COMMUNITY ENERGY:

PLANNING, DEVELOPMENT AND DELIVERY

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

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The International District Energy Association (IDEA) is a nonprofit trade association founded in 1909 to promote energy efficiency and environmental quality through the advancement of district heating, district cooling, and combined heat and power (CHP). IDEA works to foster the success of over 1500 association members who are district energy executives, managers, engineers, consultants, and equipment suppliers from 25 countries. Please visit www.districtenergy.org for more information.

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EXECUTIVE SUMMARY

District energy – what the future holds:
– more efficient use of resources;
– community-based economic engine;
– safe, secure, and reliable energy;
– affordable, high-quality thermal services;
– attractive local environments;
– livable towns and cities.

District energy is the local production and distribution of thermal energy. It is a highly efficient means of providing locally generated thermal energy for heating and cooling homes, commercial and institutional buildings, and industrial processes. District energy systems comprise of two main elements:

- A central energy plant containing equipment that produces thermal energy in the form of steam or hot water for heating, or chilled water for cooling. The central plant may also incorporate **combined heat and power (CHP)** units which produce electricity and useful thermal energy.
- A network of insulated pipes to distribute the thermal energy from the central plant to the buildings.

The steam, hot water, and/or chilled water that are distributed can provide a range of services to building owners including space heating, domestic hot water services, and cooling. The nature of the service required and other local conditions will determine the most appropriate medium (hot water or steam) to carry the thermal energy.

District energy is a proven means of meeting demand for these services. It is well established in most major U.S. cities and is widespread in countries across Europe and Asia. It delivers a range of social, sustainability, environmental, and economic benefits by providing reliable, efficient, affordable, and clean thermal energy from locally controlled and highly efficient central plants. In the U.S., most systems are fired by natural gas but due to scale, have the flexibility to utilize multiple fuel sources and to harness waste heat from industry as well as local renewable resources such as geothermal, large scale solar thermal, and biomass. Many technologies using these fuels cannot be used for individual buildings. However, a **district energy network** provides the means of combining the energy demands of many buildings to achieve the economies of scale that are necessary to make these fuels practicable.

Rising to the challenge

Municipal leaders across the country are facing growing economic, social, and sustainability challenges and are increasingly interested in local energy production as a means of addressing them. Community leaders responsible for framing strategic approaches to energy are looking to develop and champion local energy projects, but may feel they lack the knowledge and expertise to do so. Drawing on the experience of communities in the U.S. and abroad, this *Community Energy Development Guide* has been developed to help and guide them.

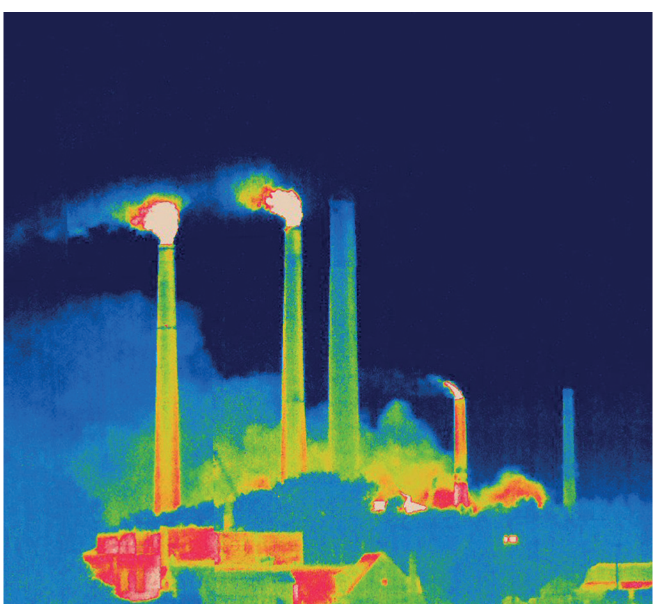


Figure 1: The 2011 Department of Energy Quadrennial Technology Review used this thermal image of a house in front of a coal-fired power plant to illustrate that the average coal plant only converts about one-third or 33% of energy to electricity; the rest is lost as heat.

Tyrone Turner/National Geographic Stock

PREFACE

District energy provides a wide range of benefits for communities. These can be broader than simply matters of energy generation, distribution, and supply.

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. 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.

In a number of states, tax incentives and other energy and environmental policies have opened up unprecedented opportunities to make money, replace cut budgets, and put assets to more productive use, while meeting wider social and environmental objectives. To take advantage of these benefits, many communities, municipalities, and other 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.

Assessing the potential value and impacts of local energy in order to become a project champion, sponsor, or developer requires a general understanding of the opportunities. A perceived lack of skills, money, or understanding of the project development process can seem daunting obstacles. Crucially, public project managers will need to adopt the commercial approach of a private developer. Land-use planning has a role to play in supporting **project developers (PDs)** in the early stages by mapping energy opportunities and making data available. This guide is intended to help project developers through the entire development process.

Global and local considerations

The world is in a period of growing energy insecurity, and municipal and business leaders are focusing attention on improving the energy resiliency of their towns and cities. Geopolitical pressures and the peaking of global oil reserves, coupled with political instability in parts of the world with a high proportion of available reserves, are driving energy prices higher and increasing the volatility of the global energy market. Environmental regulations are reducing the viability of coal for power generation and, while exploitation of **shale gas** reserves has softened natural gas prices recently, concerns over extraction techniques and the impact on clean water supplies may affect future supplies and prices. The March 2011 tsunami tragedy and nuclear plant meltdown in Fukushima, Japan, has slowed a nuclear resurgence and even led countries like Germany to reduce dependency on nuclear for electricity. Improving local resilience can help communities minimize the impact of disasters such as the Northeast blackout of 2003. Worries over escalating carbon emissions are adding urgency and uncertainty for policymakers seeking to mitigate the potential impacts of climate change. These issues highlight the need to develop energy infrastructure at a local level, which maximizes resource efficiency and exploits indigenous opportunities. Such steps enhance the energy security and resilience of local communities and shield them from the negative impacts of rising and volatile global energy markets.

Preparing for such instability also increases economic competitiveness. Cities and communities that take steps to improve their energy security and resilience are more attractive to businesses, which provide employment for residents who will, in turn, be attracted by a lower-cost, less polluting, and more secure energy supply. This economic vibrancy is enhanced through an economic multiplier effect, as cash that would otherwise leave the area to pay for outside energy supplies is kept within the local economy to be spent on local goods and services. This strengthens the local tax base, enabling the municipality to provide high-quality services to residents and businesses.

Ultimately, the consideration given by elected officials and community leaders to maintaining the economic attractiveness of their areas will be reflected in other aspects of the public realm. Compact communities that integrate a diversity of uses and density of buildings enhance the opportunity for district energy, and provide the densification that reduces sprawl and supports good public transit systems. A diverse and compact community provides residential, civic, retail, cultural, and entertainment facilities, all within easy, "walkable" distances. This, together with district energy, adds up to a high-quality and attractive place to live and work.

District energy

District energy is a long-term investment to improve the physical infrastructure of the community it serves. It consists of a network of underground pipes carrying hot water, steam, or chilled water from a central plant to the buildings using the service. Many established **district heating** projects in the U.S. use steam as the carrying medium, while new developments tend to use hot water. There are pros and cons to each approach which are typically determined by local conditions. The heat supplied to buildings can be employed for space heating or domestic hot water, or be converted to chilled water for cooling via steam turbine-drive or **absorption chillers**.

District energy networks offer a complementary infrastructure to gas and electricity networks. They can exploit a variety of fuel sources, both fossil and renewable, such as natural gas, oil, coal, biomass, geothermal, large-scale solar thermal, and waste to energy. They are also able to capture and distribute surplus heat from industrial processes and power generation that would otherwise be wasted. Heat networks aggregate the thermal demand of multiple buildings to a scale that enables the use of technologies with higher efficiencies, or ones that may not be economical to deploy at the individual building level, such as biomass, waste to energy, or combined heat and power (CHP), also known as **cogeneration**. While natural gas has been, and is likely to remain, the preferred fuel choice in the U.S. due to increased availability and favorable emissions profiles, many CHP plants can be operated by a variety of renewable fuels such as municipal waste, landfill gas, and digester gas.

Electrical generation in the U.S. is primarily in large power plants remote from the towns and cities where the electricity is required. These plants have an average efficiency of 33%, a number that has remained static for decades. Shifting the generation of electricity from very large power plants many miles from most customers to community-scale plants (5–50 megawatts) closer to populated areas allows the heat that is normally wasted by dumping in oceans, lakes, and rivers to be captured and distributed to buildings through district energy systems. This means there is no longer any need to burn fuel in individual buildings for heating and, as the electricity is generated closer to where it is used, less energy is lost during transmission and distribution. If this shift is well managed, it can also help to ensure that energy is more affordable to consumers.

Instead of building large power stations in the middle of towns and cities, establishing a smaller CHP plant within, or adjacent to, urban areas can offer significant benefits. CHP refers to a plant that generates both electrical and thermal energy in a process that can achieve efficiencies of 75% or even higher. These CHP plants offer the flexibility of using different fuel types. Integrating **thermal storage** with CHP allows electricity and heat production to be decoupled so that chilled water or heat produced by the CHP unit during periods of **peak demand** for electricity can be stored and used later during peak thermal demand periods. This avoids the need to burn extra fuel to meet these peaks. Additionally, if electric boilers are included, they can be used to balance periods of over- and underproduction of electricity from

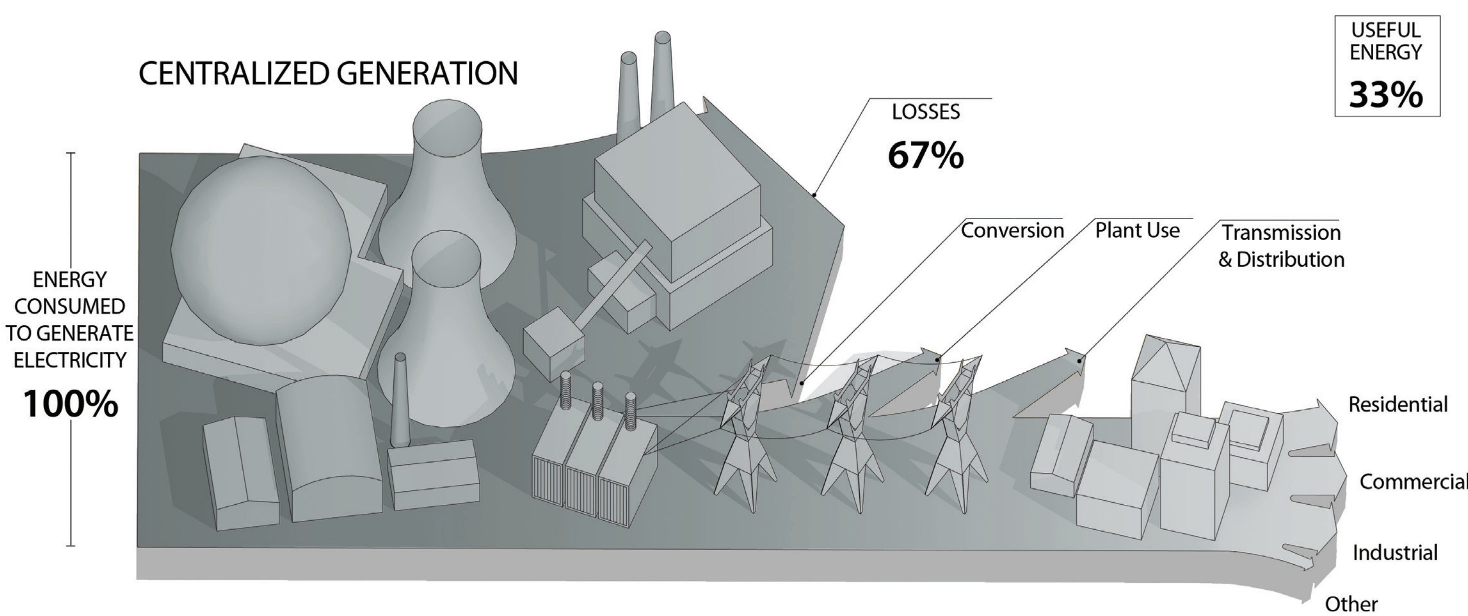


Figure 2: The typical centralized power generation process wastes approximately two-thirds of primary energy in the form of heat rejected into the atmosphere. District energy captures this heat and is 80–90% efficient.

generators and intermittent resources like solar and wind turbines, reducing stress on the grid. Over- and underproduction periods are reflected in the volatile wholesale price of electricity, which can fluctuate wildly between negative and positive. Energy centers incorporating CHP units with back-up boilers, electric boilers, and thermal storage can respond to the wholesale price signal and play the market and, consequently, provide balance in the grid, while simultaneously providing secure thermal energy and power services to the local area. This reduces stress caused by congestion on the grid and also reduces transmission and distribution losses, improving overall efficiency and providing better energy security.

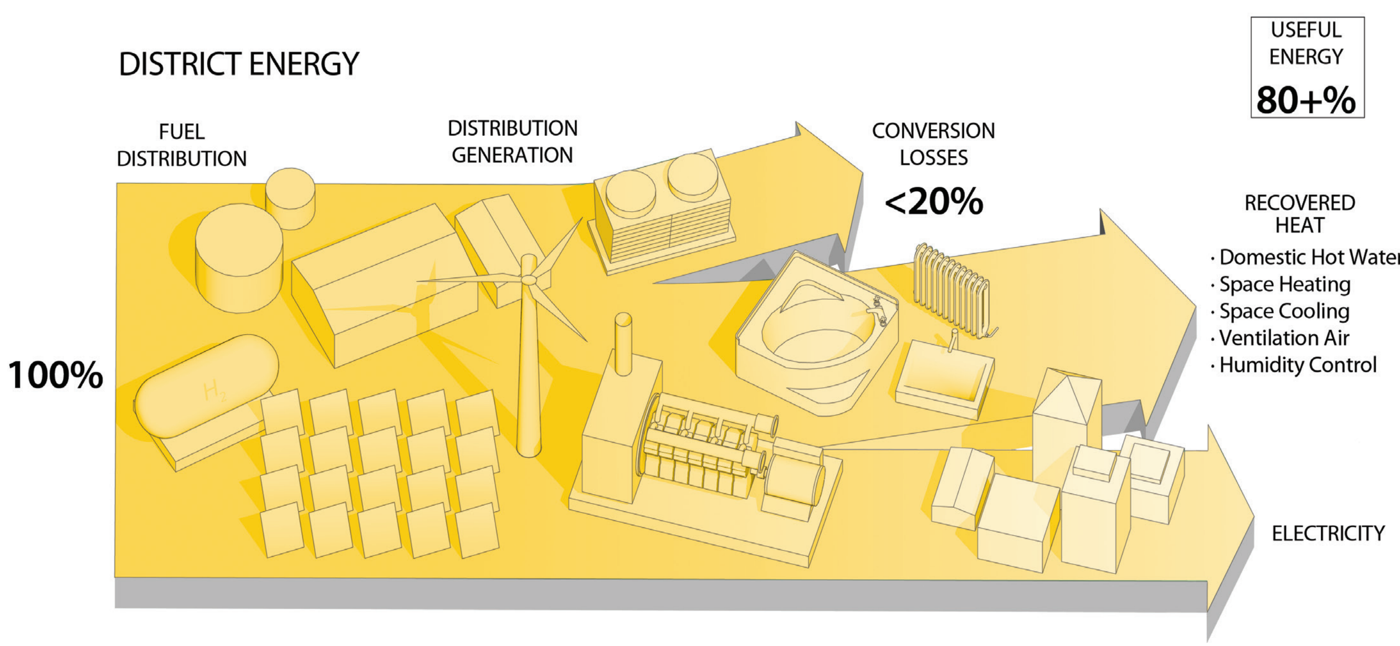
Local opportunities and resources

Thermal energy can be transported over long distances. Major district energy networks in Europe (Paris, Berlin, Copenhagen, Stockholm, and Helsinki) extend over 30 miles in length. In the U.S., district energy networks are mainly found in central business districts of cities, on college/university, healthcare, and institutional campuses and military bases, and at airports. In larger U.S. cities, such as New York, the district energy system has a grid network of over 100 miles of underground piping supplied by seven central plants serving about 1,800 buildings on Manhattan Island.

However, district energy systems can be deployed in smaller towns, campuses, and planned developments, where the density of thermal energy demand is sufficient to support the commercial development of the infrastructure. As the central production and distribution of thermal energy are inherently local activities, district energy helps communities identify opportunities to deploy local resources, such as biomass from forestry, tree clippings, or waste wood from construction or demolition; or local sources of heat, including geothermal, wasted industrial heat, and municipal waste to energy.

Incorporating district energy encourages land-use planners to shape building development in a way that supports the use of district energy networks by, for example, locating producers of excess heat next to users of heat, or developing buildings with a high heat density in a linear fashion to facilitate the building of a shared heat 'spine' main. Likewise, **district cooling** systems can be constructed to provide chilled water for air conditioning where there is a density of multiple-use buildings.

District energy will not be suitable everywhere. This guide will help developers identify opportunities where district energy may be feasible and avoid inappropriate investment.



Illustration, copyright AEI / Affiliated Engineers, Inc.

Figure 3: The University of Missouri, Columbia's award-winning power plant blends up to 10% of locally supplied woody biomass in its fuel mix.
Image courtesy of the University of Missouri

Benefits

– ***High efficiency, 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.
– ***Flexibility and resilience:*** The ability of district energy networks to take heat from 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 district energy networks alongside gas and electricity networks improves their energy resilience. District energy networks allow town and city managers to secure the optimum supply position. Lastly, district energy systems "future proof" communities, since new and emerging technologies like heat pumps, fuel cells, or biofuels can be easily and rapidly retrofitted, without the need to install equipment in each building.
– *Local control:* Local operational control also ensures that investment decisions are being made close to the point of impact. Thermal energy services can be delivered through a variety of business vehicles, including local municipal companies. These can later be transferred into the private sector by the sale of shareholding. Large utilities and multi-national companies are also interested in developing such businesses as for-profit entities.

Alternatively, thermal energy services can be delivered through community-owned, not-for-profit **special purpose vehicles (SPVs)**. This allows surpluses to be taken as revenues by local municipalities to help deliver other front-line services. Or, by putting an asset lock on SPVs, it is possible to ensure that surpluses are re-invested in the business to extend the networks into areas with lower returns, or to engage in demand-reduction projects, for example insulating customer buildings or updating control schemes.
– ***Reducing carbon emissions:*** High resource efficiency in using fossil fuels and the ability to make use of renewable fuels reduces carbon emissions. This will make a local contribution to the global threat of climate change.

WHO IS THIS GUIDE FOR?

Project developers will come from different positions. Each will have their own specific objectives and varying opportunities, resources, and levels of understanding.

This guide is intended for use by elected municipal officials, government energy, economic development and sustainability officials, and land-use planners, who can be project champions or sponsors. Land-use planners and community economic development officials also need to consider energy as part of any area of development as they seek to make communities, towns, and cities more energy efficient. They need to be able to identify energy opportunities and commission projects. This requires a certain level of understanding in order to ask the right questions, understand recommendations, and choose the optimum solution. Public project managers will need to develop the commercial approach of private developers. This guide will help them do so.

About this guide

This guide will help land-use planners and project developers, both public and private, to:

- understand and create or influence energy maps (see pages 9 and 19) and other information for use in **master plans** or development plans;
- gain an understanding of energy use in buildings and developments;
- recognize where there are opportunities for district energy projects, and understand the value of incorporating thermal energy considerations in planning efforts;
- translate energy opportunities into financially viable and deliverable, sustainable projects;
- understand the stages of developing an energy project and who is involved in each.

What is in the guide?

Energy must be considered by a wide range of public and private land-use project developers – for commercial, residential, and industrial developments. Growing interest in developing a community's energy resilience and reducing reliance on sources of energy from outside the region is making local energy more attractive to communities across the U.S.

Each project developer has specific and varying objectives, opportunities, resources, and levels of understanding of the technologies available. This guide contains the information needed to recognize and understand the opportunities that will best meet their objectives. The main focus is on two kinds of energy supply systems: district energy, including district heating and district cooling, and combined heat and power (CHP), but is relevant to low- and zero-carbon energy in general.
Project developers may prefer to delegate key parts of the process, or even the whole job, to consultants or companies that specialize in energy projects. However, it is important that the customer has a sufficient level of knowledge to understand and assess the recommendations made by the consultant.

Types of project developers

This guide describes the complete process from project inception to delivery for six broad categories of project developer.

— ***Local governments:*** Local municipalities can sell thermal energy and electricity and become an energy utility in their own right. This presents a unique opportunity to generate new income and fund wider objectives. It is crucial that public sector developers understand and adopt a commercial approach to district energy projects, more commonly associated with private sector developers. Although district energy projects can deliver a number of societal and environmental benefits, they must be financially viable, and economically sustainable over the long term. Therefore, a pragmatic commercial approach should be adopted.

— ***Communities:*** District energy provides the opportunity for communities to come together and reap the benefits of energy generated on their doorstep. A growing number own, manage, and financially benefit from low- and zero-carbon energy, while setting themselves up with secure energy supplies.

— ***Other public sector developers:*** For example, city or state public housing authorities and their private sector partners are major builders and building operators. They, too, can profit from energy projects and play a key role in providing anchor loads (see page 18).

Figure 4: Institutions such as the University of Massachusetts, Amherst operate highly efficient district energy and CHP systems (top picture) to capture and use the heat that is wasted by typical central power generation (bottom picture).

Top picture: Courtesy of R.G. Vanderweil Engineers Power Group, Engineer of the Record for the UMass CHP Project

— ***Institutions:*** Colleges, universities, and healthcare providers have historically relied on district energy networks to provide highly reliable, efficient, and lower-carbon energy services to entire campuses, often comprised of 150 to 200 buildings.

— ***Property developers, landowners and building operators:*** In meeting building code obligations, these types of developers may need to provide energy solutions for buildings, on-site energy networks, or land for energy centers. They also may need to contribute financially to the expansion of projects, via planning obligations and connection charges.

— ***Private sector developers:*** **IDEA** members include many companies who are able to offer a range of approaches from contracting to deliver specific elements, to total project development, operation, and ownership.

Each of these developers may play more than one role in a project, and there can be numerous points of entry into the stages of development. For example, a municipality might set an area-wide energy vision and play the role of champion or project sponsor, so the section on energy maps (page 19) will be of particular relevance. Equally, a municipality that owns land and assets may wish to invest them in developing projects themselves. Municipalities and other public sector developers may be key to the viability of a project simply by making anchor loads (see page 18) available. A community could decide to take an energy opportunity and cede some or all of the stages of development to third parties. A property developer might see a project through all ten development stages (see page 10), or only deliver a small part of a larger project, perhaps in partnership with a local municipality, energy company, or cooperative. There are many stages of development in district energy projects and understanding these stages and their progression underpins the development of a successful project.

Energy as part of livable cities

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 district energy network can improve capital efficiency, conserve space, improve operating efficiency through better load management, and create opportunities for community-scale resource conservation and energy efficiency.

By doing this, the city's inhabitants can experience both health and financial benefits compared to traditional generation and delivery of energy. For example, manufacturing facilities may generate excess heat that can be supplied for the benefit of others in a district energy 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.

Starting points

How do project developers go about identifying suitable projects or approaches to energy supply? Many communities already have **Climate Action Plans**, and revisiting those to integrate thermal considerations can open up a range of new opportunities. In cities that have a comprehensive plan, or a plan for new development, or redevelopment of a specific area, municipal leaders may be able to consider that plan in the context of local energy generation potential. Many cities are planning new development areas and revitalizing aged industrial areas by undertaking urban renewal or brownfield projects that would benefit greatly from a district energy system. Ultimately, planners and government leaders can identify their community's priorities and use the steps and tools provided in this guide to see how local energy generation can contribute to sustainability and economic goals.

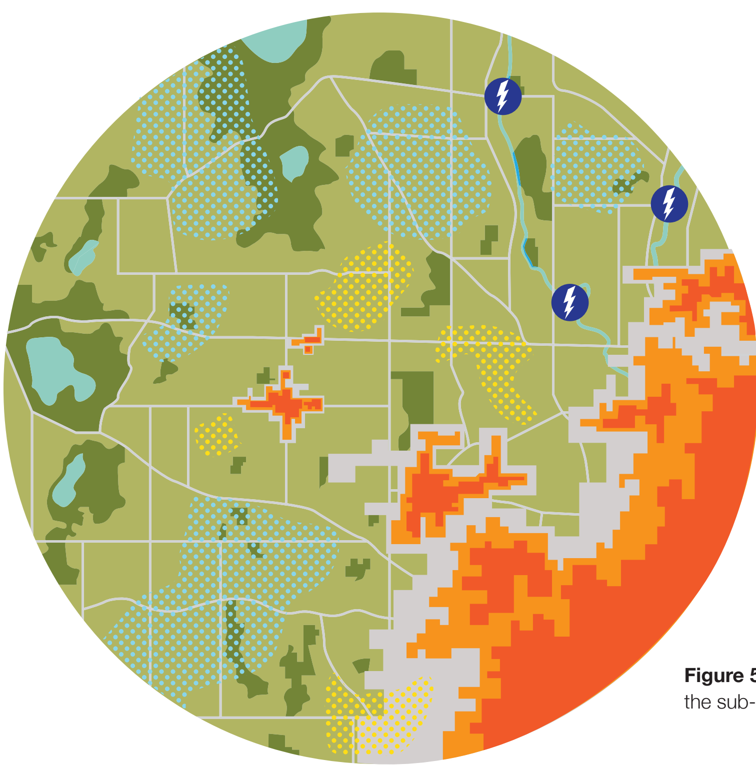


Figure 5: Energy maps can be used to identify opportunities at scales from the sub-regional down to the neighborhood.

STAGES OF DEVELOPMENT: Introduction

There are ten development stages to follow to bring an energy opportunity to fruition. These are described in detail throughout the rest of this guide.

The stages

The ten stages of development are outlined here. The results of each stage can be used as part of an energy strategy for an area, planning application, or simply as an action plan.

— ***Stage 1*** considers the objectives frequently adopted by communities and municipalities for district energy projects.

— ***Stage 2*** covers the types of data that must be gathered, focusing particularly on building density, mix of uses, and anchor loads. It also discusses how this data might be assembled and presented as energy maps to facilitate the planning of thermal networks.

— ***Stage 3*** looks at how to identify the buildings to be connected to form a district energy project and what might motivate different types of building owners to commit to the development of the project.

— ***Stage 4*** then tests what technical option might best meet the energy needs of the buildings comprising the project while meeting the project objectives. This is sometimes referred to as a "high-level feasibility study".

— ***Stage 5*** subjects the project to a feasibility study. This is a technical exercise to investigate the selected option in detail. It considers the different fuel types and generation options; the configuration of thermal production equipment and storage within the plant facility and its optimum location, network design, and route; and the phasing of development. It will also provide a high-level assessment of the financial viability of the option.

— ***Stage 6*** develops the financial model for the project. It considers its overall capital cost and operating costs. Potential sources of capital are suggested and revenues listed. Risks to the financial viability of the project are identified with suggestions of how these might be appropriately allocated. The financial model should be subjected to a sensitivity analysis or "stress test" to determine if it is robust.

— ***Stage 7*** considers different business or commercial models that may be put in place to take the project forward. The relationship with risk and control is discussed, and how these factors can impact the cost of capital.

— ***Stages 8, 9, and 10*** review the legislative and regulatory environments that affect projects. Consideration is given to procurement routes, commissioning, and delivery.

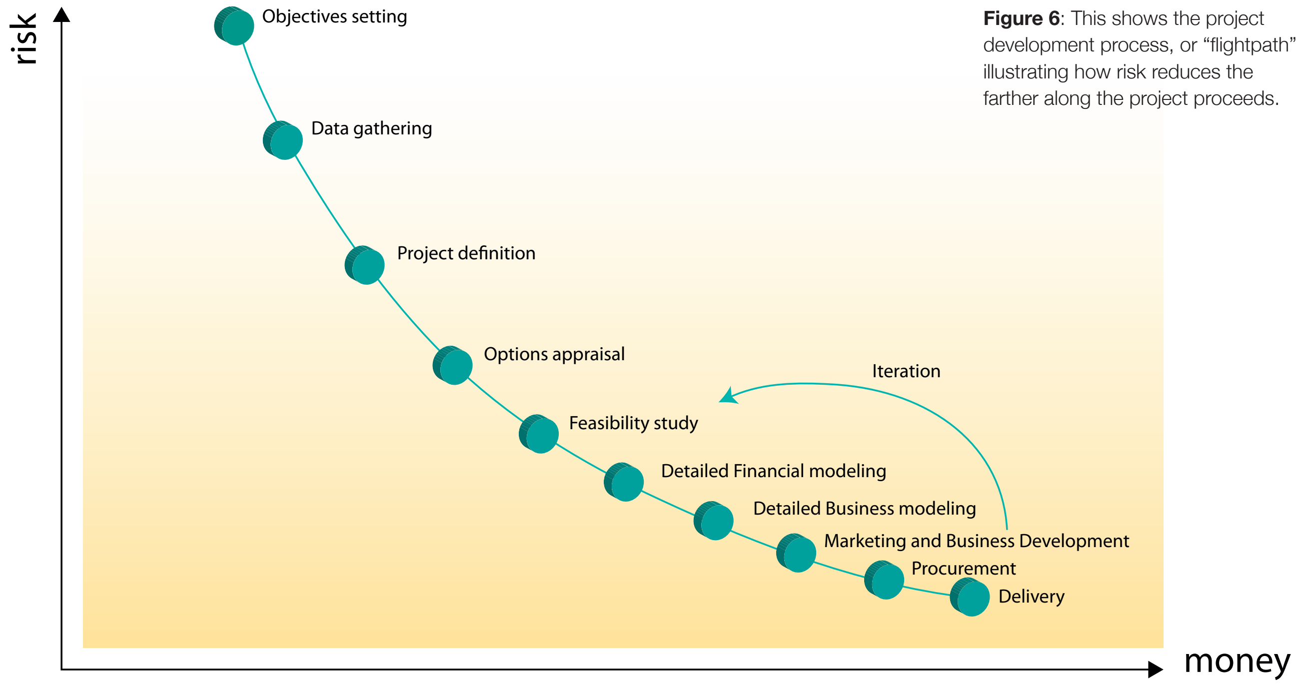


Figure 6: This shows the project development process, or "flightpath", illustrating how risk reduces the farther along the project proceeds.

When to consider energy

In the life of any area, development, or building, there are trigger points when energy should be considered. For example:

- 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.

Making the right decision

Generally, an energy system is expected to last between 15 and 40 years, although the underlying infrastructure may last far longer. The choices made at these trigger points can have long-term repercussions. They may lock an owner, occupier, or entire community into one system for a long time, limiting their options in the energy market and tying them in to particular suppliers and equipment. Over time, there will be changes in technology and the supply chain, from which consumers could benefit. This is why flexibility is important and a strategic, long-term perspective on energy supply should be taken as early as possible.

Energy project "flight-path"

People familiar with the development of energy projects, both large and small, follow a well-established approach designed to minimize risk. This approach has a staged trajectory from inception to delivery and forms the basis of the ten stages recommended in this guide (see Figure 6, above).

Overall, the cost of project development can amount to a significant proportion (between 10% and 20% depending on project size) of the total capital cost of delivering the project. Each stage has to be financed, of course, and progressively increases in cost. But the risk of project failure declines as the process progresses. So, while not prescriptive, the ten-stage approach helps avoid spending large amounts of money to no effect, and provides an appropriate sequence of increasing specificity. Much like when landing an airplane, as altitude declines as you approach the airport, finer details of the landscape come into view, so the closer a project gets to delivery, the more details come into view, and clarity and scope of the project improve.

Importantly, the stages along the flight-path are likely to be iterative. Although financial and business modeling is carried out in detail later, it is important that they are considered from the start and revisited throughout the process. For example, different investors have different expectations of rates of return, so understanding the business model at the outset is crucial. This is particularly critical in the case where a project developer has choices of different procurement, financing, and operation models, because technology selections may change slightly or participants may desire comparative scenarios for risk assessment.

STAGE 1 Objectives setting

Defining objectives for the project at the outset will establish a benchmark against which all later decisions can be compared.

1 Defining objectives

All projects must be financially viable. Beyond this basic assumption, objectives must be defined from the start. This creates an obligation to address the objectives to be achieved, to align the objectives of different internal departments or external stakeholders, and to deal with any conflicts.

1.1 Main areas

The objectives for an energy project fall into three areas.

1.1.1 Economic considerations

Reducing reliance on imported energy supplies and strengthening local economies through supply diversity and locally available resources is a growing economic consideration for regional and local governments. Energy infrastructure is capital intensive. Developing the infrastructure to exploit locally sustainable energy supplies can involve initial capital investment where the upfront capital costs of some low- or zero-carbon energy systems can be higher than for traditional energy arrangements where the infrastructure costs have been paid off. If this cost is passed immediately and directly on to customers (through bills or service charges), the energy may seem non-competitive in the short-run. Consequently, innovative financing mechanisms need to be explored to overcome the high capital threshold and spread the costs over a longer term (see Stages 6 and 7). The financial approach will also need to address the lag between investment made during the project's construction and the commencement of revenue flows. This is discussed in more detail on page 30. However, the financial model will need to allow sufficient cash to cover this gap.

In residential settings, lower income households tend to respond to higher bills by reducing consumption, with potentially adverse impacts upon their health and well-being. Prices will probably rise in the medium to long term. Investing in district energy systems will mitigate this impact and help keep the energy rates down and more stable for consumers in the long run. For commercial landlords, it is easier to contract properties with lower energy rates.

At this early stage it is also crucial to understand the project developer's (PD) exposure and attitude to risk. This determines the most appropriate business model in respect of the availability of capital (including the assessment of reasonable return) and of the operating risks. This, in turn, will provide the most appropriate method by which affordable energy can be delivered.

During the construction phase, high-quality jobs are generated in infrastructure construction: plant and systems design and construction. During the project's life, it will be valuable to assess the economic multiplier of using local fuels, such as natural gas or renewable fuels, and the impact on the local economy of retaining energy dollars.

1.1.2 Energy security

Energy is vital to modern life, but the fossil fuels society depends on are finite and often come from regions of the world over which the U.S. has limited influence, or which suffer from political instability. Growing demand and dwindling supplies mean prices will become more volatile, which could adversely affect supply. Furthermore, most buildings last for 100 years or more. The neighborhoods in which they sit may last far longer. A secure energy supply is vital to the occupants and businesses throughout the life, and different uses, of the building or place.

Although discovery of natural shale gas deposits have softened natural gas pricing at present, continuing growth in demand and environmental concerns will continue to impact our reliance on carbon-based fuels. Global market drivers, including population growth and increased economic growth, as well as urban density in developing nations will impact market pricing and availability of traditional commodity fuels. However, supply interruptions can be mitigated by increasing the use of locally available fuels such as wood waste, biomass, geothermal, crop fuels, and certain renewable thermal sources like cold lake water or ocean water for chilling. In addition, for those projects that do plan on utilizing natural gas, efficiently producing the most energy output from this limited fuel source, through CHP, simply makes good common sense. District energy infrastructure has the flexibility to harness, balance, and maximize the efficient use of all these different available fuel sources.

Summary of the strategic options appraisal process

Objectives setting

1. Economic
2. Energy security
3. Environmental

Data collection

1. Understand the energy thumbprint (see page 19).
2. Collect data on the following:
   - existing energy consumption;
   - likely future energy consumption based on rates of new construction, future growth, and improvements to the energy efficiency of existing buildings;
   - the suitability of different low- and zero-carbon technologies;
   - fuel sources and how the energy will be delivered or transported;
   - the pros and cons particular to the location in terms of energy sources, distribution, transport, land use, form, and character.

→ Municipal or project-specific energy map

→ Municipal energy character area (see page 20)

Define project

1. Set out type of project.
2. Identify partners or stakeholders needed to make the project happen.
3. Collect commitments from potential partners and customers.

→ Corporate strategies of municipal, public bodies or private developers

Appraisal of energy options

For each technology, consider:

1. Scale of the development.
2. Parts of the site served, including connection to surrounding development.
3. Annual energy output.
4. Annual CO_2 emissions reductions.
5. Ability to integrate local or renewable fuel sources.
6. Implications for phasing.
7. Key project delivery requirements.
8. Contribution to regulatory and planning requirements.
9. Indicative benefits, including consideration of revenues.
10. Indicative project costs.

→ Preferred energy strategy

As consumers utilize more electronics, which increase demand on the regional electricity grid, system reliability is of growing importance. Furthermore, the increased supply percentages of intermittent renewable sources like wind and solar are creating balancing and capacity management challenges for independent system operators. By shifting peak electric demand for air conditioning off the electricity grid onto thermal-based chilling, renewable cooling, and thermal storage, the strain on the electricity system can be reduced. Furthermore, by locating sources of distributed generation, such as CHP, close to load, electric system reliability and national security are enhanced.

For these reasons, public officials are increasingly keen to encourage new and more diverse energy supplies and their efficient use by introducing district energy systems that can use a range of technologies and fuels, and offer greater opportunities for diversity of ownership.They also have the advantage of converting fuel into usable energy more efficiently, thereby reducing CO_2 emissions and saving fossil fuel reserves. Customers benefit from more reliable systems with a higher level of comfort.

1.1.3 Emission reductions

As stated in the Fourth Assessment Report (2007) from the **Intergovernmental Panel on Climate Change (IPCC)**, a majority of scientists agree with virtual certainty that the increase in CO_2 in the atmosphere is responsible for changes in climate that will increasingly cause hotter, drier summers; warmer, wetter winters; more extreme weather; and rising sea levels.

The Fourth Assessment Report states that:

"warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."

In the United States, there has been no federal legislation enacted into law that defines a cohesive national approach to reducing CO_2 emissions. Discussions on how to best respond to climate change have primarily taken place at a state and regional level. However, the issue remains relevant at the federal level through agency and executive branch activities. Examples include the establishment of offices such as the **Office of Climate Change Policy and Technology** at the **Department of Energy**; participation in the international **Clean Energy Ministerial** group; and passage of Executive Order 13514, which directs all federal agencies to set and achieve measurable energy and environmental performance objectives. Notably, the Department of Defense has declared that climate change and energy security are issues of national security. In acknowledging the security implications of global climate change, the Department of Defense has asserted its intent to be proactive in response efforts. Military branches including the Army and the Navy have released ambitious plans to reduce energy intensity and greenhouse gas emissions on bases and from the transportation sector in order to help reduce the adverse effects of climate change on mission effectiveness.

The majority of activity in the emission-reduction field is taking place at the regional, state, and local levels. Local governments, especially mayors, have agreed that dealing with weather or climate-related events will largely be their responsibility. Flooding, grid-related power interruptions, water-level rise, and droughts are manifested at the local level. Storm cleanups and response, depending on the scale and severity, are often managed at a municipal or state level.

Survey results from the U.S. Conference of Mayors June 2011 indicated that:

"mayors are seeking the economic benefits of clean energy solutions as drivers of their energy strategies," and that, "one in three cities cite adapting to climate change as an element of their capital planning or capital improvement programs."[1]

An overwhelming number of mayors with city populations of over 30,000 citizens are committed to using clean energy technologies and energy efficiency solutions to address environmental issues and move forward on energy independence and security objectives. Cutting emissions of greenhouse gases will require substantial infrastructure investment to reduce energy intensity, increase end-use energy efficiency, and move toward lower-carbon solutions. Reaching more sustainable energy and environmental targets will only be achieved if all new and existing buildings and neighborhoods make a substantial contribution to emission reductions. As climate change objectives increasingly drive municipal policies and decisions, changes to building regulations and standards, such as the U.S. Green Building Council's **Leadership in Energy and Environmental Design** (**LEED**) certification program, will be an important influence on the energy decisions of project developers.

Overall, there appears to be a growing awareness of and desire for lower-carbon energy solutions driven by the acknowledgement that cleaner energy delivers a multitude of long-term economic benefits, particularly at the community level. Energy systems have a major effect on the overall CO_2 emissions of a place or building, so choosing a system with the minimum carbon impact is extremely important.

More efficient district energy and CHP systems, with their lower-carbon footprint, are a sound and practical approach to a more sustainable future, as opposed to larger, central power stations, and individual building heating and cooling systems.

1.2 Prioritizing objectives

District energy projects will benefit from defining the objectives they must achieve from the start. As outlined above, these are likely to be drawn from the three categories discussed. However, district energy is capable of addressing all three areas and so it is necessary to prioritize which is the most important for the stakeholders involved in the project.

Case study: Energy security for hospital

The new $388-million, 500,000-square-foot, 192-bed Shands HealthCare Cancer Hospital, based at the University of Florida, wanted to ensure energy security, efficiency, and improved reliability under all operating conditions. A unique public/public partnership between Shands HealthCare and Gainesville Regional Utilities (GRU) resulted in a state-of-the-art CHP plant that meets and surpasses these objectives.

Designed by Burns & McDonnell, the CHP plant delivers reliable energy, heating, and cooling to the hospital. The 4.3 megawatt (MW) Solar Turbines Mercury 50 gas turbine was selected for its low-carbon footprint design, reliability, and quality of power production. The system's reliability is further enhanced by multiple redundant systems, housed in a structure designed to withstand Category 4 hurricane-force winds.

In late 2009, the new GRU South Energy Center began supplying the electric, cooling, heating, and medical-gas needs of the hospital. The South Energy Center is one of the only CHP plants in the Southeast capable of providing 100% of a hospital's energy needs. Unlike most other hospitals, the Shands Cancer hospital does not have to shift to emergency generators or shed power loads of critical hospital equipment to continue to provide care during power outages as the energy center is located on-site, feeding electricity to the hospital via underground lines. A back-up generator and two electrical feeds to the power grid provide 200% redundancy.

The GRU/Shands partnership provides a good example of how public bodies can work with a private entity to provide reliable, highly efficient, and clean energy. GRU will own and operate the facility under a 50-year agreement with Shands and will occupy the land under a 99-year lease.

By using CHP, Gainesville South Energy Center achieves total system efficiencies of over 70% and annual energy savings equal to the power needed to run more than 3,000 homes. The Shands Cancer Hospital was awarded LEED Gold certification in 2010, due in large part to its onsite district energy and CHP facility.

Image and text courtesy of Solar Turbines and Burns & McDonnell

Figure 7: Gainesville Regional Utilities won an Energy Star CHP Award for the South Energy Center, which has an operating efficiency of over 60%.

STAGE 2 Data gathering

High-quality and appropriate data is the foundation of a successful strategy or project. For the purposes of options appraisals and evaluating high-level feasibility (Stage 4, page 24), it is not necessary to compile detailed data; that comes later. At this stage it is possible to use "benchmarking" data to get a high-level understanding of the opportunity.

2 Data required

To make rational decisions about a new energy generation and distribution system, it is necessary to:

— collect data on existing and likely future energy consumption of new construction and existing buildings, taking account of improvements to their energy efficiency;
— take account of the rate of construction for new buildings;
— consider fuel and power sources and how the energy will be delivered or transported;
— recognize the pros and cons particular to the location in terms of energy sources, distribution, transport, land use, form, and character;
— consider the sustainability of different low- and zero-carbon energy technologies.

2.1 Development density

A major part of the cost of a district energy system is the distribution system and the pipes needed to carry the thermal energy. The shorter the distance energy has to travel, the lower the cost. The more densely-packed the buildings, and the greater the demand for heating or cooling, the more efficient and viable the network is likely to be.

A number of techniques and measures are available to help reduce costs for heat distribution in areas with low heat demand density. Expressed in terms of heat densities, it is considered that areas with a heat density of 0.93 kWh/ft^2 or with linear heat demand of 9146 kWh/ft can be economically served by district heating (**IEA** DHC/CHP). The United Kingdom (U.K.)-based Energy Saving Trust suggests that around 22–23 new buildings per acre (55 per hectare) are necessary for financial viability. Another U.K. study suggests a minimum heat density of 26.5 **MMBtu** per square mile (3,000kWh per square kilometer) per year. In considering market potential for a district energy system, another perspective involves the prospective energy consumption volume of connected buildings per trench foot of distribution piping to be installed. Typical U.S. energy density considerations on a distribution trench foot basis appear in the box below. Project designers can optimize the network layout to minimize the costs associated with different levels of energy density.

District Heating System Density	Annual delivered energy (MMBtu/trench foot)
Low density	3.1
Medium density	8.5
High density	15.6

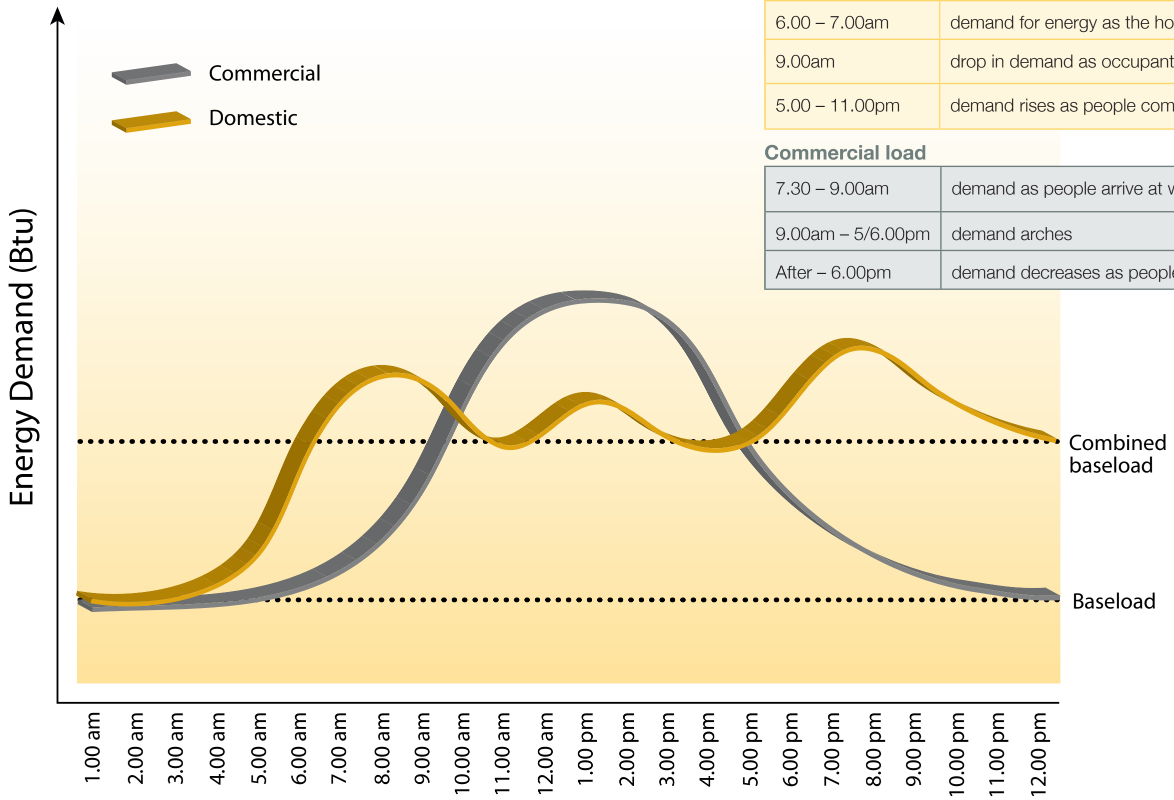
2.2 Demand loads

Demand load is the amount of energy consumed in a given building or development. This varies with weather and the patterns of activity of the building's occupants. For example, residential and hospitality uses tend to have an inverse daily pattern to commercial uses (they typically use energy at different times of the day). Some buildings, such as arenas, convention centers, and stadiums will exhibit **event loads** that occur only on dates when events are scheduled to occur, while buildings like hospitals, universities, and hotels, are used 24 hours a day and have fairly steady loads.

Daily **load profiles** are put together to form annual load profiles. These show different profiles in summer and in winter. The **peak load** is the period of highest demand and the **base load** is the period of lowest demand. The base load is never zero as there is demand for hot water and electricity for ancillary equipment, such as kitchen appliances, at all times.

It is important to create load profiles for any project so an energy system of the right size can be designed to meet demand. Figures 8 and 9 show typical graphs of different load types.

Hourly energy use



Domestic load

6.00 – 7.00am	demand for energy as the household gets up
9.00am	drop in demand as occupants leave for school/work
5.00 – 11.00pm	demand rises as people come home from work

Commercial load

7.30 – 9.00am	demand as people arrive at work
9.00am – 5/6.00pm	demand arches
After – 6.00pm	demand decreases as people leave work

Figure 8: This graph shows a typical domestic and a typical commercial load profile, and how they complement each other.

Yearly heating and cooling

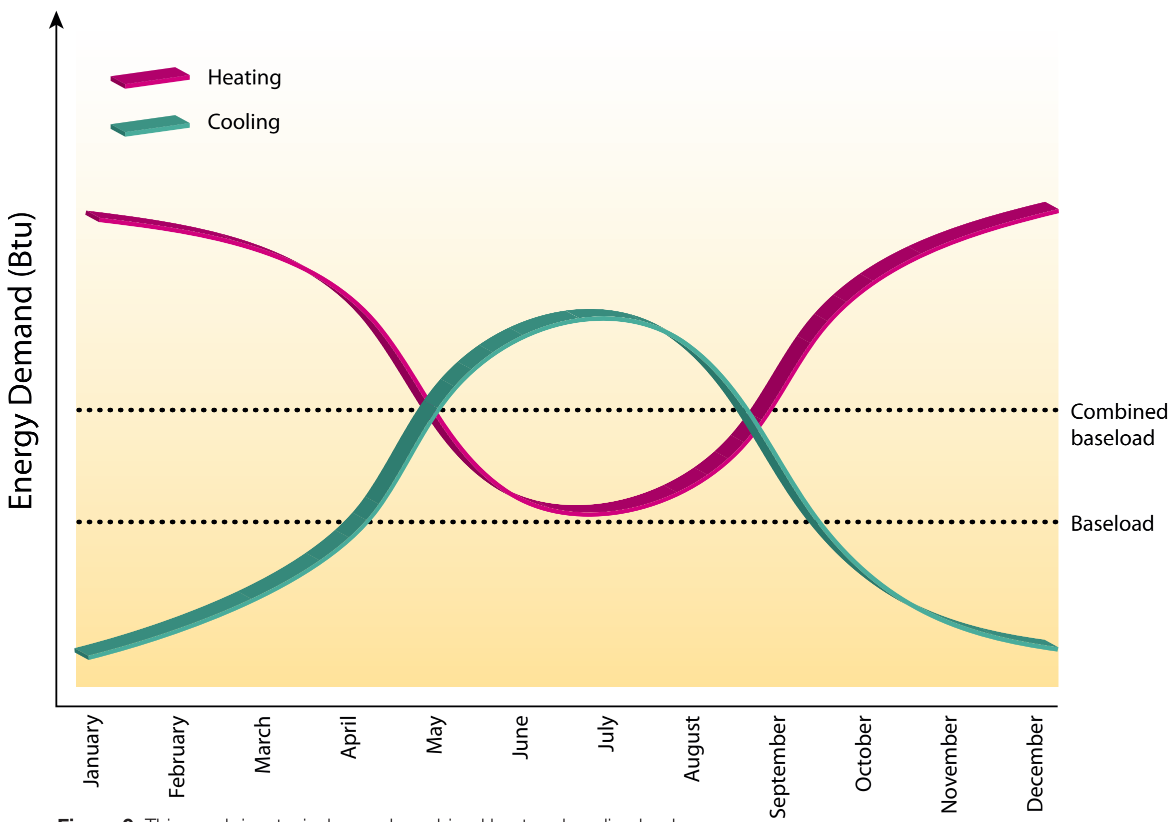


Figure 9: This graph is a typical annual combined heat and cooling load profile. This shows higher heat demand during the winter months and higher cooling demand during summer months when heat demand is low.

2.3 Mix of uses

Having a mix of end uses, reflected in different load profiles, helps in matching demand to supply to get the most out of the central plant. Boilers and generating engines operate most efficiently when there is a steady, smooth load. Most individual loads contain abrupt increases or "spikes" of demand. These spikes can be compared to the inefficient use of fuel in a car in "stop-start" city driving, compared to the greater efficiency of smoother highway driving. Spikiness also affects maintenance requirements and overall equipment longevity.

Boilers for a single building have to be sized to meet peak load, but energy use is only at peak demand for a fraction of the time. As a result, most boilers are oversized and running below their optimum performance, especially condensing boilers, which are most effective after a steady period of demand.

If several residential properties share a boiler or cooling plant, via a district energy network, spikiness gets smoothed out by the overlapping demands of the customer buildings. If commercial buildings are added to the network, they smooth the load out even further, with their complementary energy-use pattern. This gives a smooth load curve over 18 hours. It also raises the level of the base load. In this case, the energy system, when providing heating, can be designed with a **lead boiler**, also called a **prime mover**, to provide the base load, and a back-up or top-up boiler to help with the peak load. In this system, the lead boiler can be a smaller size and run at optimum efficiency a lot of the time, while the back-up boilers meet any additional demand.

When configured in this way, the boiler filling the role of prime mover can be replaced by a CHP engine or turbine. These units produce electricity as well as heat and so increase the efficiency of converting the primary energy of the fuel source into usable energy in the form of power, heat, and cooling. As having a good mix of uses connected to the district energy network improves the efficiency of the central plant, it requires less input fuel for a given output. Additionally, it has a beneficial impact on the need for maintenance and plant longevity. All of these issues contribute to the improvement of the business case for the project.

2.3.1 Cooling

With tighter building envelopes and increases in the use of computers, electronics, and other heat-producing devices, as well as greater density of occupancy, commercial buildings no longer need cooling in just the summer months, but year-round, although the greatest demand, of course, is always during the hottest weather. Air conditioning imposes the greatest strain on the electricity grid and often accounts for 50% to 60% of the electric peak demand in a building with its own cooling equipment.

District cooling systems produce and distribute very cold water to customer buildings in order to provide air conditioning and process cooling for data centers and similar applications. The chilled water is supplied through an underground piping network and flows into the building either to a heat exchanger, or it circulates directly through the building's heating, ventilation, and air-conditioning system (HVAC). The cold water from the district cooling system absorbs heat from the customer building, increasing the temperature by 12 to 18 degrees Fahrenheit. The water then flows back to the central plant through a separate return pipeline. The difference between the temperature of the water flowing towards the building and the water returning to the central plant is known as the **Delta T** and is a critical factor in the design of cooling systems as the narrow range of difference does not allow room for error. Typically, cooling is generated by electric chillers, although absorption chillers can be connected to a heat network to convert heat directly into cooling. Absorption chillers are not as efficient as electric chillers, but in areas with variation between warm summers and cold winters, absorption chillers perfectly complement the drop in demand for heating in the warm months (see Figure 9, page 17). The available thermal energy can be used for cooling instead, keeping overall thermal demand steady all year and avoiding the need to dump heat.

2.3.2 Load diversity

A good mix of uses (or **load diversity**) increases the project's financial viability, and will attract the attention of commercial energy services, investors, and financiers. Mixed-use developments with greater load diversity are more viable than entirely residential developments. Since the mix of uses in any project is usually decided during the master planning of a site, it is important to think about the energy system early in the planning process.

2.4 Age of buildings

The age of the building affects load diversity. Changes to building energy codes since the 1990s (Energy Policy Act of 1992, **ASHRAE** Standard 90.1 and ASHRAE 189, see: http://www.energycodes.gov/about/) mean that newer buildings are more energy efficient and have a relatively low demand for heating, except in very cold weather. This actually presents a challenge for people interested in installing communal heat and power systems, since there may not be sufficient heating demand to justify investment in a CHP system. This can be overcome by having a mix of uses and connecting adjacent existing buildings that have different energy requirements, and therefore different energy demands, via a district heating network. On the other hand, district energy systems are particularly beneficial when retrofitted to serve historical buildings as they can provide lower-cost energy services with lower carbon content without the need for any substantial changes to the buildings' fabric or design.

Therefore, data must be collected on the age and energy demands of the buildings in the surrounding area. This can be measured using benchmarks or actual energy-use data.

2.5 Anchor loads

Certain buildings, such as hospitals, hotels, large housing complexes, prisons, swimming pools, and ice rinks, as well as military bases and universities, have a large and steady demand for energy over a 24-hour period. Managers of such public sector buildings can take a long-term view on energy provision, and increasingly have to try to achieve carbon reductions, energy security, and affordable energy supply. Buildings like these also often have space available where energy centers could be placed. Therefore, they make ideal cornerstones for the development of district energy networks, and are known as **anchor loads**. Similarly, convention centers, arenas, and stadiums have large but infrequent singular demands linked to the number and frequency of full-occupancy events. They can also act as anchor loads.

It is a good idea to note any buildings of this type in the vicinity of a new development, refurbishment, or regeneration project, along with information on their demand loads, ownership, and any plans for refurbishment. Identifying anchor loads early in the master planning and project development process is beneficial because the owners of the relevant buildings can champion the project at initiation and as it moves forward.

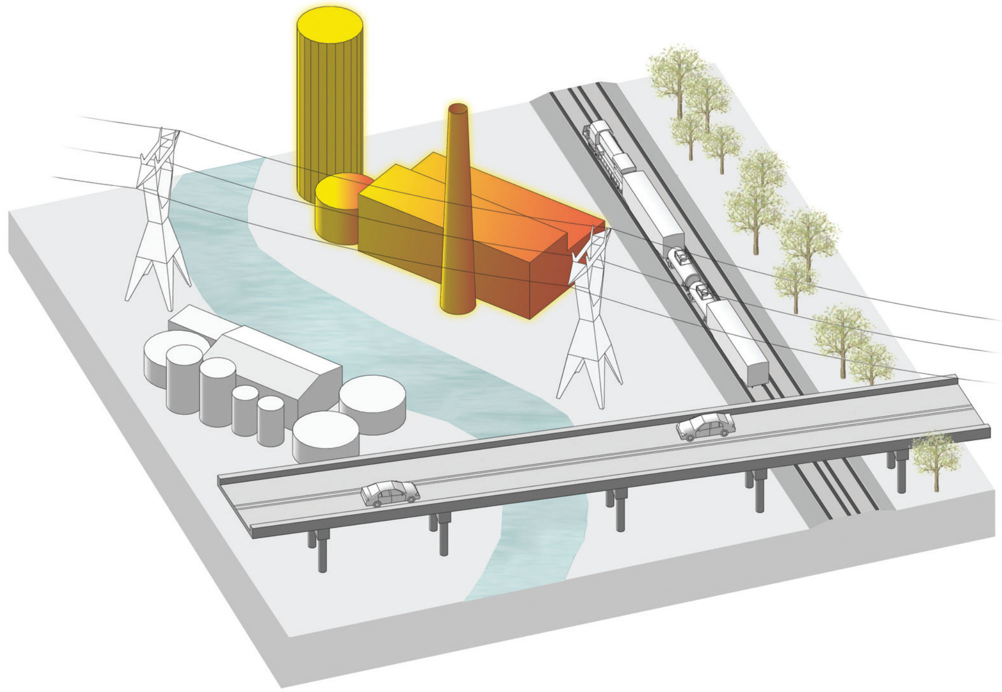


Figure 10: Potential barriers must be identified and taken into consideration. These might be: railway lines/subways, storm water drains, highways, canals, or rivers.

2.6 Other issues for consideration

Development of an energy system using underground networks may encounter some of the problems shown in Figure 10, above. But they need not be show stoppers and can be overcome, for example, through close liaison with highway authorities. They may also present opportunities. Existing energy systems can also present challenges since they may affect how many buildings will sign up to a new district energy network.

It may be necessary to gather further information and data for consideration on infrastructure, such as:

- gas and heat networks and electricity sub-stations;
- existing power plants, including low- and zero-carbon energy sources, power stations, waste-to-energy plants, and industrial processes that are dumping heat;
- transport infrastructure such as canals, rivers, wharves, docks, and railways, which could be used to transport bulky fuels such as biomass;
- the different opportunities and constraints presented by the urban and rural form and character, including topography and significant elevation changes, that might impact pumping requirements and location of thermal storage facilities.

2.7 Organizing the data in a visual representation

The data gathered in Stage 2 creates a location's unique **energy thumbprint**. It is important to organize this data so the project developer can analyze this thumbprint in order to indicate which energy solution is most appropriate and effectively convey the findings to potential stakeholders such as public officials, investors, and decision makers. An **energy map** (see Figure 5, page 9) is a tool that can be used to organize/present data as the basis for defining energy character areas (see page 20) as part of energy planning.

Energy maps are commonly used by European land-use planners and district energy developers and have recently begun to gain popularity in the U.S. While energy maps are not a prerequisite to project development, they can help identify opportunities for new energy projects; determine suitable technologies and approaches to energy generation, distribution, and supply; highlight opportunities to link to other projects or share energy centers; and aid decisions about prioritizing projects. They are particularly useful during options appraisal (Stage 4).

Energy maps provide evidence for district energy implementation and the basis for rational decisions to support planning policies; they also provide information for local infrastructure plans. Project developers can choose to use an energy map as a starting point for energy strategies for new developments, revitalization projects, and as a way to highlight possible or priority projects.

2.7.1 What can energy maps show?

Energy maps are normally Geographic Information System (GIS)-based, and are often prepared at the local or municipality scale. An energy map might be used in a variety of ways.

— ***Energy strategy:*** a map could form the starting point for the energy strategy for a development by identifying energy options (these will need to be fully appraised in Stages 1 to 4).

— ***Identifying energy solutions:*** a map may be used to identify likely energy solutions, such as implementation of a district energy network, as part of an urban renewal project.

— ***Priority projects:*** the map might point to possible investment opportunities for a project developer.

— ***Inform growth options:*** energy maps provide information that can aid decisions on the allocation of development sites.

— ***Exclude inappropriate areas:*** for example, where nature conservation or landscape character are concerns.

Figure 11: Pipes run over a canal at Thermal Energy Corporation, the district energy company that provides heating and cooling to the Texas Medical Center in Houston, the largest medical center campus in the world.

Courtesy Thermal Energy Corp. Photo Paul Howell

2.7.2 How to prepare an energy map

There is no one, defined process for preparing an energy map. The project developer will determine the level of detail necessary. For a given area, a map might include:

- an assessment of existing building energy demands and energy installations as a baseline;
- likely locations of new development at different stages in the planning pipeline, and an assessment of how this will affect energy demands over time;
- the availability of potential local and renewable fuels;
- a **heat map**, showing the location of large public buildings and other anchor loads.

When you get down to the neighborhood or building scale, more detail can be added or a new map created if there is no district level map. It can then be used to define and appraise an energy project (pages 22–25).

2.7.3 Energy character areas

Energy maps can also be used to define **energy character areas**, where the particular characteristics of an area are used to define the appropriate energy solution or planning policy. For example, mature residential suburbs are usually lower-density areas with little mix of use and many owners. These areas may be most suitable for micro-generation technologies (small, often building-integrated technologies, such as solar power). In contrast, city or town center locations have a higher density of buildings with a mix of uses, including offices, shopping centers, hotels, and public buildings. While there still may be many different building owners, they usually have standardized decision-making processes for procuring energy services. Areas such as these can develop large-scale heating and cooling networks served by CHP plants.

In this way, energy maps can illustrate energy character areas and help project developers make good investment decisions and plans, whether at the single-building, neighborhood, or city scale. Energy maps can be an overlay to zoning and use planning so that appropriate uses are targeted and concentrated.

2.7.4 Using energy maps to influence developments

It is important that energy is an early and integral part of the planning and master planning process. Energy maps provide encouragement to think about planning and master plans in a different way. They can be combined to inform the development of a municipal energy strategy. The strategy will seek to achieve municipal energy objectives through, for example, the encouragement of renewable energy generation in appropriate areas by green permitting, retrofit weatherization programs in areas of older buildings, ordinance requiring disclosure by commercial building owners of energy efficiency standards, setting code standards for new construction, and specifying district energy systems for appropriate areas.

Case study: Mapping the potential for district energy

The City of Seattle understands that district energy can be a key part of its goal to achieve Carbon Neutrality by 2030. A leading green city, Seattle is working to make its aggressive climate protection goals a reality through smart planning initiatives and policies. Seattle Steam Co. has been supplying steam since 1893. City officials understand the value of reliable, efficient district energy and a recent report confirmed an expanded role for district energy in Seattle's effort to reduce greenhouse gases. It also outlined future policy reforms to support new and expanded district energy.

Seattle hired Affiliated Engineers of Seattle (AEI) to complete a District Energy Pre-Feasibility Study in 2011. With the help of sub-consultant COWI, AEI collected data on density, future development, heating/cooling system types, and accessibility to energy sources to determine the potential for district energy in each of ten designated districts. AEI also identified opportunities for gradual, nodal system development and gave special consideration to greenhouse gas (GHG) reduction potential, in accordance with Seattle's goals. AEI used a number of sources to compile a complete set of data for each Seattle district and highlighted the flow from input parameters to final results through a flow diagram that was created to assist with the decision-making process. Specific data gathered included:

— building types;
— square feet of heated space per building type;
— projected growth rates;
— energy use assumptions (specific heat demand per building type);
— specific peak and total heat demand;
— efficiencies and district heating net loss;
— district heating production units;
— allocation of existing heating methods;
— rate of conversion to district heating and deployment;
— fuel costs;
— cost of conversion and connection to district heating;
— investment costs of district heating;
— O&M costs, financial rates, and system lifetime;
— CO_2 emission factors.

Two of the most important pieces of information in the data-gathering/analysis were the growth factor, based on Seattle's Comprehensive Growth Plan projections, and heat density numbers, determined for both 2011 and 2030 through annual heating load data and the area of the connected loads in each district. Ultimately, AEI and COWI identified five districts as highly promising, three as promising after further development, and two as promising if heat densities increase substantially.

After the study, Seattle created a District Energy Interdepartmental Team in its Office of Sustainability and the Environment to focus on policy reforms, further planning studies, and implementing a new system in First Hill, the most promising area identified in AEI/COWI's study. Comprehensive data provided the necessary justification and identified the best starting point for a city looking to turn lofty goals into economical, efficient reality.

Source: http://1.usa.gov/KWN2fz

Figure 12: Seattle created a District Energy Interdepartmental Team after a pre-feasibility study identified five districts of the city as highly promising for district energy.

STAGE 3 Project definition

Securing the support of other stakeholders is vital in order to define the outline of the project well enough to take it to the next stage. In the absence of a heat map, data will still need to be gathered for a project to progress. Other stakeholders are the route to accessing such data.

3 Defining your project

The project objectives, together with the collected data, heat map if available, and in the case of municipalities, energy character areas, will enable you to define the project; particularly, the buildings to be connected, the project's scale, extent, the range of partners needed to make it happen, and their roles.

3.1 Collecting commitments

In order to maximize the technical feasibility and financial viability of the project, especially district energy systems, where a critical mass of demand is essential, it is necessary to gain commitment from partners and potential customers to participate in investigating the opportunity further. If enough commitments can be collected, then the outline of the project can be defined well enough to take it to the next stage. A commitment could include a **memorandum of understanding (MOU)** or a **letter of intent (LOI)**.

3.2 Selling the idea

Thought needs to be given to engagement with owners of the buildings identified for connection as well as the wider community. This could start with producing an information sheet setting out the project concept, describing the technology and the benefits of participation, and mapping out the development process. Stakeholders could be invited to attend workshops or forums where the project champion can distribute information material, deliver a presentation, and provide the opportunity for questions and concerns to be raised. A high-level advisory group of external stakeholders could be formed as a channel for communication and to manage the engagement process.

The principal driver for building owners will be energy services at a lower cost than traditional arrangements. There are a number of additional benefits which are listed on the right.

Although the benefits of connection to a district energy system may be common to building occupants and owners from all sectors, each will have their own drivers and may accord different priorities and emphasis to the benefits to be derived. These are discussed in the box on the right.

3.2.1 Public sector

Public sector organizations, including hospitals, universities, government buildings, and military campuses are now motivated by a range of policies and incentives to improve the energy

Principal benefits of community-scale district energy

Economic: reduced operational and capital costs

- Economic development: a vibrant downtown connected to district energy has an economic multiplier effect. The environmental and economic benefits will attract new businesses, creating a thriving district that, in turn, attracts new residents.
- Building owners who are connected to district energy enjoy cost savings, capital avoidance, and space savings.
- District energy can also help building owners earn LEED certification, a valuable tool for attracting commercial and residential tenants enabling them to meet their climate mitigation commitments.
- Building owners are able to offer "green" space on the rental market.

Energy security: increased reliability, greater local control, and fuel flexibility

- Local energy generation gives a community greater control over its energy supply. Moving thermal energy production out of buildings to a district energy plant centralizes the operations and maintenance process and eliminates this burden for building owners.
- The opportunity to generate electricity using CHP reduces a community's reliance upon the potentially vulnerable electrical grid.
- Many new district energy technologies can safely operate on more than one type of fuel, further enhancing the system's autonomy and increasing security of supply, reliability, and cost savings.

Environmental: improved energy efficiency and enhanced environmental protection

- District energy reduces emissions through the efficiency benefits of greater economies of scale, the ability to productively use energy that is typically wasted, and the deployment of energy sources that are not viable at building scale.
- Improved indoor air quality.

efficiency of their buildings. These types of bodies are very likely to initiate district energy projects, and may be willing to make a commitment to connect, thereby catalyzing the development of a new system and providing an anchor load for the project, by sharing its plant capacity with neighboring buildings.

Securing the commitment of the key anchor load is similar to a retail development securing an anchor tenancy which provides the cornerstone around which the project can be built. As public sector organizations can take a long-term view and may be motivated by other non-energy objectives, such as area economic regeneration, they may be willing to provide the anchor load.

Viability of a project generally improves with the project's size and diversity of loads. Therefore, partnerships between different building owners in the private and public bodies are attractive.

3.2.2 Commercial developments

Some commercial building owners have corporate commitments to reduce carbon. However, it is more likely that owners will primarily have other drivers. For new buildings this may be the need to meet building codes and planning requirements to achieve LEED thresholds, add value through increased leasable space, and reduce the cost of heating and cooling their buildings. Owners of existing buildings are also motivated by reduced heating and cooling costs, but are interested in avoiding the cost of replacing existing aging boilers, too. They may be unwilling to make a commitment to connect until they know the probable costs, including:

- — the capital cost of connection compared to the cost of installing individual boilers or replacing an existing plant;
- — the cost of use over time.

Although developers may need further cost information, they could be interested enough to sign a MOU, agreeing to explore the opportunity further through an Options appraisal (Stage 4) or Feasibility study (Stage 5). As always, obtaining commitments from multiple building owners is more complex than for single buildings. Once there are enough commitments and memorandums of understanding, energy ideas can be confirmed and the project can move forward.

3.2.3 Community developments

Local communities may want to benefit from district energy systems. To do so, it is likely that they will need to work with relevant officials in local government and other public sector organizations. Community-owned legal forms can provide the opportunity for local control of the energy infrastructure that allows local communities to determine pricing and service bundling and to aggregate their demand as consumers to drive down infrastructure costs. Net profit can be re-invested in the business or community and/or distributed as dividend to members.

Such opportunities can play a part in a broader approach to the development of livable cities. However, as the interests of consumers and communities may not always be absolutely aligned, it is important to define the principal stakeholders and how the benefits will accrue.

3.2.4 Other utility services

There are parallel drivers increasing the demand for other decentralized and local utility infrastructures, notably cable, non-potable water supply, and waste management. There may be cost benefits in energy projects installing these additional services. While it is unlikely that these services will be contained in the same business, they could cooperate by sharing the same contractor to dig a common trench. Some district energy developers have added a vacant conduit while installing the pipe network. This has later been leased to other service providers, particularly cable companies, bringing in additional revenue. Consequently, in defining the energy project, the opportunities to include future delivery of one or more of these other infrastructures should be taken into account.

Figure 13: The control room of Thermal Energy Corporation in Houston, Texas, where a recent $377 million energy infrastructure expansion added 48 MW of CHP that operates at 80% efficiency.

Courtesy Burns & McDonnell

STAGE 4 Options appraisal

The next stage is to use all the data to examine energy technology options in order to decide which are the most suitable. An options appraisal, or high-level feasibility study, compares the energy solutions available, evaluating simple payback periods and the cost-effectiveness of each energy option. Later, the selected option will be subjected to a more detailed feasibility study that assesses with more rigor the technical feasibility and financial viability, while identifying the potential constraints and project risks.

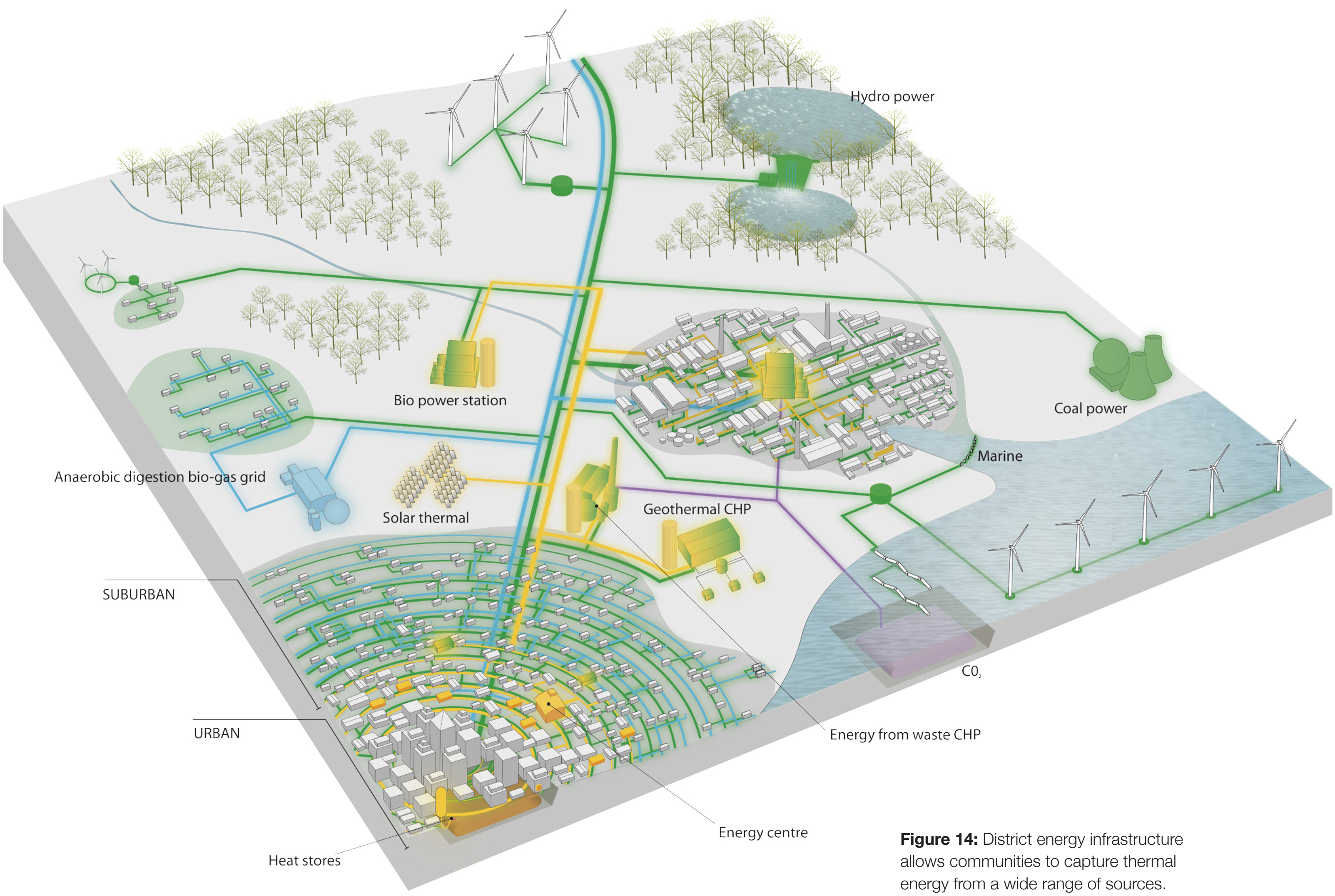


Figure 14: District energy infrastructure allows communities to capture thermal energy from a wide range of sources.

Illustration, with permission of UK CHPA

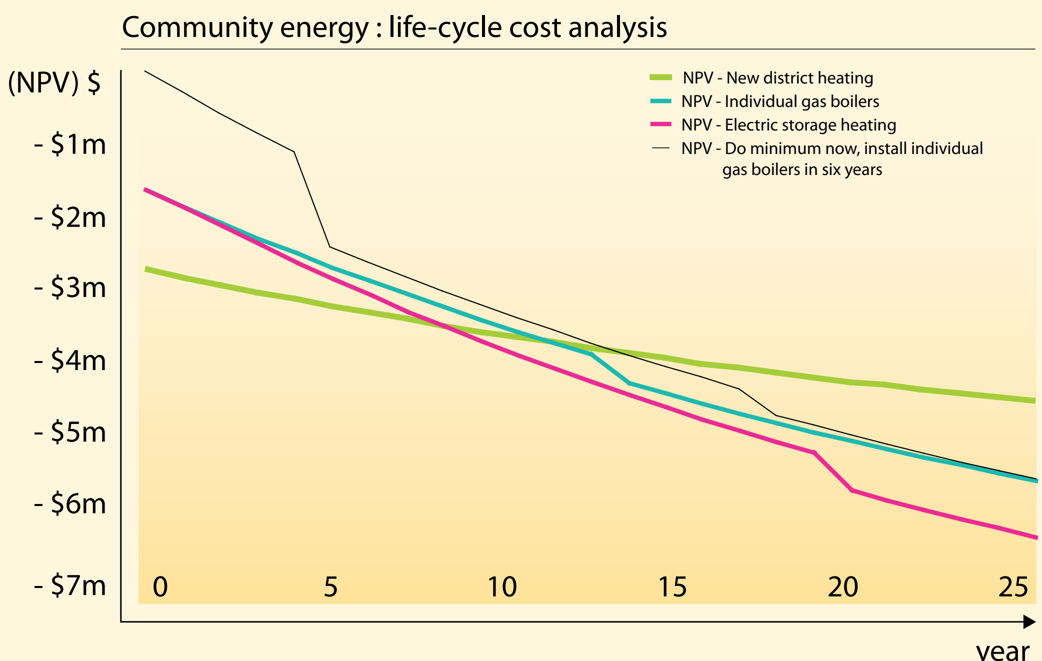
4 Looking at the options

Based on the data collected for the defined project in Stages 2 and 3, together with the heat map showing adjacent buildings, technical options for meeting the project's energy demands now need to be appraised. This involves comparing a limited number of typical solutions, including the business-as-usual case where a traditional energy system is to be installed or replaced. An options appraisal is not a detailed feasibility study, so estimated capital costs, data on demand loads, and simple payback methodology may be appropriate at this stage. However, it is important to roughly evaluate the technical feasibility and financial viability of the different options. At a later stage it will be necessary to use more sophisticated financial methodologies. These are described later in the guide.

IDEA, in collaboration with the **U.S. Department of Energy's Clean Energy Application Centers**, has developed a District Energy Screening Tool, which is useful in organizing the energy data and development scenarios to perform an early-stage feasibility appraisal. The screening tool analyzes energy load growth, capital and operating cost estimates, building energy needs, various system configurations, and timing sensitivities. The tool will help planners assess the financial viability of a district energy system. It is not a full-blown economic or life-cycle analysis, but will help a planner determine whether to invest time and resources in further evaluation of district energy..

Internal staff may not have the technical expertise to interpret the data in an options appraisal, in which case a technical consultant will need to be engaged. It is important to check the track record of consultants carefully to ensure that they have done similar work before, and to check their references to learn whether previous clients were satisfied. IDEA maintains a database of well qualified consultants.

This process will identify the most cost-effective option. It may be appropriate to consider other services and utilities, such as water, sewage, and cable or fiber-optics at this stage, to assess whether they could add value to the project.



Assessing financial viability

Different methodologies can be used to assess financial viability.
—***Payback:*** gives a simple indication of when investment in a particular technology will break even and begin paying back. This gives a very crude indication of viability and does not place a value on future cash flows.
—***Discounted cash flow:*** discounts future costs and revenues at a given rate in order to bring them back to present-day values.
—***Net present value (NPV):*** uses discounted cash flow to give a project an overall **net present value** which is either positive or negative. If it is positive, the project is viable. If it is negative, it will need more capital to bring it to a positive value.
—***Internal rate of return:*** many organizations use a given fixed rate as an internal threshold which projects must meet to be worth further investment.
—***Life-cycle costing:*** Government agencies use a life-cycle cost (LCC) analysis over a 25-year term to determine if a public sector energy project is a sound investment. This approach considers the capital costs of each option as well as other costs over an extended period of time, typically 25 years or more. This adds up the capital costs for each option as well as taking other costs into account (see the graph above).
—***Operational costs:*** these include fuel, maintenance, and replacement costs; the latter must be included because some technologies will need total or partial replacement within a 25-year period.
—***Future costs:*** there are for operations (fuel, maintenance, and replacement costs), brought back to present values using NPV at a discount rate appropriate for the type of organization.
—***Discounting costs:*** including discounting costs avoided, for example, for plant replacement and maintenance.

STAGE 5 Feasibility study

A feasibility study is a technical exercise to investigate the selected option in detail. It will also provide a high-level assessment of the financial viability of the option.

5 A detailed technical study
Once the most appropriate technology option has been identified, it must be subjected to a detailed technical feasibility study. A study for a CHP/district heating and cooling project is described here.

5.1 Detailed analysis
The data on heating, hot water, and cooling loads that has already been gathered needs to be analyzed in detail. Feasibility is also affected by:
— ***Age of buildings and existing energy systems:*** These must be taken into account. Each building must be evaluated for connectability and compatibility with the current heating and cooling systems. Buildings relying on electric heating may require retrofitting of hot water coils, adding costs and impacting competitiveness and project penetration rates. For new buildings, changes to building regulations should be considered.
— ***Heat production:*** Consideration of the configuration of boilers to meet base and peak loads, as well as opportunities for renewable sources such as solar thermal, or available heat sources from large power plants and energy-from-waste plants.
— ***Thermal storage:*** The possibility of including thermal storage to provide a buffer in the system and reduce heat dumping.
— ***CHP:*** Potential opportunities for integrating CHP to produce thermal and electrical energy from a single fuel source.
— ***Cooling production:*** Compression or absorption chillers, ice storage to buffer the system, and potential opportunities for combining heat and cooling on the same network.
— ***Phasing:*** For new developments, the phasing and timing of construction of new buildings must be considered. It can help reveal the optimum route and size of pipes for the network and good locations for the central plant, which might influence the phasing plan.
— ***Routing and network measurements:*** Length of the network, height of the buildings, and local topography are needed to calculate the temperatures and pressures for the network.
— ***Network heat losses:*** How much heat escapes from the pipes between the heat source and the customers.
— ***Connections:*** The type and scale of connections and pressure breaks between different network elements (for example, transmission and distribution), including the customer interface that transfers the thermal energy to the building's internal system.
— ***Land availability:*** The appropriate and optimum location for the central plant will need to be determined.

5.1.1 Central plant
The data on loads is used to specify an appropriately sized lead heat or cooling generator, or prime mover, to supply base load, and back-up boilers to meet peak load. At this point in the feasibility study, it is important to determine whether CHP will be integrated into the system. If the scope of the project involves CHP, a number of additional factors must be considered in the feasibility study, including:

- thermal profile;
- heat or cooling rate;
- heat or cooling to electric ratio;
- price sensitivity of fuel;
- the potential to sell excess power to the grid/local utility.

A thorough evaluation of the electricity market is required to determine the opportunities to export excess power for sale and the policy drivers affecting the viability of interconnection. This power can be sold on a wholesale basis to the utility grid under federal law and, under certain state laws, depending on the circumstances, used directly by or sold to end users, displacing their retail electric purchases. Only after demand has been characterized and power use/sales potential verified can the plant configuration be determined. The most popular CHP plants are natural gas-fired turbines coupled with steam turbines and **heat recovery steam generators (HRSG)**. CHP sizing software is available on the **EPA** Combined Heat and Power Partnership website: www.epa.gov/chp/.

The electrical or thermal output of a CHP system can be used to produce chilled water. Hybrid plants integrate electric and steam-driven chillers and often provide valuable balancing benefits to CHP facilities. Direct or steam absorption chillers can also be used to take advantage of excess heat.

Central plants can accommodate a variety of different heat production equipment. Gas-fired heat-only boilers are very flexible and can be used to provide backup heat or base load demand, along with further boilers to meet peak demand. When biomass or a solid fuel such as coal is used, it is typically deployed to meet base load, since it has less flexible cycling and ramp times. Gas peaking boilers or thermal stores, which store heat, can respond quickly, and are used to meet peak loads. Electric boilers can also be included, as they provide balancing services to regional grids and microgrids, which require a high level of intermittent, renewable generation capacity.

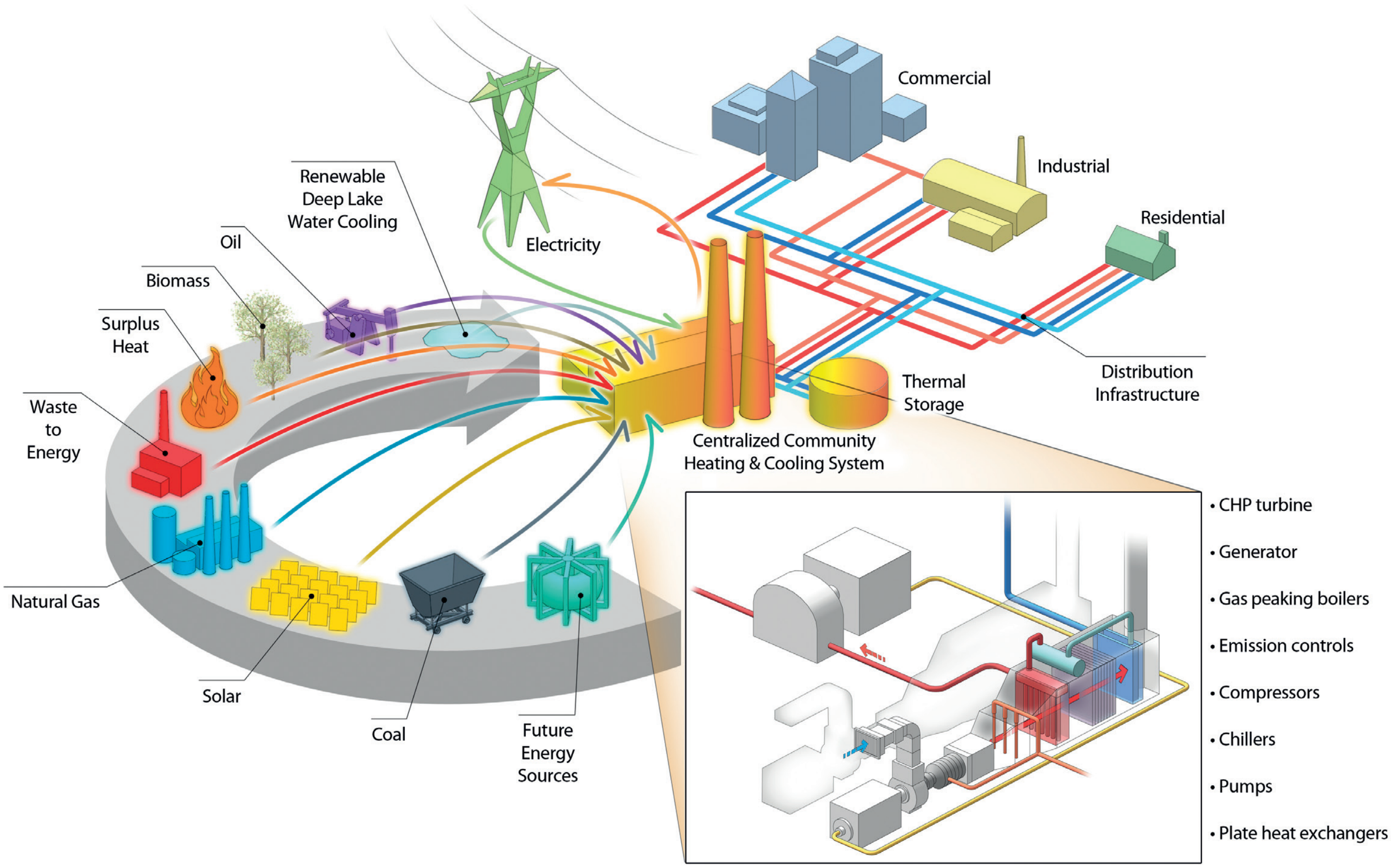


Figure 15: District energy can integrate a variety of fuel sources to take advantage of market conditions and local resources. The central plant houses the prime movers which will vary based on the plant design and configuration.

Planning the siting of a central plant requires detailed consideration to identify the optimum location. Access for transportation can be a factor if bulky fuels such as biomass are being used. Canals and navigable rivers can be used to transport such fuels cheaply and with minimal impact. Plants using natural gas have more flexibility in their location. Many towns and cities may have former industrial sites on the edge of downtown areas, which could be used.

Such former industrial sites are ideal for re-planting thermal networks serving adjacent central business districts. Consideration should also be given to large industrial plants that could be the catalyst for the development of a network to make use of any spare capacity to heat or cool neighboring buildings.

Lastly, the planning of a new power production plant should identify sites that can co-locate with significant heat demands to facilitate the development of district energy networks. Steam from such plants can be used during the summer in absorption chiller plants to provide air conditioning and therefore reduce peak demand on power production and ease capacity constraints on power networks. Integrating electrical and thermal output in this way maximizes overall system efficiency.

These decisions require a fairly involved review, which should be conducted by a qualified engineering firm that can help complete an extensive analysis. They will also need to be familiar with regional permitting in respect of air quality requirements. An in-depth evaluation of the economics of the available options will determine the optimum configuration.

5.1.2 Fuel

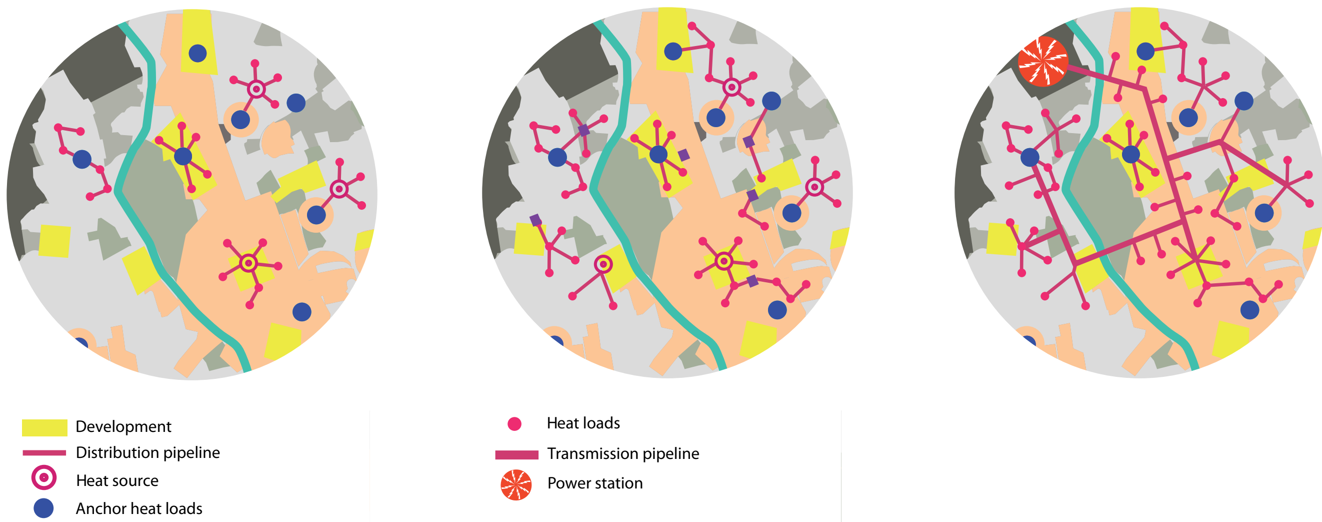
Some thought must be given to types of fuel and their supply chains, as well as space for the delivery, storage, and handling of bulky fuels, such as biomass. These issues will help determine the feasibility of the heat or cooling production systems.

5.1.3 Future proofing

This includes:

- planning space for additional capacity within the plant utility to cover future expansion of the network;
- a building design that will allow plant replacement and the later fitting of new technologies, such as fuel cells or biomass CHP;
- sizing pipe work to allow future expansion of the network.

Ideally, these factors should be considered as an integral part of the master planning process in new building developments.



1. Nodal networks develop around anchor loads, often linked to new development, served by a small heat source.

2. Networks expand and larger heat sources start to emerge to meet growing demand.

3. Networks begin to link to each other in order to share excess heat capacity. Original heat sources are replaced as they reach the end of their life, potentially with waste heat from a power station. A transition main will carry large volumes of heat over long distances.

Figure 16: These diagrams show network development.

5.2 Gradual development

Many projects develop as heat- or cooling-only projects until the network, and therefore the load, is large enough to justify full CHP. This is a useful approach in the phasing of new-build projects. Other opportunities for heat production that could augment the project, such as solar thermal, heat pumps, and geothermal, as well as sources of waste heat near the project, need to be considered at the same time. These opportunities should be considered since:

- technologies may not be compatible with CHP. Solar thermal, for example, might result in an excess of heat in summer;
- different technologies may produce temperatures that are too low for district heating.

Another approach is to build a **nodal network** that involves development of smaller, localized district energy systems sized to meet the needs of the immediate area. Ultimately, these smaller systems would be linked together as market penetration allows and system interconnection merits.

This gradual approach is in line with energy strategies adopted by a growing number of cities for the emergence of extensive district heating networks over the long term. Meanwhile, developments need to be designed to be ready to connect when they are able to do so. Planning policy, informed by energy maps, is central to supporting this process and ensuring future customer connections (see page 19). In Seattle, Washington, Resolution 31329 provides for mapping and system development to proceed in localized increments. Similarly, the Portland, Oregon Development Commission has advanced an effort to plan for energy at a district and neighborhood scale.

In other cases, it may be heat available from large industrial boilers or a CHP plant with spare heat capacity that is the catalyst for developing a district energy network. San Francisco's plans for a Central Corridor EcoDistrict include a district energy network to link to the existing district energy plant.

5.3 Finance

The capital, operational, and maintenance costs, along with likely revenues from heat, cooling, and electricity sales, should be roughly estimated at this stage, too. Here it is appropriate to use a more sophisticated financial appraisal methodology than in Stage 4. For example, discounted cash flow, that takes into account future cash flows and discounts them to present-day values; and life-cycle costing that identifies avoided future costs such as boiler replacement. This will help to establish whether the proposed project is economically viable and affordable for customers.

Rates of return can be calculated and reviewed based on a variety of sensitivity analyses, including debt-to-equity ratios, weighted average cost of capital, and various forms of capital resources. Capital resources include bonds, loan guaranteed debt, and potential government program funding from grants, loans, or tax policy. Some projects may be eligible for clean energy development bonds and, on a state level, energy efficiency credits, or even **renewable energy credits (REC).** It is important to fully evaluate the range of financial resources available to project development. For more information, see Stages 8, 9 and 10.

5.4 The optimum solution

The feasibility study may produce a range of scenarios, using different permutations of technologies and design arrangements, in order to identify the optimum technical solution. It is important to conservatively project revenue and the timing of sales revenue from customer connections, and to include reasonable capital costs and contingencies to capture the project capital risk. Some time should be allotted for running iterations on a sensitivity analysis to evaluate the impact on rates of return for various scenarios. Depending on whether the project principals are private investors, public entities, or partnerships, this may alter the rate of interest targets and financial viability of the project. There is more information on undertaking options appraisals and feasibility studies available from the U.S. Department of Energy Clean Energy Application Centers.

Case study: District cooling in Canadian city fed by deep lake water

Figure 17: Enwave's Deep Lake Water Cooling uses the icy water of Lake Ontario to provide renewable cooling for the city of Toronto.

Image and text courtesy of Enwave

An innovative renewable district cooling system and upgrades to Toronto's district heating system have brought efficiency and environmental benefits to a reliable system with a long history of serving the city's commercial and residential inhabitants.

A unique partnership between Enwave and the City of Toronto enabled the city's downtown core to use an alternative to conventional, energy-intensive air conditioning, and to implement the largest lake-source cooling system in the world.

Commissioned in 2004, Enwave's 75,000 ton (TR) Deep Lake Water Cooling (DLWC) system uses Lake Ontario's icy water as a renewable energy source. In winter, the surface of the lake cools to about 39° F. This cold water's density increases, causing it to sink. In summer, the surface water heats up, staying at the surface as it is not dense enough to sink. No matter how hot the summer, the deep water remains very cold. Over time, this phenomenon has created a permanent cold water reservoir at the bottom of Lake Ontario.

Three pipes that run along the natural slope of the lake bottom pump water from a depth of 83 meters to the Toronto Island Filtration Plant. There, the cold water is processed, then directed to Enwave's Energy Transfer Station, where heat exchangers facilitate an energy transfer between the cold lake water and Enwave's closed chilled water supply loop. The lake water continues on to the city's potable water system. Only the coldness of the lake water is harnessed, not the water itself. As a result, DLWC provides a unique, green alternative to conventional air conditioning.

DLWC reduces electricity use by up to 90% and reduces 61MW of demand on the electrical grid each year, a shift that provides environmental benefits to all customers. The DLWC system eliminates ozone-depleting refrigerants and reduces emissions of harmful pollutants, including NOx, SOx, and CO_2. The environmental benefits are equivalent to removing 15,800 cars from the road.

In 2011, Enwave completed an extensive efficiency upgrade of its Pearl Street Station district heating plant in downtown Toronto. This has reduced natural gas consumption and carbon dioxide emissions, and lowered energy costs. The Pearl Street Station plant now achieves seasonal efficiencies of greater than 92%.

Developers building in areas with district energy are freed from environmental permitting challenges and energy production uncertainty and can focus on designing buildings that take advantage of the increased leasable space created by removing in-building heating and cooling systems. Planners and city officials can attract developers of state-of-the-art buildings to populate a strong, transit-oriented and walkable downtown district that attracts high-quality commercial and residential tenants. These are true economic advantages in a competitive global market.

STAGE 6 Financial modeling

The feasibility study and the financial modeling usually need to be undertaken in a reiterative process. They each inform and have consequences upon the other. However, the financial modeling undertaken in the feasibility study is relatively basic and now needs to be investigated in detail.

6 Feasibility and finance

Having determined the technical feasibility and basic financial viability of the project, viability needs to be tested in more detail. In many proposals, factors beyond the project boundary will have a positive impact on the viability of the project. For example, linking the new-build development to existing buildings or communities, particularly anchor loads, achieves a greater economy of scale and makes the scheme more attractive to investors.

The type of business model (see page 36) chosen for the project will affect its financial viability. Particular organizations have different perspectives on capital costs. Public sector organizations generally view investment in infrastructure as a means to an end of achieving broader objectives and are willing to accept a longer-term payback. They can also access capital at a lower cost, whereas capital costs to private sector, profit-making organizations are higher and they require shorter-term paybacks. Therefore, it may be appropriate to undertake the financial modeling using a range of rates of return. This will help determine the appropriate business model to deliver the project.

Once again, for complex projects, expert help will probably be required. Some engineering or multidisciplinary consultancies employ expert staff in this area, but financial advisors with the relevant expertise may also be helpful. Selling heat is relatively simple, but trading in electricity is extremely complex, involving a wide range of policies, regulations, charges, incentives, taxes, and exemptions. It is advisable to choose a consultant who is very familiar with this field.

6.1 Aims and objectives

Financial modeling should begin by re-stating the project's aims and objectives.

— ***Financial viability:*** The financial model must have a positive value. At first pass it may not, in which case, adjustments to the technical and business model, innovative financing, or further fundraising may be necessary.

— ***Affordability to consumers:*** For commercial customers, connection to a district energy network must be a competitive proposition in comparison to the business-as-usual case (gas supply and cost, operation, and maintenance of plant). For residential customers, it may be that convenience and quality of service are equally important.

— ***Reducing emissions, including SO_2, NOx, CO_2:*** This may be considered on a regional basis. It is important to determine what market mechanisms might exist to monetize emission reductions progress.

— ***Supply security:*** This has a value to commercial customers and is especially important for mission-critical facilities such as hospitals.

— ***Sustainability:*** Communities that pursue transit-oriented development to achieve livable communities centered on lifestyle and convenience create a valuable local economy that can attract new businesses and residents. Companies want to locate in eco-districts and see a strategic value in investing in such locations.

6.2 Creating a spreadsheet

The next task is to set out all the costs and benefits in a spreadsheet (see Figure 18, page 31). Below are the costs you need to include.

6.2.1 Capital costs

All the capital costs required for the development and delivery of the project, including:

- land for plant utility;
- plant: CHP engine sized to meet base load; back-up and peak boilers to meet peak load; as well as pumps and ancillaries;
- pipes for distribution network;
- consumer hydraulic interface units for bringing heat from the distribution network into the building (not including internal heating system);
- soft costs including engineering permitting, land-use approvals, and rights of way;
- construction and installation costs.

Cash Flow Analysis of 13 MWe Natural Gas Turbine CHP Plant and District Heating and Cooling in Town Center (In Thousands of Dollars)

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Capital Costs																
District Energy CHP Plant costs (including plant, boilers, chillers, etc.)	(12,766)	(12,766)	-	-	(11,489)	-	-	(11,489)	-	-	(2,553)	-	-	-	-	-
District heating and cooling network costs	(2,924)	(2,193)	(1,462)	(1,462)	(1,462)	(1,462)	(731)	(731)	(731)	(731)	(731)	-	-	-	-	-
Cost of building connections	-	-	(724)	(724)	(483)	(483)	(483)	(241)	(241)	(241)	(241)	(241)	(241)	(241)	(241)	-
Operating Costs																
Natural gas costs	$-	$-	$-	$(755)	$(1,510)	$(2,264)	$(3,019)	$(3,522)	$(4,026)	$(4,277)	$(4,529)	$(4,781)	$(5,032)	$(5,032)	$(5,284)	$(5,535)
Plant O&M costs	$-	$-	$-	$(330)	$(659)	$(989)	$(1,318)	$(1,538)	$(2,483)	$(2,639)	$(2,794)	$(2,949)	$(3,104)	$(3,104)	$(3,259)	$(3,415)
Revenues																
Revenue from sale of heat	-	-	-	913	1,826	2,739	3,653	4,261	4,870	5,174	5,479	5,783	6,088	6,088	6,392	6,696
Revenue from sale of cooling	-	-	-	1,408	2,815	4,223	5,630	6,569	7,507	7,976	8,446	8,915	9,384	9,384	9,853	10,322
Revenue from sale of electricity to grid	-	-	-	527	1,054	1,580	2,107	2,458	2,810	2,985	3,161	3,336	3,512	3,512	3,688	3,863
Total revenue	-	-	-	2,848	5,695	8,543	11,390	13,288	15,187	16,136	17,085	18,034	18,984	18,984	19,933	20,882
Total cost in year	(15,690)	(14,959)	(2,186)	(423)	(9,907)	3,345	5,839	(4,233)	7,705	8,248	6,237	10,063	10,606	10,606	11,148	11,932
Cumulative Costs	(15,690)	(30,649)	(32,835)	(33,258)	(43,165)	(39,820)	(33,981)	(38,214)	(30,509)	(22,261)	(16,024)	(5,961)	4,645	15,251	26,399	38,331
Net present value	(15,690)	(29,936)	(31,919)	(32,285)	(40,435)	(37,815)	(33,457)	(36,466)	(31,250)	(25,934)	(22,105)	(16,221)	(10,315)	(4,691)	940	**6,679**
Discount rate	**5.0%**															

Figure 18: Financial modeling spreadsheet: phased development of public sector project with initial phase operating natural gas boilers and electric chillers. 6.5MWe of CHP capacity added in Year 4 and in Year 7 to meet load growth. **Courtesy of FVB Energy Inc**

6.2.2 Operational costs

All costs associated with the operation of the project over a 25-year term. These are:

- — input fuel (natural gas, oil, and/or biomass);
- — electricity for lighting and pumping;
- — maintenance;
- — billing and revenue collection, including bad debt provision;
- — operational management;
- — customer care, including emergency cover;
- — capital interest and repayments;
- — insurance;
- — property and income taxes;
- — contributions to sinking fund for replacement of the system at the end of its life. To ease the financial burden, this may be introduced after senior debt has been discharged;
- — legal and financial advisor fees.

6.2.3 Capital contributions

— *Debt:* Most district energy projects are developed using a mix of debt and equity financing. Loans are obtained from banks, based on robust financial models showing positive cash flows over the full term. Repayments are made from revenues. Long-term contracts can be used as collateral to secure debt at competitive interest rates. Interest payments on debt are tax-deductible for the entity making the payments, whereas equity payments are not. Project developers should seek expert advice on tax matters. Increasingly, innovative financing programs have been employed by states to encourage investment in energy projects. For example, a Connecticut law allows municipalities to establish **Energy Improvement Districts (EID)**, which can develop and operate distributed resources such as small power plants.[2] The municipalities are given a wide range of powers to support the EID, including authority to issue and guarantee tax-exempt bonds to pay for the construction and development of energy projects.

– *Equity:* This may come from a variety of stakeholders, ranging from those with a direct interest in the project, to remote investors. It can also come in a variety of forms, including assets and cash. Different sources will have different expectations in terms of return. Typically, viable projects will attract private equity investment in return for an appropriate equity stake. The predictability of positive cash flow associated with a district energy project is the key aspect that attracts equity. Investments may also include equity from consumers and/or communities, notably pension funds.

— *Grants:* There have been several federal grant opportunities, for example the **Energy Efficiency and Conservation Block Grant** (**EECBG**) Program, initially funded through the **American Recovery and Reinvestment Act (ARRA)** of 2009. Although ARRA funding has largely expired, some states leveraged energy grant money by establishing **revolving loan funds (RLF)**. RLFs extend the impact of the initial ARRA grants, which were limited by a three-year timeframe, by providing loans for energy projects at lower interest rates and using the repayments to enable more lending. More information on funding available through state-administered revolving loan programs is available from the **National Association of State Energy Officials (NASEO)**. Grant availability will change over time. For current information, check the IDEA website: www.districtenergy.org

— *Connection charges:* To help offset the capital cost of installing and building a network, customer connection charges can be used. By connecting to a network, buildings or developments will avoid the expense of installing their own on-site system and may, therefore, be able to contribute towards the cost of a network. This cost might be set at a slightly lower rate than the on-site alternative as an incentive to connect. A hurdle rate analysis is typically used to evaluate the economics of connecting new customers. The developer determines the minimum acceptable rate of return on equity needed to ensure the system remains financially viable. If a customer does not meet this minimum or hurdle rate, the developer can ask for a contribution to the cost of connection to compensate.

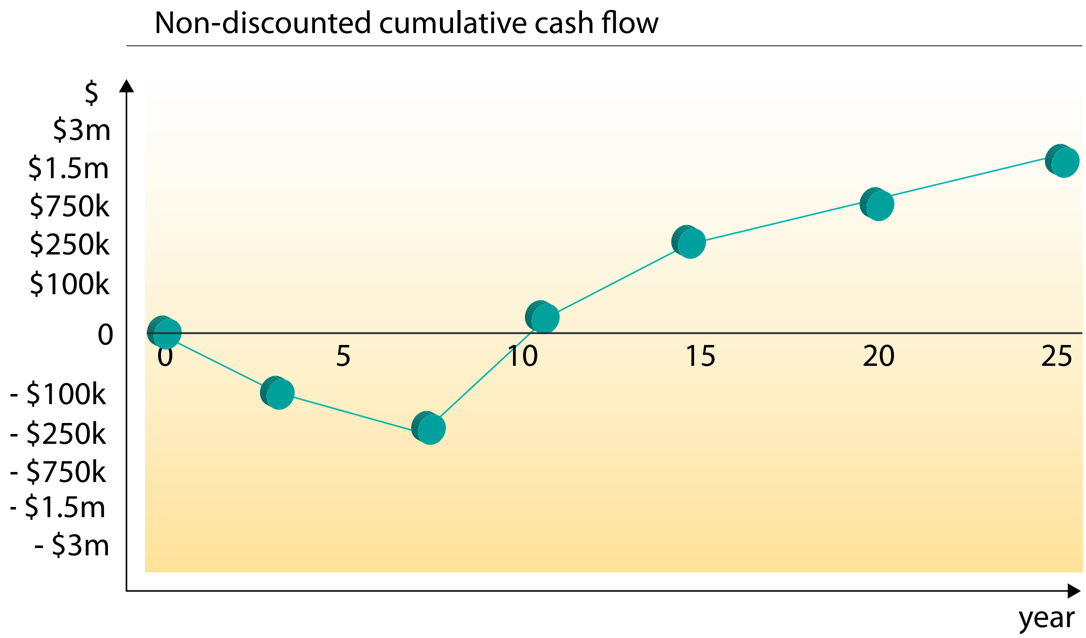


Figure 19:
This graph shows projected cumulative cash flow over a 25-year term.

— Land availability: Public sector landowners may be open to making land available for plant sites for free, or below market values, in return for an equity stake in the project or special purpose vehicle, which is a separate company specifically set up to oversee all aspects of development of the energy system.

6.2.4 Revenues: income

— Thermal energy charges: Payment for the supply of thermal energy to customers. Often tariffs or service agreements include two principal components: a Capacity Charge and a Consumption Charge. The Capacity Charge is based on the fixed-cost recovery of plant, the piping network, and customer interconnection costs, and is allocated based on total capital investment to be recovered over the life of the asset. It is billed monthly and is often determined based on the one-hour peak requirement of the customer. The Consumption Charge is based on recovery of direct variable costs, like fuel and water, and is billed monthly on the recorded metered usage in Btus for heating or cooling. Income may also be derived from state-level revenue support mechanisms as there is also growing recognition of thermal energy in Attribute Sales. In Washington State, for example, renewable thermal energy qualifies for Renewable Energy Credits (RECs).

— Electricity revenues: These will only apply when a power-generating plant is included, such as CHP. States with programs such as **Renewable Portfolio Standards (RPS)**, **Alternative Energy Portfolio Standards (AEPS)**, and **Energy Efficiency Resource Standards (EERS)** are increasingly listing CHP as an eligible technology. Electricity revenues include actual sales of power as well as Attribute Sales for Renewable Energy Credits. These vary between States. California gives carbon credits whereas Texas allows benefits for NOx reductions. Similar to the sale of thermal energy, there may also be separate revenue streams for the sale of electric energy and capacity, depending on who is buying the power and in which market.

— Maintenance charges: These cover maintenance to the plant and network, as well as equipment within the customer's property.

— Tax benefits: Credits, exemptions, and accelerated depreciation mechanisms can reduce tax rates. These may be available at a federal level, or vary by state and type of project. More information is available from the **Database of State Incentives for Renewable Energy** (**DSIRE**). See www.dsireusa.org.

Once this work is complete, the data must be analyzed using the assessment methodologies discussed on page 25. At this stage, it is most appropriate to use life-cycle costing methodology, including discounted cash flow. This will show if the project is financially viable by providing a positive or negative net present value (NPV). Simplistically, capital contributions should be offset against capital costs. Income must meet operational costs, support capital servicing (interest charges and payback of loans and investments), and leave a surplus for the project to be financially viable. It may be useful to use a range of internal rates of return, as this will help identify the most appropriate business model to deliver the project.

6.3 Risk assessment

The financial model will be vulnerable to a variety of risks. Therefore, a risk assessment must be developed. Ideally, the risk assessment is drawn up with other stakeholders in the project, as they may identify risks the project developer has overlooked. The risks then need to be evaluated in terms of how likely they are and how significant the consequences. They can next be designated as high, medium, or low risk and allocated to the party best placed to manage them. For risks that remain with the project, strategies must be developed to manage them.

At the end of this exercise, there will be risks outstanding. These will be monetized in the financial model. The model then needs to be subjected to a sensitivity analysis of these risks. The key ones are:

— balancing generation and demand, which includes the critical issue of phasing: plant and infrastructure must be installed before demand commences; development phasing must consider the preferred energy strategy at the master planning stage so that potential issues can be identified and addressed.

	Risk Description	Risk Ownership	Impact Description	Impact Severity	Probability	Action Status	Mitigation Strategy	Revised Impact	Revised Probability	Action Status
Engineering design	Poor technical design	Technical Sub-Group	Project fails to achieve objective; project fails to achieve financial viability	High	Possible	Manage	Check track record of engineer; check references; peer review; check Professional Indemnity in place	Low	Low possibility	Review
Planning and permitting	Fail to secure permits	Planning Sub-Group	Project cannot proceed	Extreme	Possible	Actively manage	Early understanding of requirements; early engagement with officials; ongoing engagement, adjustment, and review	Low	Possible	Actively manage until secured
Construction	Poor construction and installation	Technical Sub-Group	Work requires correction and remediation; adverse impacts on project schedule and budget	High	Probable	Actively manage	Monitor and review; set standards in contractor agreements; obtain insurance cover	Off-set	Off-set	Monitor and review
Performance	Plant and equipment fail to achieve performance specification	Technical Sub-Group	Project fails to achieve objective; impact on financial viability	Medium	Possible	Actively manage	Include performance specification in supplier/contractor agreements; obtain insurance	Off-set	Off-set	Monitor and review
Demand	Does not meet expectations; reduces due to customer actions and/or behavior	Commercial Sub-Group	Impact on technical performance; impact on financial viability	Medium	Possible	Actively manage	Early and ongoing engagement with customers; accurate consumption data monitoring; cooperation agreements on customer equipment; volume or price guarantees in contracts	Low	Low possibility	Actively monitor and review
Input fuel pricing	Prices increase more than anticipated	Commercial Sub-Group	Impact on financial viability	Medium	Possible	Manage	Use market forecasting service; secure long-term or flexible supply contracts; adjust technical design to allow use of alternative fuels	Low	Possible	Review
Output pricing	Revenues fail to cover costs	Commercial Sub-Group	Impact on financial viability	High	Possible	Manage	Active monitoring of costs; liaise with Technical Sub-Group on performance; indexation in customer contracts	Low	Possible	Actively review

Figure 20: Example of a risk assessment.

- — permitting and regulatory risks of plant siting;
- — cost over-run in construction;
- — plant efficiencies failing to reach design specification;
- — plant failure;
- — fuel price variation;
- — non-payment by customers;
- — delay in insurance payments for damage to property.

The analysis must look at the likelihood of the risks occurring at various levels and how sensitive the financial model is to them. For example, would the project still be financially viable if fuel costs increased by 5%, 10%, 15%, and 20%? If so, then the model is robust. See an example of a risk assessment in Figure 20, on page 33.

6.4 Project risks

One of the biggest issues in developing district energy systems is the lead/lag on capital investment and revenue return. It is critical to evaluate cost-effective energy efficiency and environmental mitigation strategies, and develop realistic assumptions on the timing of capital deployment, system operations, and market penetration. Capital must be expended before revenues start coming in. This initial investment in plant and distribution piping has to be timed so customer connections follow as soon as possible. Delays in generating revenue from thermal energy sales will negatively impact the rate of return. Sequencing phases of capital deployment to match customer uptake is vital, particularly where new construction is an integral and early portion of the customer mix. This must be considered in the master planning and in the development plan. The overall penetration and timing of completion and occupancy of new buildings can impact the onset of revenue streams and may also affect the type of business model selected to deliver and operate the project. The financial study should consider these issues to ensure there is sufficient capital in reserve to overcome this gap.

Projects that fit connections to pre-existing buildings have the advantage that heating/cooling loads already exist and can provide a revenue stream from the moment of connection. Projects financed with debt have to make capital re-payments from the start of the loan. This may not be a problem, but if there is a lot of capital involved and the break-even point is lengthy, it may create cash flow difficulties for the financial model, or even render it unviable. Projects financed with equity do not have the same problem.

However, the particular constitutional arrangements for the business model may limit the use of equity. Alternatively, the overall capital requirement may be reduced by structuring the business model so it tenders out the energy center and equipment on a **design, build, finance, and operate (DBFO)** arrangement to a third party.

It is clear that the business model must be considered at the start of the project and again at the same time as the financial modeling, as one may need to be adjusted in light of the other.

Case study: district cooling at Atlantic Station

Figure 21: A central chilled water plant and district cooling network provide efficient air conditioning to the buildings in Atlantic Station, a model mixed-use development in Georgia

Atlantic Station, a mixed-use development at the northwestern edge of Midtown Atlanta, is a model for smart growth and sustainable development. Atlantic Station combines a mix of middle-income and upscale housing with restaurants, theaters, and retailers, with a philosophy of “live, play, and work in the same community”. Providing homes for 10,000 people, employment opportunities for 30,000, and shopping and entertainment for millions more, Atlantic Station is a 24-hour community. First planned in the mid-1990s and officially opened in 2005, its 138 acres represent urban renewal on the former brownfield site of the Atlantic Steel mill. To date, five million square feet of space have been constructed, with the ultimate build-out projected to include 12 million square feet of retail, office, residential, and hotel space, as well as 11 acres of public parks.

With average high temperatures in Atlanta exceeding 80^{o} Fahrenheit from May through September, reliable air conditioning is needed. To ensure the comfort of the residents, workers, and visitors at Atlantic Station, Veolia Energy North America owns, operates, and maintains a central chilled water plant, consisting of state-of-the-art York electric chillers and a pipe distribution network of two miles. The 7,500-ton capacity plant cools Atlantic Station efficiently, without the need for individual air conditioning units throughout the development, and serves as the cornerstone for a dedicated district cooling network. Plant operations are remotely monitored, with only one employee on site. Notably, most of the piping that distributes the chilled water from the central plant to the various buildings within the development is located in the common parking structure, and is not buried under the ground. Constructing distribution pipes above ground is less expensive than burying them.

Image and text courtesy of Veolia Energy North America

STAGE 7 Business modeling

There are four basic business models within the context of district energy projects: **private project development companies** (**PPDs**), public project development companies, hybrid public/private partnerships, and stakeholder-owned special purpose vehicles (SPVs). Sources of finance, the roles required to deliver and operate a low-carbon energy project, and the proportion of private and public sector involvement must all be considered.

7.1 Risk and objectives

Throughout this guide, the importance of the project developer's attitude to risk and their desire for control has been discussed. Most organizations wish to minimize their exposure to risk but, as a general rule, risk should be assigned to the parties that are best able to manage it. However, transferring risk can have financial implications. Risk will be monetized and this could add to the financial burden carried by the stakeholder that accepts it.

Public sector project developers can generally accept a lower rate of return than private sector ones. They can also access capital at lower rates than private companies, as financiers can be more certain of getting their investment back. Consequently, if a project is transferred from the public sector to a private company, the weighted average cost of capital is likely to increase and this may affect the viability of the project.

Furthermore, if the ownership of a project is transferred to a private company, then the host organization for a project may relinquish operational control over its future direction. This may not be a problem unless the primary objectives are long-term social or environmental benefits. For example, a municipality may want to develop a district energy project as part of the regeneration of a run-down area. Low-cost energy may add to the pace and viability of an urban renewal program and regeneration package. As such, the municipality may be willing to take a long-term view as it knows that if the regeneration is successful, it will stimulate economic activity, building developers will invest in renewal or new construction, property values will rise, and business sales and tax revenues will increase. However, a private company cannot take such a long-term view and it will want a shorter return on its investment.

Alternatively, a private real estate developer may wish to engage a private energy company to design, build, own, and operate a district energy project serving a new development. The primary purpose for the property developer is to comply with planning obligations, build out the property for lease, and prepare it for sale and subsequent exit. It will not want a continuing relationship with the occupants through supplying them with energy. However, if the project provides a sufficient rate of return for the project development energy company, a longer term operating arrangement may be an attractive business model.

Project champions considering which model to adopt will need to select the one that is going to provide the project with the best chance of success.

7.1.1 Project developers (PDs)

For the reasons given above, it is important for the host organization to decide on its objectives, what risk it is prepared to accept, and how much control it wishes to have over the project in the long term. These considerations will then help it decide on the most appropriate business model to apply to deliver the project.

Such business models frequently include utilizing project developers (PDs) of one sort or another. PDs vary in the scope of services that they offer. Some may offer the full spectrum of the **DBOOM** set of roles (**design, build, own, operate, and maintain**) while others may specialize only in offering subsets of those services under contract.

PDs may be public or private organizations, hybrid public/private entities, or third sector organizations, such as residents' cooperatives. The key features of a PD are that it has a separate budget and business plan from the host organization and it provides a focused management of the energy project. The business plan will typically be over a long period and should be sound enough to attract external investment into the project. Below you can see the strengths and weaknesses of the different PD arrangements.

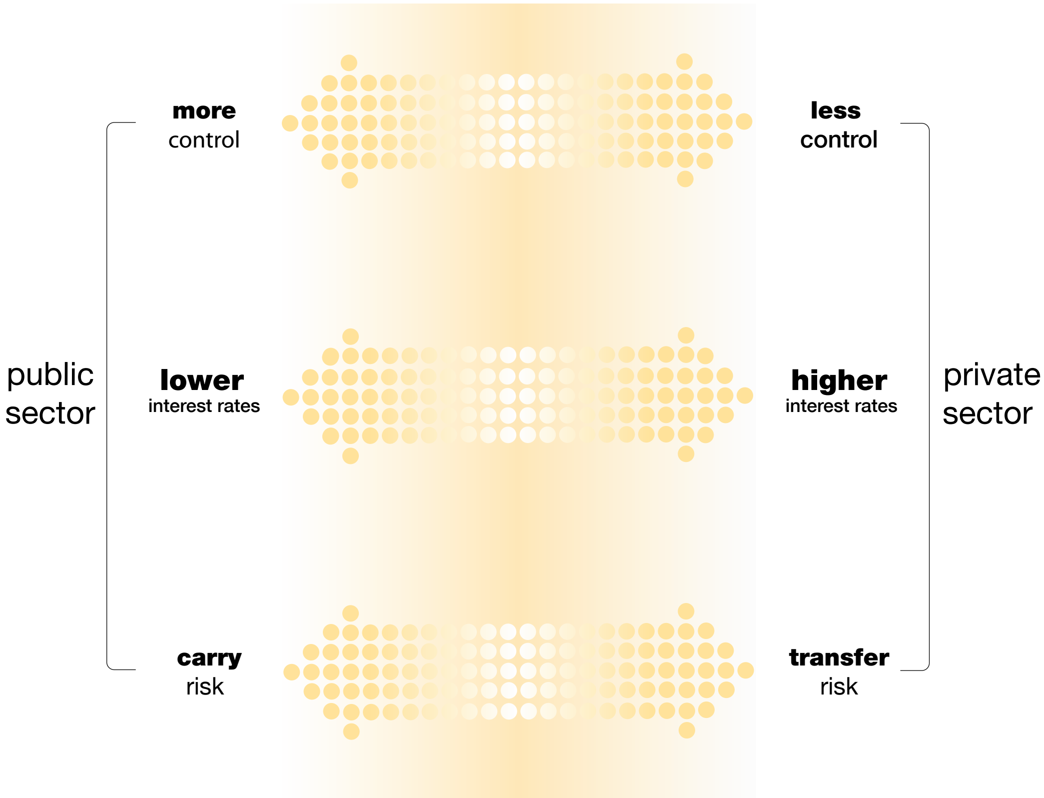


Figure 22: This diagram shows the relationship between risk, control, and the cost of capital for public and private sector projects.

7.2 Private Project Development Companies (PPDs)

There are a number of private companies operating in the energy services market with specialized expertise in the design, construction, operation, and optimization of central plants and district energy networks. Around the globe, PPDs provide energy management services to municipalities, governments, institutions, and other private sector entities as part of a concession arrangement. Recently, larger utility companies have entered this market, either directly or by buying or taking a stake in a specialist company, thus providing solid financial backing. These are profit-making organizations. To interest them, projects need to be sufficiently scaled (approximately one million square feet of new commercial space or 200-500 housing units in the first phase), with appropriate densities and/or an attractive mix of uses and loads. Small (less than one million square feet or 200 units), wholly residential developments may not interest them. This threshold will drop if there's a mix of loads or a large anchor load nearby.

PPDs may also be interested in extending existing systems to new or existing buildings where the cost of connection will be lower for the building owner than installing or replacing their own plant. These companies can arrange external funding, although the building owners or developers may still need to make a capital contribution for the project to be viable within a reasonable contract length. At a minimum, this is likely to be the cost of providing the business-as-usual case.

The strengths of this approach are:

- the private company invests and carries the financial risk;
- they bring substantial expertise specific to the technology, with extensive project management and operational skills, enabling them to carry the technical risk;
- they continue ownership and operation over the long term.

Weaknesses are:

- higher rates of return are required and energy charges may be higher;
- public sector sponsors lose control and are unable to direct future development, particularly for projects with a low rate of return;
- customers are tied into a private company with the risk of monopoly abuse.

7.3 Public Project Development Companies

A large number of municipalities own and operate public municipal utility companies for purposes of distributing electricity. Many are listed at: www.utilityconnection.com. These public power companies generally serve the buildings and citizens only within the border confines of their city or town. Local governments can form municipal utilities for the purpose of building, owning, and operating district energy companies as well. For example, in Minnesota, a number of municipal district energy companies are owned and operated as non-profit energy providers, including those in Duluth, New Ulm, and Hibbing.

It is possible to establish a municipal utility or special purpose entity with a defined business plan separate from the municipality, which provides a tightly focused management. Utilizing a project financing strategy, it can also borrow against its assets and revenue streams. However, any debts are likely to be consolidated into the municipality's accounts, meaning it carries the financial risk. Thus, the business case should be soundly based on "invest to save" principles. This also allows it to access capital at close to public sector rates. Publicly owned municipal utilities may be subject to different local taxes, enjoy lower borrowing costs, and, within their charter, have a cost advantage in serving not just other publicly owned buildings, but also nearby privately owned ones.

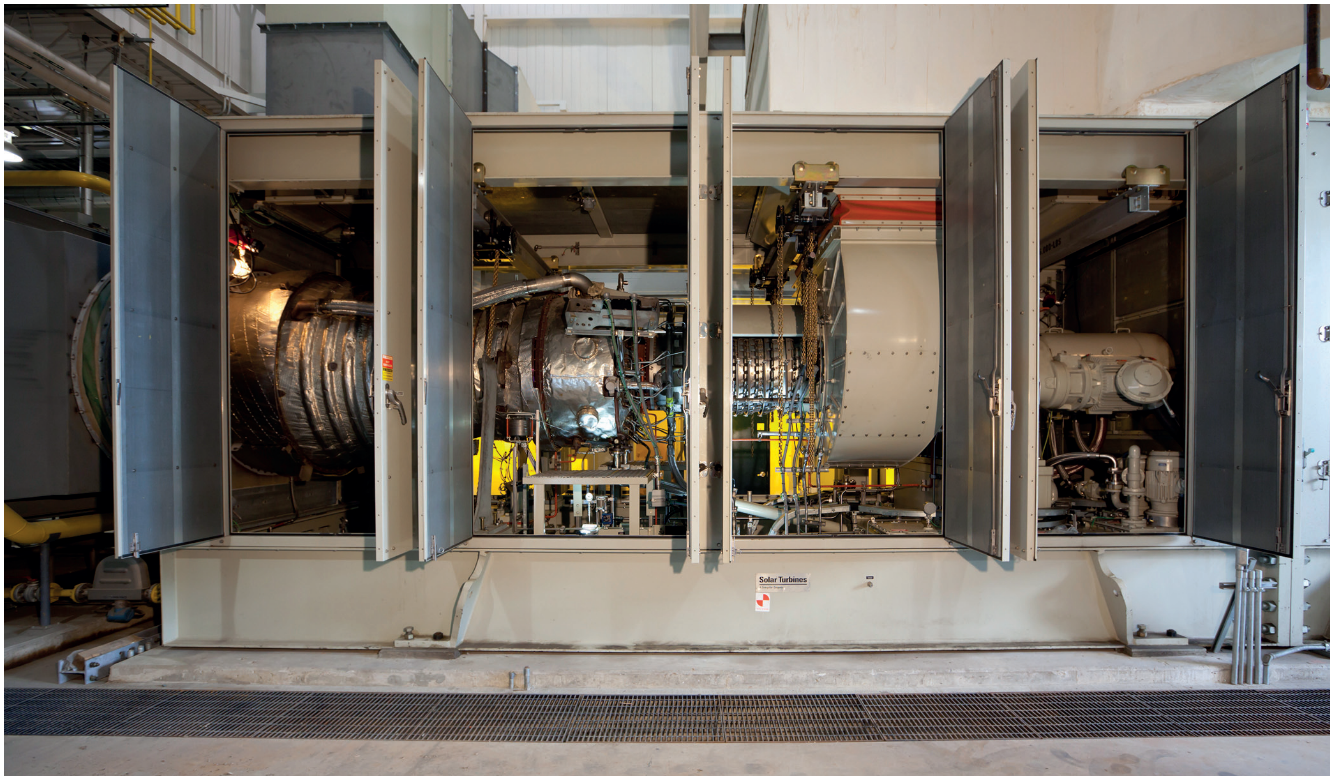


Figure 23: A Solar Turbines Titan 130 generator set provides district heating and electricity to London District Energy in London, Ontario, Canada.

Although the ownership may be with the municipality, the technical design, build, and operation can be contracted out to specialist professional private companies, and it may be that the assets are held by the private sector under manufacturer financing arrangements or forward revenue purchase deals from banks. Thus, technical and financial risk is reduced or passed through.

The strengths of this approach are:

- municipal ownership and control ensures close alignment with municipality social and environmental policies;
- municipal ownership provides covenant strength in obtaining finance, and this will be at a lower cost compared to private sector borrowing;
- dividends can support the delivery of other services;
- future expansion can be coordinated and controlled by the municipality.

Weaknesses are:

- company is reliant on financial strength of the municipality and it will remain on the municipality's balance sheet;
- municipality must be rated as fair or better;
- municipality carries the financial risk.

7.4 Hybrid public/private partnership arrangements

A hybrid PD company may be established in order to share risk between the public and private sectors and to allow it to access external capital at the lower rates available to the public sector. These hybrids could be structured as joint ventures or as special purpose vehicles in which the different parties have a shareholding or membership. It is helpful to think about the different roles necessary for the delivery and operation of a district energy project and to assign these to different parties, or contract them out to specialist professional companies.

For example, in Nashville, TN, the Metropolitan Government of Nashville and Davidson County entered into a contract with a private company to **build, own, operate, and maintain** (**BOOM**) a district energy plant in order to replace an aging County-owned waste-to-energy facility. It structured a long-term contract and established construction milestones under a long-term agreement. See www.nashville.gov/des/news/grand_opening.asp.

Hybrids must follow the requirements of the legislation that was enacted to bring them into being. Possible roles are set out in **7.6**, below.

Establishing a joint venture or an SPV 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**. Below these, there will be a suite of contracts defining relationships necessary for the provision of the energy services. Although sample contracts are available in various publications, they will inevitably require refining to the specific requirements of the host organization.

The strengths of the hybrid approach are:

- close alignment with the socio-environmental aims of the public sector;
- greater flexibility than either wholly public or private approaches;
- able to access capital at lower-cost, public sector rates.

Weaknesses are:

- some risk remains with the public sector;
- liabilities are consolidated into public sector accounts;
- has to comply with public sector procurement procedures.

7.5 Stakeholder-owned special purpose vehicle (SPV)

This is similar to the hybrid approach, above, except ownership is shared amongst a variety of stakeholders. These may be:

- the customers receiving the energy, for example major building owners within a defined location;
- strategic bodies such as the municipality;
- communities or cooperatives.

An example is District Energy St. Paul, which was formed as a private, not-for-profit organization to take advantage of access to public funding and grants, and to foster a cooperative-like business model. The board of directors comprises representatives of the City of St. Paul, Ramsey County, and various designated, rotating representatives of the customer community. This type of vehicle, common in many parts of the U.S., is best suited to projects where their location, scale, and/or nature challenge traditional financing and ownership models, which will often require a risk premium to accept unconventional terms. This option may be well-suited to delivering long-term solutions to areas requiring regeneration or to isolated communities in rural areas. It may also offer greater accountability and transparency. In the near to medium term, a district energy network will be connected to a monopoly supplier. Owning the network reduces the risk of monopoly abuse and may also provide a useful way of gaining acceptance and buy-in to a project, by offering residents or communities a stake in the project.

7.6 Potential roles needed for a successful project

— ***Project champion:*** identification and definition of a project, achieving stakeholder buy-in, initiating technical feasibility studies and financial investment appraisals, initial fundraising, and driving and promoting the project. The project champion could be the local mayor or the sustainability officer seeking carbon reductions, or the economic development officer seeking to create jobs.
— ***Regulation:*** establishing and monitoring standards of performance and/or consumer protection across a wide area, such as a town, city, or region, with which all district energy projects in those areas must comply.
— ***Governance:*** this is specific to the particular entity and is concerned with providing strategic guidance, stakeholder accountability, and high-level relationships.
— ***Developer:*** a more limited engagement concerned with the physical delivery, including design and construction.
— ***Asset owner:*** the party that owns the actual physical assets. This could be a bank or financial investor.
— ***Operator:*** responsible for the project's technical operation.
— ***Retailer:*** responsible for the retailing of energy across the project, for example, buying it from the central plant operator, arranging its transportation to the end-consumer, and its sale to that consumer.
— ***Supply chain manager:*** responsible for the procurement of fuels, equipment, and services necessary for the development and operation of the project.

These roles can be organized in different configurations in order to maximize the benefits and outcomes to the different stakeholders in the most cost-effective fashion. For example, District Energy St. Paul has acted as a project champion in developing district heating in the city. It established the District Heating Development Company initially to construct a new hot-water-based district heating system to serve buildings downtown as an arm's length, not-for-profit company limited by guarantee based on membership. This provided a focused management and a business plan and budget separate from the City and County governments. The City and County are active in guiding the company, with representation on the board, and can therefore influence regulation and governance. It also allows the company to access capital at lower-cost, public sector rates.

However, the company owns the assets and is responsible for development, supply-chain management, and for operation, although many of these activities are contracted out to the private sector. The company retails electricity to a private energy company and variously retails heat to private customers.

Case study: Chicago Lakeside, from steel mill to innovation mill

Figure 24: District energy will provide clean, cost-effective energy services to a brownfield site in South Chicago.

The brownfield site left after the closure of Southworks steel plant, South Chicago, is the focus of an ambitious plan to create a clean, resource-efficient, next-century neighborhood. A cornerstone in the urban concept is a district energy infrastructure, supplying heating and cooling to the neighborhood from local renewable energy sources. District energy enables large-scale utilization of local renewable resources such as biomass, solar, waste, etc.

A study by Ramboll, Denmark, has proven that district energy solutions based on local renewable energy resources offer the cleanest and most cost-effective supply of energy. it also adds comfort for future residents, replacing noisy chillers and other in-house energy supply units. The main features of the proposed district energy systems are:

— ***Efficient use of energy:*** a Lakeside Green Code will set new standards for energy-efficient building design to avoid wasteful energy use. All buildings are required to connect to district energy systems, and in-house energy systems must be designed for low-temperature heating and high-temperature cooling.

— ***District heating system:*** a low-temperature district heating system will supply all buildings of the neighborhood. In the initial stages, when demand is still low, the system will be heated by natural gas. As demand increases, CHP from biomass and/or natural gas will be established. The system will also be able to accommodate other clean local sources such as solar heating, energy from waste water, etc.

— ***District cooling system:*** a district cooling system will be extended throughout the neighborhood. Cooling will be supplied from the bottom of the lake, where the temperature is adequate throughout the year.

— ***A neighborhood utility:*** the district energy system will be managed by a neighborhood-based utility organization/company. This entity will be under the control of the local stakeholders, and it will secure a consistent design of buildings, pipe infrastructure, and supply systems.

The next phase of the project will be to look at the outlined solutions in more detail before more specific design aspects are addressed in concept design and detailed design phases.

Text courtesy of Ramboll Energy

STAGES 8, 9 and 10 Marketing and business development; Project procurement; and Delivery

Stage 8, Marketing and business development;
Stage 9, Procurement of the necessary services, potentially including assigning a project manager and contractors; and Stage 10, Delivery, are the final stages to be completed.

Marketing and business development

8.1 Business development overview

Once the general project has been defined, even with preliminary project schedules and maps, it is important to develop presentation materials and consistent content that describes the physical project, lays out preliminary project phases, and provides an overview of the features and benefits of a local district energy system. Conceptual renderings, development maps, and system interconnection guidelines can be created. Depending on whether the project is a municipal endeavor, a public-private partnership, or a third-party private investment, customers in the marketplace will need to be informed and educated on the merits of the proposed project. Generic materials can be developed from resources provided by membership in the International District Energy Association (IDEA) (www.districtenergy.org), including Power Point presentations and community outreach.

Throughout the project development phase, it is important that potential end-users are identified and that a communications strategy is developed to cultivate buyer interest and identify critical customer locations. Very often, federal, state, and municipal buildings serve as anchor loads and their energy requirements need to be fully understood, including timing of major renovations, equipment replacements, or adaptive re-use. From the outset, market intelligence on the potential customer buildings is strategically important and should be a high-priority for a professional business development specialist on the team.

8.2 Project Information Memorandum or Request for Qualification

Costs and prices in the financial modeling are, at best, estimates and assumptions. It is therefore a good idea to try to determine if budgets are correct, assess if qualified vendors are present, and verify the project fundamentals. If the project will be tendered to the private sector, testing will reveal if there is an appetite in the market to bid for the project as defined. As this is a specialist area, an experienced consultant is required to undertake this activity. The market for energy services is evolving rapidly. It is best to seek advice on the range of services available, and from whom.

Market testing can be done through a **Project Information Memorandum (PIM)** that contains a description of the project, plus key documents, such as the technical feasibility study. This market testing provides a chance to adjust the model to make it more attractive to the market. Potential providers can be identified by issuing a **Request for Qualifications (RFQ)** through an industry clearinghouse to alert regional industry participants of the potential opportunity. This will develop a list of pre-qualified bidders and allow project sponsors to verify projections in the financial model.

Some industry providers are willing to provide turnkey contracts or Design/Build agreements, although these approaches may attract additional price premiums. Private sector partners may have a preferred business model and should be encouraged to identify pros and cons related to risk-sharing and cost recovery mechanisms. Ultimately, the project host must determine the most suitable solution and it would be wise to test any offer against your own project aims and objectives, bearing in mind the different strategic objectives of private and public sector organizations (see page 36). Often, the same companies are willing to provide discrete elements of the project as separate contracts. This could be for installation of the equipment (central plant and equipment, distribution networks, and consumer interface units, including metering), as well as for ongoing operation and maintenance. It is advisable to identify multiple approaches and develop a risk analysis to determine the best scenario for the project.

9 Procurement

9.1 Procurement route

This will depend on the business model selected.

— Private sector route: public authorities procuring a private sector company to design, build, own, operate, and maintain (DBOOM) a project will need to follow public procurement procedures carefully. They will have to establish an evaluation panel representing a range of skills and expertise, as well as representing appropriate interests within the host organization. Once again, the services of a specialist consultant will be needed in the preparation of tender documentation based on a refined Project information Memorandum or Request for Qualifications (RFQ). This will then be published in appropriate media as an **Invitation to Participate**. This is a pre-qualification exercise, in which the financial and technical credibility of potential contractors and/or partners and the relevance of their track record can be evaluated. Considerations like relevant experience, bonding capability, etc. can be used to evaluate and compare respondents.

A tender list can then be assembled and companies on it invited to submit initial proposals. Companies responding will need to visit the project locations and meet the host organization to understand the project. In order to ensure impartiality, all visits and meetings should be organized collectively and be open to all pre-qualified companies. Initial proposals can then be evaluated and the tender list focused down to a limited number of companies that are then invited to develop full proposals.

Further meetings and exchanges will then follow. Strict impartiality should always be maintained. Bidders will then submit their best and final offers. After evaluation, a preferred bidder is selected and invited to negotiate. The two parties will identify and agree on key areas for negotiation in a memorandum of understanding or Term Sheet document. Negotiation will then fine-tune the technical, financial, and business model until financial close is achieved and contracts exchanged and signed. Further information can be found at: www.epa.gov/chp/documents/pguide_financing_options.pdf.

— In-house provision route: public authorities can establish in-house entities to produce plans and specifications for partial bidding and procurement. This route would typically involve the host retaining the services of a qualified consulting engineering firm, architect, legal and permitting specialists, and owner's engineer to oversee quality and project implementation. With qualified technical and project staff, this approach can be useful in mitigating project costs, but the host organization also retains a larger share of project financial risk.

— Hybrid/special purpose vehicles route: municipalities may have the option to establish a special purpose entity such as a Project Partnership or a Limited Liability Corporation (LLC) that will establish a separate functional organization with a distinct charter, and may include shareholder definitions and financial records. If this route is chosen, the services of a specialist lawyer will be required to draw up the documentation to establish the organization. If the plans include a public authority, it will still have to comply with relevant public bidding and procurement procedures and the process laid out above.

— Stakeholder-owned route: the procurement route can also depend on who the stakeholders are. Private, non-profit organizations can be formed to act on behalf of the principal customers, as in a cooperative model. Tax implications, ownership and business objectives, market penetration, and capital availability are all important considerations that factor into the final structure.

10 Delivery

10.1 Delivery plan

As part of the negotiations with the preferred bidder, the parties will have set out a project delivery plan, summarized in a Gantt chart. Key milestones will have been set in the final contract. It is advisable to appoint a contracts supervision officer to provide a focus point between the two parties, oversee the delivery of the contract, and deal with any problems that may arise. Additionally, project delivery will involve permits, rights of way, traffic planning, and street construction disruption, and it will be appropriate to appoint a community-relations or resident-relations officer.

For district heating and cooling distribution projects, you will need to open roads in order to lay the pipes. Powers to do this are generally defined in local franchise arrangement with the municipality. Disruption is inevitable and construction coordination and permits and approvals will need to be established with the appropriate local municipal department such as Facilities, Public Works, and/or Highway Department. Very often, special permits define duration and nature of traffic patterns, safety, and signage. In urban settings, it is important to be mindful of a special events calendar that might cause traffic congestion, such as professional sports events or seasonal festivities that draw crowds.

Commissioning is often used to establish that the project construction has been completed and the equipment and systems operate to design standards. Pressure testing of underground piping can be accomplished through a series of inspections, non-destructive testing, x-ray analysis, and functional burst testing. Most piping components have a standard operating and pressure test in place for acceptance. Major plant equipment should be evaluated through a series of increasing performance standards, from operation confirmation, to delivery performance testing, to confirm that the overall system operates as designed. In a large district cooling system, it may be challenging to simulate a sufficient-size cooling load to evaluate system performance overall. Many large projects now budget a commissioning phase to test the individual components as well as the system performance overall to ensure return on investment and compliance with specifications.

Lastly, all new energy systems will go through a period of teething problems. These could take up to a year to settle down. It is important to be mindful of this fact and endeavor to take a long-term view.

Summary of the project development process

Set overall objectives – see chart on page 13 *(economic, energy security, environmental).*

1. Gather data.
2. Define project – buildings to be served (density levels, load diversity, presence of anchor loads).
3. Options appraisal (consider technical solutions that meet overall objectives for defined project).

→ Other technology

District energy/CHP

1. Implement detailed feasibility study.

→ Not technically feasible
Consider alternative technical solution.

Technically feasible

1. Build financial model.

Financially viable

1. Build business model that fits risk transfer and control requirements.

Not financially viable
Adjust level of risk transfer and/ or identify other avoided costs and/or further fundraising.

Business model

1. Market test model (check cost and revenue assumptions).
2. Evaluate procurement model.

Private Project Developer

1. Prepare documentation *(Project Information Memorandum, Request For Qualifications, Invitation to Participate).*

Then:

1. Decide evaluation criteria Establish evaluation panel.
2. Award preferred bidder.
3. Final negotiation.
4. Financial close.
5. Contracts commence.

Hybrid

1. Decide on business structure *(Joint Venture, Public/Private Partnership, stakeholder-owned cooperative).*
2. Decide role allocation.

Public Project Developer

1. Procure separate project elements *(plant room, CHP and ancillaries, distribution infrastructure)*
2. Procure as turnkey contract. Prepare documentation *(Project Information Memorandum, Request For Qualifications, Invitations to Participate).*

Then:

1. Procure operation, maintenance and billing/ revenue collection services.
2. Franchise turnkey contract.
3. Contracts commence.

POLICY CONSIDERATIONS

Awareness of policy considerations is vital to any energy project development. Communities can benefit from state energy incentive programs and projects must secure necessary permits.

Policy considerations

Policy, program funding, and regulatory considerations can impact project development. It will be necessary to acquire an understanding of the policy landscape. This will vary between states. A sampling of policy considerations is discussed below.

Policy drivers

Launching a successful district energy system is a substantial task and will ultimately require significant investment of time and money. While detailed engineering studies and sound financial and business models are absolutely necessary in the project development process, a developer who does not consider regulatory and policy issues may see a technically sound project stalled or derailed entirely. Project developers may find it challenging to understand complex statutory language and remain informed on these fluid issues, but it is critical to a project's success that a knowledgeable individual understands the policies and regulations that affect a project's development, financial viability, construction, and operation.

While this guide focuses on policies in the U.S., there are a number of exemplary international policies that have fostered significant industry growth, particularly in Europe. As new policies are introduced and existing ones amended, the policy playing field can be a moving target. In the interest of remaining current and succinct, this guide does not attempt to catalog all of the relevant existing policies, incentives, and regulations that exist across the U.S. at federal, state, and local levels. Instead, it aims to provide an overview of significant policy mechanisms, briefly describe the policy landscape that a community-level district energy developer will encounter, and highlight a few policy best practices that are contributing to successful deployment of projects around the U.S. To learn more and to access the most up-to-date policy information, as well as to learn more about district energy policies around the world, please visit www.districtenergy.org.

Federal policy overview

In the U.S., national energy policies tend to focus on electricity generation and often overlook opportunities to recognize and reward energy savings from efficient use and deployment of thermal energy technologies. As a result, key funding opportunities are often limited to renewable electricity and power generation projects and not readily applicable to district energy projects. Although the district energy industry has grown without external policy drivers or even equitable policy support, increased attention to the importance of heating and cooling in policy and legislation efforts would greatly benefit the U.S. policy dialogue. Leaders in countries such as Denmark and the United Kingdom have explicitly included thermal energy considerations in national energy policies and, as a result, enjoy increased energy production efficiencies, lower levels of polluting emissions, and a decreased need to import foreign fuels.

National energy policy

Comprehensive federal energy policy limiting greenhouse gas emissions does not currently exist. Further, federal energy policy encouraging the use of more efficient energy-generation resources and technologies, such as district energy and CHP, is unlikely to become a legislative priority in the near future. However, in early 2012, Senator Jeff Bingaman (D-NM) proposed the Clean Energy Standard Act of 2012, which would introduce minimum clean energy requirements for large utilities and slowly increase them annually through 2035. This approach would encourage utilities to get their energy from cleaner sources. The initial draft bill indicates positive treatment of district energy and CHP by providing credits for efficient thermal energy and CHP. It calls for the Department of Energy (DOE) to undertake a study of clean energy resources that do not generate electric energy but may substantially reduce electric energy loads, such as energy efficiency, district heating, biomass, and other thermal technologies. While Senator Bingaman's Clean Energy Standard legislation is an encouraging arrival on the federal policy scene, it is intended to serve as a starting point for additional policy discussions and is unlikely to proceed as stand-alone legislation.

DOE, a leading supporter of district energy and CHP, has demonstrated its commitment to increased deployment of these technologies through notable commitments and objectives. DOE and the Oak Ridge National Laboratory estimate the total CHP potential in the U.S. could be roughly 240,000 MW, or about 20% of total U.S. electric generation capacity, by 2030. A vision of substantially increased deployment would provide numerous economic, environmental, energy security, and system benefits to the United States. It would also provide end-users with an economically competitive, environmentally beneficial, and highly reliable alternative to electricity provided by the electric grid, which is especially important for mission-critical facilities such as hospitals and airports.

Figure 25: The Central Utility Plant at the University of Cincinnati in Cincinnati, Ohio provides heating, cooling, and power to the University campus and hospital.

According to the Oak Ridge National Laboratory,

"CHP in the United States today avoids more than 1.9 quadrillion Btus of fuel consumption and 248 metric tons of CO_2. This CO_2 reduction is the equivalent of removing 45 million cars from the road."[3]

If the U.S. increased its current 9% CHP capacity to 20%, it would be equivalent to removing more than 154 million cars from the road.[4] The Industrial Energy Efficiency and Combined Heat and Power (IEE/CHP) Working Group is helping the State and Local Energy Efficiency Action Network (SEE Action) address energy efficiency in the U.S. manufacturing sector by providing guidance on model programs and policies that support industrial efficiency and implementation of CHP. The working group has developed a blueprint for action with the following goals:

— achieve a 2.5% average annual reduction in industrial energy intensity through 2020;
— install 40 gigawatts (GW) of new CHP capacity by 2020.[5]

The Department of Energy administered one of the most important federal energy policy initiatives in recent history, the 2009 American Recovery and Reinvestment Act (ARRA), which provided stimulus funding to a number of important clean energy initiatives. ARRA created a number of programs that helped communities complete energy plans and fund local clean energy investments, such as CHP and district energy system expansion. Although the majority of ARRA initiatives have expired, the Department of Energy CHP Program of 2009 demonstrated the untapped and unmet growth potential of the district energy/CHP industry, as the program was oversubscribed by 25:1.

Federal financial incentives

There are several available funding mechanisms that may be useful to a district energy project developer.

— ***CHP Investment Tax Credit (ITC):*** To be eligible, a CHP project must be smaller than 50MW and exceed 60% energy efficiency, subject to certain limitations and reductions for large systems. The efficiency requirement does not apply to CHP systems that use biomass as at least 90% of the system's energy source, but the credit may be reduced for less efficient systems. The CHP ITC is currently a 10% tax credit for the first 15MW of a system. There have been numerous bills attempting to expand the ITC to 30% and to remove the capacity and size limitations. These are still pending.

— ***Renewable Electricity Production Tax Credit (PTC):*** Set to expire at the end of 2013, the renewable electricity PTC is a per kilowatt-hour (kWh) federal tax credit for electricity generated by renewable resources. The PTC provides a corporate tax credit of 1.1 cents/kWh to landfill gas, open-loop biomass, municipal solid waste resources, qualified hydropower, and marine and hydrokinetic (150 kW or larger) projects and 2.2 cents/kWh to electricity from wind, closed-loop biomass, and geothermal projects. This has been a powerful incentive for construction of renewable energy projects, but the short-term nature and sunset provision may stall continued development.

Regulatory overview

Securing permits to ensure compliance with environmental regulations is an important part of the community energy development process. The Environmental Protection Agency (EPA) sets limits on a variety of emissions which impact individual plant operating decisions. Environmental regulations should be considered very early in the planning process as they may influence technology selection. It is important to consider current regulations and potential future regulations as well as the timing necessary to complete the permitting process. Project developers are advised to employ the services of qualified environmental consultants early in the development phase.

Generally, state and local pollution control agencies are responsible for reviewing a project and issuing permits to ensure that the project complies with federal and state Clean Air Act mandates. Some states may have their own permit requirements and programs that have been approved by EPA. The primary pollutants of concern are NOx, CO, SO_2, particulates, and certain hazardous air toxics.[6] Please visit EPA's web site for more information: www.epa.gov/nsr/info.html.

A few of the key federal environmental regulations of particular note to a district energy project developer are described below.

New Source Review

New Source Review (NSR) requires stationary sources of air pollution to get permits before they start construction. There are three types of NSR permitting requirements that may apply:

- Prevention of Significant Deterioration (PSD) permits, which are required for new major sources or a major source making a major modification in an attainment area;
- Non-attainment NSR (see www.epa.gov/nsr/naa.html) permits, which are required for new major sources or major sources making a major modification in a non-attainment area;
- Minor source permits (see www.epa.gov/nsr/minor.html).

A permit will specify allowed limits on various issues related to the construction, emissions, and operation of a major source. Generally, a major source in a non-attainment area is any stationary pollutant source with potential to emit more than 100 tons per year. In PSD areas the cut-off level may be either 100 or 250 tons, depending upon the source.

Greenhouse Gas (GHG) Reporting

EPA's Greenhouse Gas Reporting Program, launched in October 2009, requires the reporting of GHG data from large emission sources across a range of industry sectors. EPA issued the Mandatory Reporting of Greenhouse Gases Rule (74 FR 56260) to collect accurate and timely GHG data to inform future policy decisions. Suppliers of certain products and direct emitting source categories are covered by the Rule, generally referred to as 40 CFR Part 98 (Part 98). Facilities that emit 25,000 metric tons or more per year of GHGs are required to submit annual reports to EPA.[7] There is also a Voluntary Reporting mechanism for GHG emissions generated by CHP. The purpose of this inventory is not fully defined, but EPA has shown policy recognition that efficient CHP projects can effectively reduce regional greenhouse gas emissions even though the site emissions may increase.

Boiler MACT

EPA finalized the reconsideration process for its Clean Air Act pollution standards, the National Emissions Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters, commonly referred to as the Industrial Boiler Maximum Achievable Control Technology (MACT) standard, or the Industrial Boiler MACT, in Spring 2012. The Boiler MACT rule requires large and small boilers and process heaters in a wide range of facilities and institutions to reduce emissions of a number of air toxics. Boilers that will be affected are those that have capacity above ten million Btus per hour, are used more than 10% of the year, and burn fuels other than natural gas or refinery gas. The re-proposed rule will regulate emissions of the following hazardous air pollutants (HAPs) such as particulate matter, mercury, and carbon monoxide, but does not regulate emissions of criteria pollutants such as sulfer dioxide or nitrous oxide. For more information, please visit EPA's website at www.epa.gov/airquality/combustion/actions.html.

Output-based emissions standards and interconnection

Output-based environmental regulations are a way of promoting fair recognition of the efficiency benefits of producing electric energy and useful thermal energy from a single fuel source in district energy and CHP plants from an emissions allowance perspective, and are supported by the industry. Output-based standards are available in many states and have begun to replace traditional environmental regulations, which are largely based on fuel input and do not consider the increases in efficiency realized by integration of CHP with district energy.

A number of states have taken steps to address some of the common market barriers and issues that arise as challenges to developing CHP/district energy projects. In the past, incumbent electric utilities have resisted local generation that may displace electricity sales and have imposed arbitrary interconnection requirements or standby charges that might impede or impair CHP project deployment. Utility reluctance has posed a challenge in the past and, for developers including CHP, interconnecting a plant with the electric power grid may be difficult. Standardized interconnection procedures have been instituted by states looking to remove this potential barrier. For more information, please visit www.epa.gov/chp/funding/regulatory.html.

State policies

Meaningful clean energy activity at the federal level is largely stalled and many of the tax incentives, subsidies, and loan guarantees created through the 2009 stimulus funding have expired. The clean energy industry is looking to states and local governments as primary drivers of clean energy policies and economic development activities. Across the country, state policies offer a wide range of incentives including tax credits, tax exemptions, financing opportunities such as loans and grant programs, renewable and alternative portfolio standards, and clean energy funds. At the local level, communities have established a range of sustainable policies, from bike paths to energy efficiency building codes. In addition, many communities are sponsoring new clean energy community projects along the lines of the guidelines set out in this guide.

Each state has an energy office that can provide a comprehensive overview of the funding, policy, and regulatory items that apply in each state. Certain states have programs and policies in place that can be particularly beneficial to a community interested in developing a district energy system. For specific information on what is available in a particular state, visit DSIRE (Database of State Incentives for Renewables and Efficiency) or contact the state energy office through NASEO.

Figure 26: Municipally-owned OUCooling provides innovative, reliable cooling to customers in downtown Orlando
Image courtesy of Orlando Utilities Commission.

Clean Energy Funds

A number of states have created **Clean Energy Funds**, often called Public Benefit Funds, which support energy efficiency and renewable energy initiatives. States place a small charge on the bill of every electric customer, or mandate utility contributions to replenish these funds. According to a 2012 report from the Brookings Institution, these funds exist in over 20 states and "generate about $500 million per year in dedicated support from utility surcharges and other sources, making them significant public investors in thousands of clean energy projects."[8]

For example, Connecticut has a Clean Energy Fund and an Energy Efficiency Fund. The Clean Energy Fund is funded by a surcharge of $0.001 per kWh on Connecticut ratepayers' utility bills and is administered by the Clean Energy Finance and Investment Authority, a quasi-governmental investment organization created by the Connecticut General Assembly to develop programs and fund projects. The Clean Energy Fund can invest in a variety of eligible technologies, including CHP systems with waste-heat recovery systems and thermal storage systems.[9]

Renewable Portfolio Standards

A Renewable Portfolio Standards (RPS) or Alternative Energy Portfolio Standards (AEPS) requires a utility to deliver a certain percentage of its annual electricity from renewable or alternative energy sources by a given date. A majority of states have adopted at least one of these tools, but each state has different definitions of qualifying energy sources. Fourteen states include CHP in their RPS or AEPS,[10] Indiana includes heat recovery and a number of additional states, including Michigan, Maine, Hawaii, and Oregon permit municipal solid waste to qualify.

Tradable renewable energy credits (RECs) are offered in many states as a compliance mechanism. Compliance payments offered as part of state RPS or AEPS programs often provide an additional source of funding for state clean energy funds. For example, in New Jersey, Alternative Compliance Payments (ACPs) made by utilities not in compliance with RPS requirements for a given year are used to support renewable energy projects through the New Jersey Clean Energy Fund.[11][12]

A related state policy tool is an Energy Efficiency Resource Standard (EERS), which encourages more efficient generation, transmission, and use of energy. An EERS requires utilities to reduce energy use by a set amount that increases annually. In some states, an EERS is separate from an RPS, but in others, energy efficiency can be an acceptable way for utilities to meet RPS requirements. While all EERS programs include end-use energy efficiency, some states allow CHP and other high-efficiency distributed generation systems to qualify.[13]

Specific state legislation

California

California's leading energy policies provide strong support for district energy and CHP. Governor Jerry Brown's Clean Energy Jobs Plan of 2011 calls for construction of 12,000 MW of "Localized Energy Generation" (smaller, decentralized facilities) and 6,500 MW of combined heat and power over the next 20 years. The California Public Utilities Commission (CPUC) released a streamlined version of its Self-Generation Incentive Program (SGIP) through Senate Bill 412, which extends the program from January 2012 to January 2016 and bases program eligibility on greenhouse gas emissions reductions. Eligible technologies include CHP gas turbines, organic Rankine cycle and waste-heat capture, pressure reduction turbines, advanced energy storage, and internal combustion engines. By 2020, California intends to increase renewable energy usage to 33% renewable energy and reduce GHG emissions to 1990 levels by 2020.

Massachusetts

Massachusetts passed the Green Communities Act, a major energy reform bill, in 2008. Among other provisions, the law introduced the state's Alternative Energy Portfolio Standard (AEPS) which requires meeting a growing percentage – from 2.5% in 2012 to 4% in 2016 – of the state's electric load with designated alternative energy technologies by 2020. Qualifying sources include CHP, which earns **Alternative Energy Credits (AECs)** based on the measured useful thermal and electric power outputs of the project. These AECs are sold to the utilities to be used for compliance with the AEPS obligations – at prices that have an Alternative Compliance Penalty of $20 per MWH. In addition to new CHP facilities, the program also provides incentives for added efficiencies to pre-existing CHP or converting existing electric-only or thermal-only plants to CHP. The law also designates certain Massachusetts communities that meet a number of qualifications as Green Communities, and these communities are able to apply for additional funding set aside for grants and loans to support new, local, clean energy projects.

Connecticut

Connecticut's Clean Energy Finance and Investment Authority, an expansion of the state's Clean Energy Fund, is the first full-scale clean energy finance authority in the country. Designed to "leverage public and private funds to drive investment and scale-up clean energy deployment" in the state, the CEFIA is a model for state-level clean energy strategy and deployment efforts. A Connecticut law allows municipalities to establish Energy Improvement Districts (EID), which can develop and operate distributed resources such as small power plants. The municipality is given a wide range of power to support the EID, including the authority to issue and guarantee tax-exempt bonds to pay for the construction and development of energy projects.[14]

Washington

A law recently passed in Washington State makes renewable thermal energy eligible for state renewable energy credits. The law requires utilities to add thermal technologies including biomass heating through boilers, geothermal or ground-source heating, solar heating, heat recovery and reuse at wastewater treatment facilities to the list of alternative energy resources they provide for customers to purchase.[15] The bill provides additional financial incentive for utilities and private companies to produce useful thermal energy from additional sources beyond natural gas and fossil fuels. The thermal renewable energy credits will be offered to customers through voluntary utility green power programs, and will not count towards the state renewable portfolio standard.

Ohio

A bill under consideration in Ohio would include thermal energy as a qualifying resource in the state's RPS, by specifically stating that renewable energy resources do not have to be converted to electricity to receive renewable energy credits.[16]

North Carolina

In 2010, North Carolina signed House Bill 1829 expanding the state's renewable energy **Investment Tax Credit** to include CHP into law. Businesses that install a CHP system are eligible for a tax credit from the state equal to 35% of the cost of the equipment, construction, and installation, up to a maximum of $2.5 million.

FERC Ruling in New York State – Cornell University

Since the CHP system installed at Cornell University was designed and operated to primarily provide the thermal energy (heating and cooling) needs of the campus, the Federal Energy Regulatory Commission (FERC) ruled that the facility was not a competitive wholesale power supplier and, as a result, compelled the local electric utilities to purchase surplus or excess power supplied from the CHP system at avoided cost.[17]

New Jersey Cogeneration Laws

Through a series of laws enacted over the past several years, New Jersey has emerged as one of the leading states in the country in the area of encouraging CHP. One noteworthy example is P.L. 2009, Chapter 240 (2010), which expanded the definition of "on-site generation" to include CHP facilities which service non-contiguous thermal load customers. Most recently, the Governor's 2011 Energy Master Plan has set out a goal of 1400 MW of new CHP in the state over the next decade.

Conclusion

It is advisable that in the early phase of project definition, steps are taken to determine eligible funding and policy incentives that might impact technology selections. State and local resources, and the U.S. Department of Energy Clean Energy Application Centers may offer guidance to assist with identifying available financial and technical resources. For more information and a complete list of state, local, and federal policy resources, please visit www.districtenergy.org.

Additional resources

For more information on the specific policies in your state that may influence your project, please reference the Database of State Incentives for Renewables and Efficiency (DSIRE) or contact your region's U.S. Department of Energy Clean Energy Application Center or your state's Energy Office.

C2ES: Center for Climate and Energy Solutions (formerly the Pew Center on Global Climate Change) provides information on federal and state energy policies.

DSIRE: Database of State Incentives for Renewables and Efficiency is searchable by state and type of incentive provided.

U.S. DOE Clean Energy Application Centers: Department of Energy regional application centers supply technical assistance to potential project developers. The regional centers include: Northwest, Pacific, Intermountain, Midwest, Gulf Coast, Southeast, MidAtlantic, Northeast. Specifically, the CEACs provide:

— market assessments;
— targeted education and outreach – educational resources and case studies distributed via workshops, webinars, seminars, and training;
— technical assistance – site assessments, project feasibility studies and screening tools, technical and financial analyses, emissions calculator;
— project profiles database.

EPA CHP Partnership provides a number of helpful resources relating specifically to CHP, including:

— funding resources database;
— list of state and local incentives;
— CHP Emissions Calculator;
— CHP Project Qualifier: for determining whether CHP is worth considering at a particular facility;
— profiles of model state policies;
— technical assistance for specific projects: spark spread analyses, feasibility assessments;
— publications such as fact sheets, market analyses, technical white papers, and clean energy policy resource documents.

ACEEE (American Council for an Energy Efficient Economy): The Local Energy Efficiency Policy Calculator created by ACEEE is a downloadable analysis tool intended for use by local policymakers and stakeholders. It can be used to compare policy choices and explore the results of different implementation scenarios. Users can customize inputs to reflect local characteristics and tailor policy designs to meet their needs. The tool calculates estimates for energy savings, cost savings, pollution, jobs, and other outcomes resulting from selected policies over a time period designated by the user.

USGBC (U.S. Green Building Council): To provide more information about how district energy can help buildings earn LEED Certification points, USGBC released a publication titled Treatment of District or Campus Thermal Energy in LEED for Existing Buildings: Operations and Maintenance.

REFERENCE NOTES

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Stage	Lead	Data needs and considerations	Support
Preliminary planning City/district plan/master plan Climate Action Plan	• Planners • Economic development officers • Government officials • Project developer	• Location and demands of new development • Existing energy demands • Existing energy installations • Resource assessment • Emissions reduction • Objectives	• Engineering, planning or sustainability consultants • Community members, stakeholders and interest groups • Other planning bodies or project developers
1 Objectives setting	• Government officials • Planners • Economic development officers • Project developer	• Economics and cost-effectiveness • Environmental benefits and emissions reductions • Energy security	• Other planning bodies or project developers
2 Data gathering	• Project developer	• Development density • Demand loads • Mix of uses • Age of buildings • Anchor loads • Barriers and opportunities • Energy mapping	• Engineering, planning, or master planning consultants • Building owners and managers • DOE Clean Energy Application Centers
3 Project definition	• Project developer	• Prioritize clusters with maximum density, diversity and anchors, and identify key buildings to be connected	• Engineering consultants • DOE Clean Energy Application Centers
4 Options appraisal	• Project developer	• Detailed analysis of options identified in Stages 1 to 4	• Engineering, planning, or master planning consultants • DOE Clean Energy Application Centers
5 Feasibility study	• Project developer	• Detailed analysis of data • Technical feasibility • Financial viability • Phasing	• Engineering consultants
6 Financial modeling	• Project developer	• Detailed financial viability assessment • Capital cost • Operational cost • Revenue	• Consultants • Financial advisors
7 Business modeling	• Project developer • Government officials	• Project type • Attitude to risk • Desire for long-term control • Regulation • Access to finance and the desired Internal Rate of Return	• Consultants • Legal advisers • Tax and/or bond counsel
8 Marketing and business development	• Project developer	• Target audience • Likely customer base	• Consultants • Architectural and business community • Other project developers
9–10 Project procurement and delivery	• Project developer	• Level of public/private-sector involvement • Overall project viability	• Engineering consultants • Procurement officers • Legal advisers

GLOSSARY

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

AEC: see **REC**

AEPS (Alternative Energy Portfolio Standards): a policy requiring electric utilities to deliver a certain amount of electricity from alternative energy sources by a specific date.

anchor load: a large thermal energy load which could connect and potentially provide early income to a **district energy** project.

ARRA (American Recovery and Reinvestment Act): a federal economic stimulus package enacted in February 2009.

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

ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers): a building technology society focused on building systems, energy efficiency, indoor air quality, and sustainability.

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.

CHP (combined heat and power): 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.

CHP ITC (CHP Investment Tax Credit): a 10% federal investment tax credit that applies to the first 15 megawatts (MW) of **CHP** property.

Clean Energy Ministerial: a high-level global forum to promote policies and programs that advance clean energy technology and encourage the transition to a global clean energy economy (www.cleanenergyministerial.org).

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.**

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**.

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

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 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 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.

DOE (Department of Energy): the federal agency responsible for ensuring America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions (www.energy.gov).

DSIRE (Database of State Incentives for Renewable Energy): a comprehensive source of information on state, local, utility, and federal incentives and policies that promote renewable energy and energy efficiency (www.dsireusa.org).

EECBG (Energy Efficiency and Conservation Block Grant): a federal grant program for energy solutions that received $3.2 billion in funding from **ARRA**. Grants were competitively awarded for energy efficiency and conservation programs and projects, as well as renewable energy installations on government buildings.

EERS (Energy Efficiency Resource Standard): a policy (typically at the state level) that sets annual energy efficiency targets for a long period of time. An EERS mandates a percentage reduction in energy use through energy efficiency measures.

EID (Energy Improvement District): an area or section of a community designated by a municipality for implementation of clean energy projects. EIDs can utilize municipal bonds for financing and mandate energy performance and use criteria.

energy character area: an area that can be defined by its particular characteristics in order to identify an appropriate energy solution or planning policy.

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 thumbprint: a unique characterization of an area based on a comprehensive set of energy data.

EPA (Environmental Protection Agency): the federal agency responsible for protecting human health and the environment by writing and enforcing regulations based on laws passed by Congress (www.epa.gov).

event load: a temporarily heightened energy demand in a building as a result of a specific event, such as a sporting event in a stadium.

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

HRSG (heat recovery steam generator): a heat exchanger that recovers energy in hot exhaust gases to produce steam that can be used to drive a turbine or in heating applications. By making use of heat energy that is wasted in conventional power cycles, a HRSG increases overall energy utilization and enhances fuel savings.

IDEA (International District Energy Association): a nonprofit trade association formed in 1909 to foster the success of its members in the **district energy** industry (www.districtenergy.org).

IEA (International Energy Agency): an international organization that works to ensure reliable, affordable, and clean energy for its 28 member countries. The International **CHP/**DHC Collaborative is an IEA initiative to support global leaders increasing the use of **CHP** and **district energy** in their countries (www.iea.org).

Invitation to Participate: a pre-qualification process in which the financial and technical credibility of potential contractors can be evaluated.

IPCC (Intergovernmental Panel on Climate Change): the leading international body for the assessment of climate change established by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) and endorsed by the United Nations General Assembly (www.ipcc.ch).

ITC (Investment Tax Credit): see **CHP ITC**

lead boiler: see **prime mover.**

LEED (Leadership in Energy and Environmental Design): an internationally recognized framework for identifying and implementing practical and measurable green building design, construction, operations, and maintenance solutions (www.usgbc.org).

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

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

LOI (letter of intent): a non-binding document that outlines an agreement between two or more parties before a contract is signed.

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.

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

NASEO (National Association of State Energy Officials): a national association of governor-designated energy officials from each state and territory.

nodal network: a network that develops gradually as smaller **district energy networks** expand and link together to meet demand growth.

NPV (net present value): 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.

NSR (New Source Review): An **EPA** regulation which requires stationary sources of air pollution to get permits before beginning construction.

Office of Climate Change Policy and Technology: the entity within the U.S. **DOE** that is responsible for the development, coordination, and implementation of **DOE**-related aspects of climate change technical programs, policies, and initiatives.

PD (project developer): an individual or organization pursuing the implementation of a **district energy** system in a community or city.

peak load: see **demand load.**

PIM (Project Information Memorandum): a suite of documents describing a **district energy** project for the purposes of procurement.

PPD (Private Project Developer): a private **district energy** utility company, which often partners with a public entity using a form of the **DBOOM** model.

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

PTC (Production Tax Credit): an income tax credit for the production of energy from specific clean or renewable sources.

REC (Renewable Energy Credit): a credit that represents the property rights to the environmental, social, and other nonpower qualities of renewable energy generation that can be traded or sold. An **Alternative Energy Credit (AEC)** functions similarly and encompasses a wider range of technologies.

RFQ (Request for Qualifications): a business process in which suppliers are invited to participate in a bidding process to bid on specific products or services.

RLF (revolving loan fund): a fund that issues loans to projects on an ongoing basis as previous loans are successfully repaid.

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

shale gas: natural gas that is trapped within shale formations. Recent advances in hydraulic fracturing and horizontal drilling technologies have resulted in access to previously inaccessible shale gas deposits.

SPV (special purpose vehicle): a separate entity created to take ownership and responsibility for an energy project's development and ongoing operation.

(TES) Thermal energy storage: a process in which thermal energy is produced and stored for later use. TES shifts thermal energy production to non-peak times.

U.S. Department of Energy Clean Energy Application Centers: regional entities which promote and assist in transforming the market for **CHP**, waste heat recovery, and **district energy** technologies and concepts throughout the United States.

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AEI brings a world of insight and innovative solutions to serve your community energy needs for today while supporting your goals for tomorrow. We are a technical consulting, design, and engineering firm known for providing creative and flexible energy solutions for complex and large-scale projects worldwide, supporting the excellence of a diverse clientele. Our utility infrastructure practice includes engineering professionals who focus solely on district energy master planning and the design of chilled water, hot water and steam, cogeneration, power, and distribution systems. AEI understands the complexity involved in evaluating and developing a community district energy system and can provide engineering expertise from project ideation through delivery. We have tremendous strength in partnering with all stakeholders involved to ensure effective communication and project coordination.

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enwave ENERGY CORPORATION

Enwave Energy Corporation is the largest district energy company in Canada, supplying innovative, sustainable energy services to over 160 commercial, residential, and institutional buildings in downtown Toronto and Windsor, Ontario. The Company's 40km steam and chilled water distribution networks connect over 40 million square feet of urban space to three modernized steam plants and the lakefront cooling plant, which anchors Enwave's world-renowned Deep Lake Water Cooling system.

Enwave's mission is to improve the well-being of stakeholders through the continuous pursuit, development, and delivery of sustainable energy solutions. That means working with customers to reduce their energy consumption and finding new ways to mitigate their exposure to volatile commodity costs. It also extends beyond simply providing thermal energy, to supporting local community initiatives like the Enwave Theatre, which boasts "third-generation" renewable technology that combines Building Integrated Photovoltaics (BIPV) with heat mirror glass and glass artwork.

Enwave is now establishing partnerships with institutions, municipalities, and other entities to challenge conventional thinking about thermal energy to reduce our collective environmental footprint and the associated social and financial costs.

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RAMBOLL

Ramboll is an international engineering and design consultancy. We have significant experience within energy broadly and within district heating and renewable energy specifically. We are considered to be a world-leading district heating engineering consultancy working internationally with energy planning, combined heat and power (CHP), district heating, heat production for district heating, renewable energy, and district cooling, using the experience gained from numerous Danish and international schemes since 1965.

Ramboll is also an internationally leading consultant within wind energy and waste-to-energy. We advise on every aspect of energy, from the political decisions that are made, to the point when the energy produced is consumed. Our projects include the entire chain, from energy strategies and plans, to production, distribution, and transmission facilities.

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Solar® Turbines

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Headquartered in San Diego, California, Solar Turbines Incorporated, a subsidiary of Caterpillar Inc. is the world's leading manufacturer of industrial gas turbine packages in the 1-22 MW range. Solar Turbines has extensive worldwide experience in combined heat and power, having designed, installed, maintained, and operated systems in hundreds of facilities across a wide variety of industries and applications, each with unique energy requirements. Utilizing a Solar® gas turbine in a district energy application not only generates electricity, but also allows the waste heat to be employed in the production of heating and/or cooling for the customer. Using a CHP system dramatically increases overall system efficiency, increases reliability, and decreases the emissions of pollutants into the atmosphere.

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VEOLIA ENERGY

Veolia Energy operates and develops efficient energy solutions to help customers to control costs, reduce energy and fuel consumption, manage energy risks, extend the useful life of energy infrastructure, and reduce greenhouse gas emissions. Solutions include district energy (the delivery of locally-produced steam, hot water, and chilled water for space heating, space cooling, and industrial process use); operations and maintenance of energy equipment; designing-building-owning-operating-maintaining on-site combined heat and power and renewable energy plants; and a wide variety of energy management, energy efficiency, and engineering services to make energy more sustainable, reliable, and cost-effective for commercial, institutional, municipal, and industrial buildings.

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Notes

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