# DISTRICT ENERGY IN SYNC WITH SMART GROWTH GOALS

## Planning Figures in Pro Forma

By David MacMillan

**DISTRIBUTED GENERATION** and district energy systems represent community-scale infrastructure on a level between individual buildings and large power plants, and provide a means to address energy needs and sustainability in urban areas. Urban planners can facilitate implementation of district energy systems by focusing on high density, mixed-use developments and economical land use patterns – policies already in keeping with many municipalities' stated socio-economic goals.

Two of the most significant barriers to implementation are the higher costs of capital (relative to business-as-usual) and long-term operational profitability so it is crucial that systems are designed and built as cost-effectively as possible. This requires urban planning with district energy as a consideration before any development actually occurs because retrofits are technically difficult given physical space limitations in urban areas and economically unfeasible in many cases.

### DEMAND MANAGEMENT INSTRUMENT

In their simplest form, district energy systems are comprised of three main components: 1) a central plant that, depending on the technology employed, provides any or all of heating, cooling and power; 2) a network of pipes/conduits used for distribution; and 3) an interface between the distribution network and the building, such as a heat exchanger. They are a supply-side technology in that they do not generate power; instead they distribute the thermal energy produced by power plants, typically either as steam, hot water or chilled water.

Electricity can also be distributed as part of the network when the central plant produces thermal and electrical energy, also known as combined heat and power (CHP). The specific design of the system and technologies used, including the fuel source, the energy carrier, the number of pipes and the interface will be application-specific and depend on the types of buildings connected, end uses and required loads, physical space limitations and local building codes.

District energy is not typically considered conservation given that the purpose of the technology is energy supply, not demand reduction. However, it does support energy efficiency by moving energy from source to load with reduced energy losses, and meets the definition of demand management.

In connecting buildings with various uses through a thermal network, it allows for efficient load management by aggregating the various demands. The incorporation of thermal storage can act to further manage demands and peak loads.

District energy can also be considered energy-efficient based on the fuel used at the power plant. By switching from dirtier and less efficient fuels to cleaner and more efficient fuels (e.g. coal to natural gas), energy efficiency is improved.

Systems are designed to use local fuel sources, including waste heat, and fuels that match the end-use required, both in terms of process and temperature. For example, a natural gas-fired power plant would suit industrial uses where high temperature steam may be required, whereas renewables – such as solar thermal and biomass – would suit lower temperature applications that employ hot water as the medium.

Finally, district energy systems can be energy-efficient if designed for cogeneration of thermal and electrical energy. CHP plant efficiencies can reach upwards of 80%, whereas systems that utilize only electricity have efficiencies closer to 40%.

### DENSITY & SITE CONFIGURATION

In developing a district heating retrofit scenario for a suburb of London, UK, the BioRegional group found that it requires specific preconditions in order to be feasible, including adequate density, a mix of building types and uses, as well as an available source of waste heat. Even when a successful business case can be made, a retrofit needs to compete with other possible retrofits. BioRegional also found that, despite a district heating system reducing greenhouse gases (GHGs) at a lower cost, residents in the community preferred a traditional building retrofit because it would immediately improve thermal comfort and reduce utility bills.

**Systems benefit from groups of users that have different requirements at different times.**

In urban areas, buildings and transportation uses contribute the most to local GHG emissions, but luckily they are two sectors in which planners exhibit a measurable degree of control. Notably, density of built form is specified by planners prior to development based on a number of factors, including the types of uses sought for the area, the heights and shapes of buildings and general urban design criteria.

Density of built form also means that there will be an associated energy density, such as an aggregated thermal load for a group of buildings. District energy systems basically require a minimum energy density in order to be feasible, a number that will vary depending on the specific context. Downtown cores, where high-density buildings are concentrated, are typically better suited than lower-density residential developments.

Simulations have shown that low-density suburban development can be 2 to 2.5 times more energy- and GHG-intensive than high-density urban core development. This implies that district energy is much more cost-effective (energy output per fuel input) in these dense urban areas.

Higher-density development has the added benefit of reducing infrastructural servicing requirements, the costs of which are a direct function of the distance they must be extended to connect with users. The shape of the lot on which the building sits and the overall development pattern of the community will also affect the infrastructural requirements to serve an area. Grid patterns with rectangular-shaped lots lead to shorter roads and thus shorter distribution infrastructure.

However, when development expands out to groups of buildings, there is an optimum building density at which the energy efficiency gains provided by greater thermal load are offset by losses due to reduced passive solar gain and greater ventilation requirements. Beyond a certain density, compactness or the surface area relative to the volume of the building (also known as the A/V ratio) is a better metric for optimizing energy efficiency. Urban planners should be mindful of these relationships.

### MIXED-USE MAXIMIZES EFFICIENCY

Mixed-use development also enhances the feasibility of district energy. Consistent and measurable demand for the thermal and electrical energy supply is critical so that the power plant operates at maximum efficiency, especially if there is no available storage. Therefore, systems not only benefit from large users with high demand, but also from groups of users that have different requirements at different times.

Consider the example of a solely residential development. Even if the density was large enough so that a district energy system could be sized to meet the peak demand in a cost-effective manner, patterns of energy use (timing, loads) will be relatively similar and there will be periods in which minimal demands are placed on the power plant.

For a district heating system operating during the summer months when space heating demand is negligible, the hot water demand from a residential development may not be a large enough heat sink and much of the heat would be wasted. However, if another major user was located close to the residential development, such as an industrial plant, hospital or university campus, a case could be made for a district energy system.

The industrial plant operates for many hours a day all year round, thus representing a consistent demand; the hospital and university campus may have smaller loads than the industrial plant, but given the need for often constant operation and the variety of end uses, they could also act as significant heat sinks. Therefore, one of the key measures that planners can take to facilitate district energy implementation is to ensure development with a mix of uses, including a major anchor tenant.

David MacMillan is a Master's candidate at York University's Faculty of Environmental Studies, and is currently working with campus operations, with assistance from the City of Toronto, on a plan to expand the district energy system at York's Keele campus. The preceding article is excerpted his paper, **District Energy Planning as Part of an Urban Energy Efficiency Strategy for Ontario's Municipalities.**