown Peoples' Project, a local charity. This secured a £1.54 million grant for Phase 1 from the then-government's Community Energy Program with the balance of £1.6 million coming from the council's fuel poverty program. Waste heat was supplied by the distillery, augmented by an oil-fired boiler.

In 2005 the Community Energy Program provided a £1.38 million grant to add a CHP unit using an innovative wood fuel gasifier. This would increase revenues into the project by selling electricity to the distillery via a private wire connection as well as access revenue support available for renewably generated power. However, the gasifier proved to be problematic and the project was forced to burn higher-cost diesel fuel to meet its contractual obligation to supply electricity to the distillery. Furthermore, burning fossil fuel did not attract the revenue support for renewably generated electricity. Consequently, the project was losing money. In 2008 the council was forced to take over the company and financially support the project.

The technical difficulties with the gasifier could not be resolved. Initially the council tendered for an external party to take over the company, but no viable offer was forthcoming. The council therefore decided to close the company and revert to pre-existing electric heating arrangements or the LPG network. The assets were auctioned to recoup the council's £11.5 million investment.

Ignis Energy, a small private company that had shown interest in the company when it had been tendered, raised private equity funding from Ludgate Capital to purchase the assets including the distribution network, customer connections and boiler assets – but not the CHP unit. The project thus reduced its debt burden and avoided the technically problematic generator. Ignis Energy installed a wood-fired boiler to provide steam to the distillery, which created non-heating-season demand load while reducing its fuel costs. Residents were given the choice to connect to the public LPG network or remain connected to the heat network owned by Ignis. The majority chose to remain connected because of the more favorable charges. To secure its revenue stream, Ignis targeted residents with poor credit histories for obligatory pre-payment meters. Other residents were offered them as a choice. This approach turned out to be quite efficient, enabling revenues to be collected from approximately 75% of residents.

Ignis Energy re-focused on the development of Phase 2 to expand the project to a further 150 homes, several public buildings and the hospital. Once complete, it will form a 10 km network. When this additional demand is developed Ignis plans for the installation of a 2 MW wood-fueled CHP unit with a proven track record. The development of large industrial and institutional customers allows Ignis Energy to continue to deliver a low tariff for residential customers while maintaining the original goal of providing affordable heat.

In 2016, after some hesitation arising from concern over the financial sustainability of the business, the Caithness Regional Hospital agreed to connect to the network. At this point Ignis Energy sold the project to the Green Investment Bank and fund managers Equitex for £10 million, of which £4.8 million will be committed to the development of the project. Operation and maintenance will be contracted out to the existing project managers put in place by Ignis Energy with a separate contract with a different company to undertake further project development.

DRIVERS AND OBJECTIVES

- Address fuel poverty by providing affordable heating
- Enhance energy security by reducing reliance on oil and LPG
- Reduce GHG emissions

FINANCING AND GOVERNANCE

Financing

Caithness Heat & Power received £2.84 million grant funding from the Community Energy Program matched by £1.6 million from Highland Council. After the Council took over the company it invested an additional £10 million to maintain the project before deciding to close it and auction the assets.

Ludgate Capital invested £3 million in Ignis Energy to buy the assets (excluding the biomass CHP) and install a biomass boiler.

The Green Investment Bank and Equitex invested £10 million to purchase the project, extend the network to the hospital and install a 2 MW biomass CHP with proven track record.

Governance

Caithness Heat & Power was established by Highland Council as a not-for-profit partnership among the distillery, Pultneytown Peoples' Project and the council, with representatives from each sitting on the board. When the council took over the company it installed six elected councillors as directors. A private investor-owned company took over the assets and rescued the project before selling to an institutional investor that has contracted out the management and development functions. The project has moved through several business models, starting from a public-social, transitioning to a public and then to a private utility.

STRATEGIES FOR SUCCESS

RISK

- Use technologies with a proven track record
- Reduce bad debt risk with pre-pay meters for residential customers
- Reduce seasonal demand risk with industrial connection
- Hospital connection reduced demand risk, giving investors confidence
- Larger scale delivers greater revenues – but need to develop demand

INFORMATION

- Conducted heat and resource mapping study
- Undertook technical feasibility study
- Developers had proven track record for biomass CHP

- Grants and public subsidy helped during development stage
- Equity investor was willing to take development risk
- Insitutional investors are willing to take on de-risked projects
- Larger-scale CHP provides greater benefits but requires larger investment

- Stakeholders provided innovative and focused management
- Clear goals and objectives were maintained throughout project lifecycle

JOURNEY

Mission and vision underpinned by early load mapping and technical feasibility study → Initial vision retained. Project re-configured. Management replaced. Risk transferred to equity investor → De-risked project attracted institutional investors through transfer of ownership

LESSONS LEARNED

- A long-term approach is required to develop projects at scale
- Deploying proven technology makes a project feasibility robust
- Securing revenue streams attracts investors
- Experienced project developer can provide confidence to potential customers
- Equity investors are willing to accept risk and back a competent project developer
- Securing anchor customer de-risks project to satisfy institutional investor risk appetite

Annex XI Final Report
Governance Models and Strategic Decision-Making Processes for Deploying Thermal Grids

Appendix B: Tools

There are a variety of tools which are available to assist the decision makers and stakeholders engaged in the endeavor of moving district energy systems from concept to completion.

Using data and appropriate tools is very helpful in producing the information needed to align objectives, leverage policy incentives and evaluate options for moving forward.

This Appendix provides a partial list of useful tools including the Excel based tools IDEA has developed in conjunction with this report. They can be found at http://www.iea-dhc.org/the-research/annexes/2014-2017-annex-xi/annex-xi-project-04.html.

Tool 1: Stakeholder Identification and Contribution Tool *Source: IDEA*

IDEA has created an Excel-based tool to identify and categorize stakeholders by type of contribution. The tool provides a comprehensive list of stakeholders to start with. This list can be amended and changed to meet the needs of the specific project.

The tool further allows stakeholders to be organized by type of contribution along four dimensions: Risk, Information, Money and People. A positive contribution is identified by a Plus sign while a negative one is represented by a Minus sign.

Output
Mayor
Municipal agency energy staff
Economic development staff
Sustainability staff
Urban planners
Regulators
Project developer
Project staff
Architect/Engineers
Contractors
Suppliers and supply chain
District energy utilities
Customers – anchor
Customers – potential
Competition
Building facility managers
Building owners
Grant providers
Lenders
Investors
Rating agencies
National Labs, UNEP, NRCAN, IEA DHC CHP Collaborative
Trade associations (e.g., IDEA, DBDH, ADE, UKDEA, AGFW, Euroheat & Power)
Media and Press
Local labor unions
Student groups
Environmental NGO's
Academic institutions

The tool further allows stakeholders to be organized by type of contribution along four dimensions: Risk, Information, Money and People. A positive contribution is identified by a Plus sign while a negative one is represented by a Minus sign.

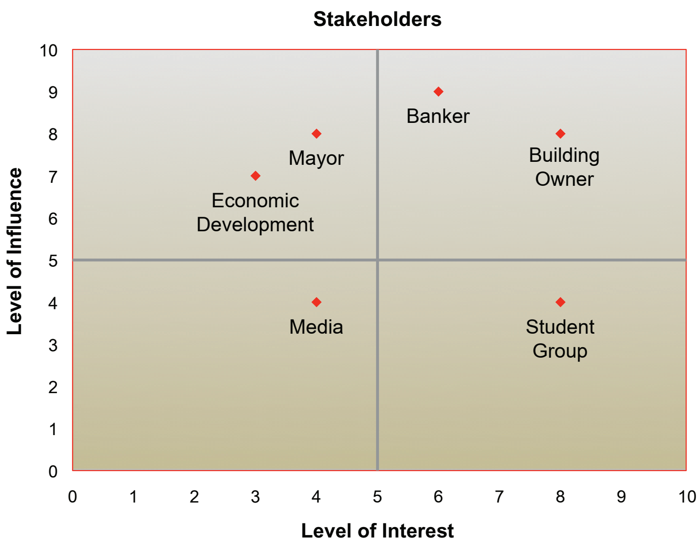
STAKEHOLDERS: HOW CAN THEY HELP?	MITIGATE RISK	SHARE INFORMATION	HELP WITH MONEY	PROVIDE PEOPLE
Municipal agency energy staff	+	+	+	+
Economic development staff	+	+	+	+
Sustainability staff		+		+
Urban planners	+	+		+
Regulators	+	+		
Project developer	+	+		+
Project staff	+	+	+	+
Architect/engineers				
Contractors	+	+		+
Suppliers and supply chain	+	+		
District energy utilities	+		+	
Customers – anchor	+			
Customers – potential	+			
Competition	-			
Building facility managers	-	+		
Building owners	+/-	+		
Grant providers	+		+	
Lenders	+		+	
Investors	+		+	
Rating agencies	+		+	
National Labs, UNEP, NRCAN, IEA DHC CHP Collaborative	+		+	
Experts & Trade associations (eg., IDEA, DBDH, UKDEA, AGFW, Euroheat & Power, ADE, Carbon Trust)		+		
Media and press		+		
Local labor unions		+		
Student groups		+		+
Environmental NGO's		+		
Academic institutions	+	+		+

Tool 2: Stakeholder Interest - Influence Tool

Source: IDEA

This Excel based tool may be used to map the Interest and Influence levels of key stakeholders and assist in targeting communication and information dissemination.

Output

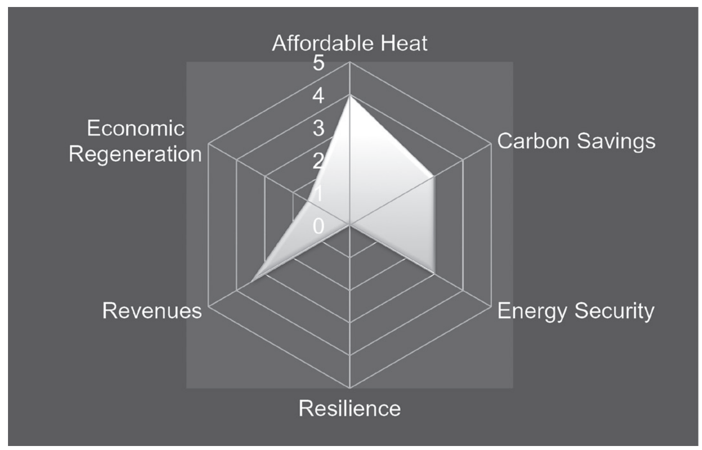


Tool 3: Interactive Objectives-Setting

Source: Building Research Environment (BRE)

A useful tool for setting objectives is a spider diagram, also known as an Excel radar chart. Participants are given a set of likely objectives and each participant is asked to ascribe a value to each one. These are the collated, aggregated and represented as a spider diagram. This is particularly helpful in determining the collective attitude of the group. An example of an objective-setting exercise to establish the key priorities for a district heating scheme is shown.

Output



Tool 4: Heat Network Stakeholder Engagement Tool (SET) *Source: Carbon Trust, UK*

An important factor in reducing project development risk in district energy is effective stakeholder management. Inadequate stakeholder engagement is one of the biggest contributors to project risk; until you can correctly understand stakeholder perspectives, you cannot be sure you have a viable project. This is coupled with project development times that can extend over several years, leading to staff changes and gaps in procurement exercises. This can result in the loss of stakeholder engagement history and loss of momentum. Systematically recording stakeholder interactions and information will ensure that stakeholder management strategies are resilient to change.

In response to this challenge, the Carbon Trust has developed an innovative Excel-based **Heat Network Stakeholder Engagement Tool (SET)** which can be used to inform an engagement strategy, capture, and report on engagement outcomes, using the Carbon Trust's five-step approach to stakeholder management.

The tool plans and tracks progress, captures and sorts stakeholder feedback and data into a logical format, and automatically generates reports to summarize the engagement across groups and individuals. It has been successfully tested and modified across a portfolio of 25+ district energy projects and can be tailored to reflect specific characteristics of any stakeholder mix. The model acts as a 'living' tool, evolving throughout the engagement program.

NOTE: Please contact the Carbon Trust for more information on accessing the stakeholder engagement tool at publicsector@carbontrust.com.

Tool 5: Plan4DE *Source: Sustainable Solutions Group, Vancouver, Canada*

Plan4DE (Plan for district energy) is an Excel-based modelling tool to assist in determining the viability of district energy in a certain district or neighborhood area, based on the existing or planned urban form within that district area. It is intended to be used as a "pre-pre-feasibility" tool during the development of community, secondary or neighborhood plans, to assist planners in understanding the relationship between built form, energy demand and the potential for district energy.

It has been developed to function as a tool to assist planners to consider the impacts of land use or development plans on the potential for district energy. Plan4DE enables swift calculation of total heat demand, district heat demand density and DE system costs for any identified area. This enables planners to quickly identify the implications of any built form for DE potential, and understand the impact of changing the built form (through land use changes or building densities) on that potential.

Plan4DE can be applied to evaluate the potential for district energy in a greenfield or brownfield development setting. Through the model interface, a user can enter the proposed building mix and district size, and see the resulting total heat demand, district heat density, and cost comparison with individual heating. By changing the input variables (representing a change in building mix), the associated results can be easily compared. This facilitates the ability to very quickly develop and evaluate different building mix scenarios (represented by different land use or development plans), essentially assisting planners to consider "ruling-in" the option of district energy rather than ruling it out.

In addition, when assessing future built environments, planners face a complex trade-off in that they need to contribute to and plan for decreased energy use at the building level (through higher performing buildings), while increasing energy density at the district level to increase the potential for district energy. Plan4DE can be used to explore this trade-off, providing useful insights for decision making.

Three versions of the model are provided (basic, intermediate and advanced) to accommodate a range of knowledge and technical user experience. The advanced version is fully unlocked, to allow customization.

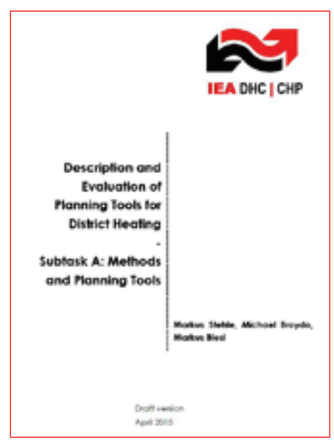
Tool 6: Exergy Pass *Source: Richtvert, Munster, Germany*

Exergy Pass is a visual evaluation tool representing the results of a technical analysis of supply and demand scenarios. In addition to the commonly used dimension "energy" it includes the dimension "energy quality." The product of both dimensions is exergy, a comprehensive and universal physical property that was first defined more than 60 years ago.

It allows a comprehensive visual evaluation of supply scenarios and industrial processes and the visual identification of resource savings potential as well as the resource efficiency of the considered system. Additionally, it provides information on greenhouse gas emissions and operating costs, which are caused by the considered energy system (building, municipality or industry).

Exergy pass is optimized to provide an easy-to-use means for a transparent and easily understandable presentation of differences in alternative demand and supply scenarios.

The tool is used exclusively by Richtvert, its cooperation partners and Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT.


IEA DHC | CHP

Description and Evaluation of Planning Tools for District Heating
-
Subtask A: Methods and Planning Tools

Markus Stehle, Michael Broydo, Markus Bresl

Draft version
April 2015

The IEA DHC CHP as part of Subtask A-Methods and Planning Tools has produced a draft report on the description and evaluation of planning tools for District heating in April 2015 authored by Markus Stehle, Michael Broydo and Markus Bresl.