Is District Energy Right For Your Community?

Part 1: The Concept

Ken Church

More than ever before, we hear the term "district energy" being used to describe the solution to a community's energy problem. However, as with the term "sustainability," confusion exists over the exact definition and role that "district energy" is supposed to play in achieving this new state of energy nirvana.

What exactly is district energy and how could it impact the future of Canadian communities? This article is the first of three that addresses energy use within the community and assists in defining a role for district energy at the municipal level. The first article discusses the basic concepts and characteristics of district energy; the second will give insight into the sizing of the system's hardware; and the third will conclude by focusing on the issues of ownership and regulation.

Concept of District Energy

District energy is often confused with energy generation technologies such as cogeneration. In and of itself, district energy is not a stand-alone technology: it does not actually produce any energy whatsoever. Physically, it is a thermal network: piping that links an energy supplier to an energy consumer. Philosophically, though, it is an energy management system that operates at a community level.

The medium that flows within that piping network from energy supplier to energy consumer can be steam; it can be hot water; or it can be cold or even chilled water. The network acquires energy at one location, and delivers it to another, providing not only economic benefits (revenue from the sale of energy) to the community, but also environmental benefits (reduction in overall fuel use and, consequently, emissions) and social benefits (improved understanding of sustainability). In some systems, multiple suppliers are accessed with a variety of energy types and customers.

The consideration of district energy as a management system comes from the fact that people, buildings and industries consume energy at different rates and in different patterns, and by linking them together, management of energy consumption becomes possible. Conventional heating and cooling plants are located in each consumer's property, and follow an individual load with resulting inefficiency of supply (boiler manufacturers always overestimate their component's efficiency). Linking these consumers in a thermal network allows energy demands to be aggregated into a steady load.

Likewise, the principle behind the use of a heat-carrying medium is to aggregate the availability of energy despite its multiplicity of forms. Hot water, for example, creates a common denominator for the fuels and energy supplies and insulates the customer from volatility in the marketplace. In times of uncertainty, economic stability may be achieved for building owners and operators by managing the use of fuels and energy streams. For example, District Energy St. Paul in Minnesota calls upon coal, oil, gas and biomass to supply its downtown system, stabilizing the cost of supplying heating, and enabling the building owner to plan ahead.

District energy does not differentiate between building type, and any group of buildings may form the basis of a workable system. However, key factors need to be identified as having influence over a system's success. These are: the customer energy profile, the spatial arrangement of the loads, and the source of the energy itself.

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Customer Energy Profile

A system with a single customer offers no real savings. A system with multiple but identical buildings increases the overall demand, but must load-follow to a greater degree (figure 1). There is no breakeven point with respect to the number of buildings that constitute a district energy system. Rather, clusters should be sought, and in particular, buildings having compatible and sympathetic load profiles, since these are highly prized customers for district energy systems. They serve to level the aggregated energy demand profile, improving both the operating efficiency and the overall system economics.

Profile levelling serves to reduce the size of energy supply needed for a particular load, and therefore plays an important role in the economics of a system. A level profile may be achieved through several means, including the creation of land-use planning policies that encourage mixed development. An example of this is in Vancouver's trendy Yaletown area, where energy intensive industries such as micro-breweries were encouraged to locate and take advantage of the availability of Central Heat Distribution's district energy system.

Alternatively, the system could incorporate some form of thermal storage. Excess energy can be stored temporarily in liquids, salt or the ground itself, and withdrawn as and when required. Natural Resources Canada is currently testing an in-ground thermal storage system in Okotoks, Alberta. The bore-hole storage system is fed from a series of roof mounted solar collectors. When charged, the system is designed to provide the bulk of the development's thermal needs.

Distribution of Loads

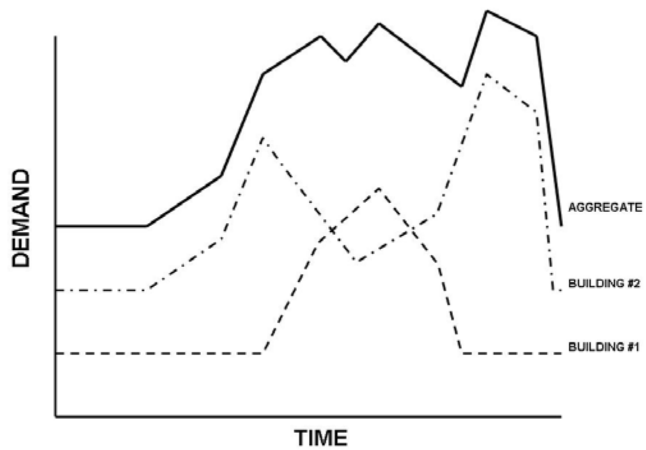
The simplest piping network for a water-based system takes the form of two parallel lines (a supply and a return line), joined at one end of the heating supply and, at the other to each other. Customers draw hot water from the heated supply line, extract their energy needs and return the cooled water through the return line. In this way, all customers, regardless of their exact location, access the same supply temperature.

In many of the older steam-based systems, a single supply pipe was installed, with the condensate being passed to the local drainage system. Current practice for steam-based systems would encourage the inclusion of a condensate return line. While steam was popular in early system designs (and is still so in industrial applications), the current trend is to reduce the supply temperature so as to allow access to low temperature energy supplies.

Most existing hot water systems supply at around 90°C, although newer designs, such as in Regent Park in Toronto, will be lower. Return temperatures will vary depending upon the demand, and building owners should be encouraged to maximize heat extraction. The importance of the supply and return temperatures will be discussed in the second part of the series.

Figure 1

Aggregated Demand-Use Profile



Several piping designs and materials are available across Canada, and designers should select them based upon design conditions and budget. Improvements in insulation techniques, construction standards and operating practices are reducing piping heat loss to a minimum, allowing the piping to be direct-buried at a depth of one metre rather than the three to four metres normally associated with water or sewer lines. This simplifies its placement significantly. It should be noted here that the cost of piping and its installation can be a significant fraction of the project budget, possibly up to 60 percent depending upon the system configuration. Piping networks are therefore best developed around a host customer, in clusters with hub and spoke arrangements, or connected sequentially and without dead-ended spur lines.

For system integrity, each customer is isolated from the system by an energy transfer station that comprises heat exchangers, control valves and instrumentation. Many of these units are custom designed, owned and maintained by the district energy company.

Source of Energy

By managing the demand for heating and cooling, greater control may be achieved over the way that the energy is produced. The savings that are manifested for both the customer and for the municipality are normally those associated with the savings in bulk fuel purchases or improvements in system efficiency over the traditional options of natural gas or oil.

However, depending upon the fuel source, the municipality can benefit in other ways. A hierarchy exists for fuel types that can assist communities in selecting the most beneficial supply. At the top of the list are fuels that are also pollutants (landfill gas, sawdust, municipal solid waste, etc.), where their use addresses both health and energy issues. Energy Revelstoke in Revelstoke, BC uses sawdust as a fuel, and replaces a Tier 1 beehive burner. In this way, particulate emissions in the area have been reduced by almost 90 percent.

The second preference for fuel would be emissions that are relatively benign, such as industrial waste heat. Thirdly, would be renewable energy including biomass intentionally produced (woodchips, fuel crops, etc.), and finally would be fossil fuel. In this way, a community can prioritize their available energy supplies.

It can be seen, therefore, that the role of district energy within a community links together land-use planning, economic development, and the effective use of local resources. Add to that some employment potential and environmental benefits, and one can see that energy management is a powerful tool for the community.

The second article in this series will further examine the three sectors of the system: the customer, the network and the energy source, but from an engineering perspective. It will highlight aspects that must be considered in establishing a district energy system within the community, and thereby provide the community with insight – enough to engage consultants for a more detailed review . MW

as published in

Municipal World

CANADA'S MUNICIPAL MAGAZINE – SINCE 1891

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