Is District Energy Right For Your Community?

Part 2: Sizing the System

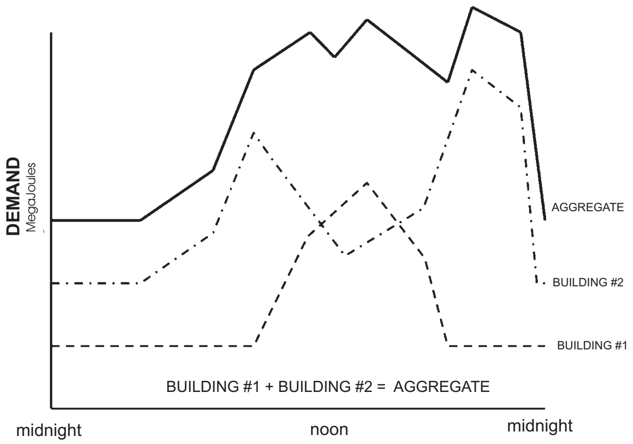
Ken Church

In the first article of this trilogy, the concept of district energy was discussed as it applies to an energy supply-side strategy for Canadian communities. Discussion centred on the opportunities for integrating district energy into land-use planning objectives, utilizing alternative energy sources, and providing economic, environmental and societal benefits to the community. This second installment will identify the basic parameters that are key to sizing the energy requirements and capacity of the system. It should be noted that the guidelines proposed here should not be considered as an alternative to a qualified engineering assessment. Rather, they provide insight into alternative options that may be scanned later for detailed practicality.

Consumer Load

Given that a district energy system provides thermal energy to a variety of customers, the availability of detailed information on their energy consumption is the key to sound system design. This data may be obtained directly from the customer, or possibly in an aggregated form from the local utility. Obtaining detailed data from the utilities is only possible with the customer's permission. Failing this, an alternative technique that employ floor areas, heat loss factors, environmental data and other empirical correlations may be used. An engineering consultant will be able to assist in this calculation.

FIGURE 1:
AGGREGATED DEMAND-USE PROFILE



The annual energy data is just one of three key pieces of information that should be determined for each consumer building. Each has a specific role to play: the peak demand – to define the customer's connection requirements; the annual energy consumption – to determine overall economics of the project; and the daily energy use profile – to determine the operating format for the energy supply plant itself.

Ken Church is the Manager of the Community Energy Planning group in Natural Resources Canada, promoting district energy as a means of addressing long-term energy stability within municipalities. He is on the Board of the Canadian District Energy Association and the Advisory Panel for Smart Growth Canada Network. Ken can be reached at <kchurch@nrcan.gc.ca>.

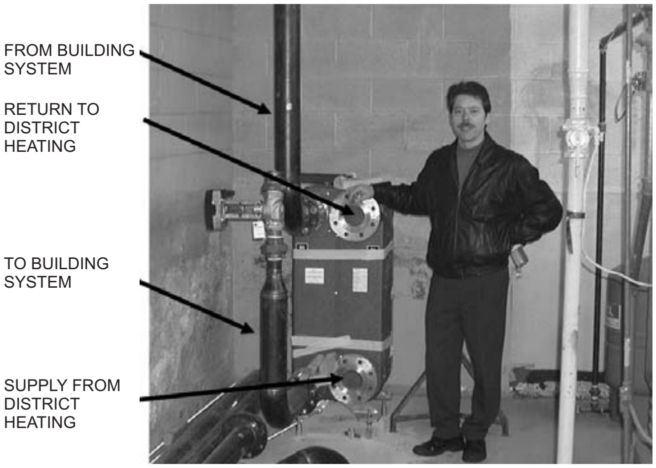
When evaluating a complete system, aggregated data should be developed. Keep in mind, though, that individual buildings have different consumption profiles. Summation of the data creates the system load curve (see Figure 1), and the operating characteristics of the proposed heating plant.

For each customer, try to understand not only the annual energy consumption, but also the profile of the energy used. Questions need to be asked of the building owner: Is the energy used entirely for space heating? What form does the space heating take (many Ontario offices have gas-fired air handling systems supplemented by electrical resistance heating at the building's perimeter)? Are there any process applications within the building, domestic hot water, or other irregular uses? If so, how much and how often?

The building structure and the design of its existing heat-

FIGURE 2

ENERGY TRANSFER STATION



ing system also play important roles in turning the building into a customer. Connection costs are normally the responsibility of building owners. As a result, major retrofits may be costly and become possible barriers to connection. Hydronic or forced air heating/cooling systems can readily be adapted to accept district energy input, but electrically heated buildings may prove too expensive to connect. Ironically, these buildings would benefit most from district energy.

Piping Network

The temperature of the water reaching the customer's building is conventionally set at 90°C, but is often reduced in summer months when the demand is low, and increased in winter when demand is high. A pressurized system is required, as is consequent compliance with provincial regulations. This compliance and the cost of staffing should not be underestimated, since it can have a severe impact on the economics of smaller projects. Research by Natural Resources Canada and the International Energy Agency favours lowering the supply temperature, eliminating the need for pressurization, and reducing staffing costs. The projects in Regent Park (Toronto) and in Okotoks (Alberta) are being designed to these newer, reduced temperatures.

Interconnections between the system and customer can be either direct or indirect. An indirect connection isolates the building from the district energy system by means of an energy transfer station that monitors the water flow and the temperature drop, as the district energy system water flows through the heat exchanger. From this data, the instrumentation calculates the amount of heat transferred – data that is used for billing purposes.

The alternative is a direct connection that connects the district energy water directly to the building's own HVAC system. This avoids the cost of an energy transfer station, but requires tight quality control of the heating system within the building.

Guidelines from the American Society of Heating, Refrigerating and Air-Conditioning Engineers set the temperature rise across a conventional boiler or furnace heat exchanger at 11°C (20°F). If designed to these conditions, a district energy system would circulate very large volumes of water, and would incur high pumping costs. The design of the energy transfer station would increase this value (see Figure 2) in order to reduce water flow and pumping costs and many European systems have achieved a "DELTA-TEE" (supply – return temperature drop) of more than 30°C. To compensate for the altered conditions, additional heat transfer surfaces, radiators, coils, etc. will also be required within the building.

Piping is available in either steel or plastic from European or North American suppliers, and is selected based upon diameter, and operating temperature and pressure. Insulated plastic piping has an upper temperature limit of 120°C, making it ideal for heat pump or solar applications. Steel piping, on the other hand, is generally dominant when diameters exceed 50 mm (2").

Piping design and construction has significantly improved with the demand from European systems. European manufacturers, for example, have their own quality assurance programs for the construction of district energy equipment and piping, and it is recommended that these are used in Canadian systems. Because of these high standards, energy loss from hot water piping is typically in the range of five to eight percent even when hot water is pumped several kilometres. Cutting corners on piping quality has proven costly, and piping manufacturers should always be consulted on design criteria, such as water treatment, optimum velocities, construction standards, etc.

Energy Plant

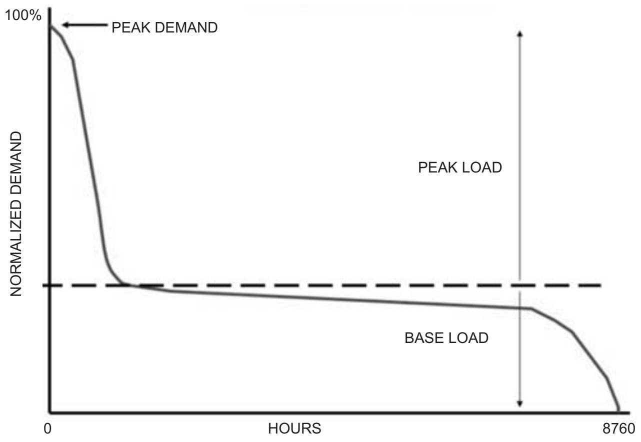
In the first article, the degree of similarity between consumer consumption profiles was shown to be important. How similar the buildings are defines the nature of the load duration curve, and ultimately the economic viability of the required heating plant.

A typical load duration curve is shown in Figure 3. The curve illustrates the operating profile of the energy supply, since its shape reflects local degree days for the community, plus any other loads, such as domestic hot water that the buildings may contain. For many buildings, domestic hot water requires around 20 percent of the overall energy supply, with space heating requiring the remainder.

The energy required for heating the plant is denoted by the area beneath the load duration curve. Its shape therefore suggests that equipment sized for the peak demand will operate at part load for much of its life, leading to inefficiencies and poor economics. For increased effectiveness, the energy supply is divided into base and peak loads. The base load would be supplied by a technology with a high capital, but a low operating cost – biomass, combined heat and power, ground source heat pump, solar thermal, etc., since its operation would be continuous and at high efficiency.

FIGURE 3:

LOAD DURATION CURVE



Equipment providing the peak load could sit idle for extended periods. For this profile, high operating and low up-front costs could be tolerated – gas or oil boilers, for example.

Experience from Canadian district energy systems suggests that, when space heating is the dominant load, the base demand is between 30 and 40 percent of the total demanded heat load. Despite its small capacity, this plant would provide between 80 and 85 percent of the system's energy needs, implying that, although the peaking plant provides two-thirds of the system capacity, it generates only one sixth of its energy.

System integrity is important, and the designer needs to include it at the same level as for any other utility generating station. Availability and reliability must be consistent with regulated targets of conventional energy options. Back-up supplies and redundancy – equivalent to the largest load in the system – must be included. These are often in the form of additional boilers, located at the central plant, as an existing heating plant within the customer buildings.

To summarize, the technical issues associated with the design of a district energy system are mostly well understood. The history of district energy in Europe and elsewhere has led to high quality in both the design technique and the standard of construction. In the third article of this series, examples will be given of ownership models for district energy systems, along with technical resources available to Canadian municipalities. *MW*

as published in

Municipal World

CANADA'S MUNICIPAL MAGAZINE – SINCE 1891

1-888-368-6125 *www.municipalworld.com*