A case study in community energy planning:

Planning for the expansion of a campus district energy network

Community Energy Planning

One of the key reasons for creating a community energy plan is recognition of the interface between energy, land use and infrastructure. The current approach to energy planning focuses primarily on large, electricity only solutions that are funded by the rate base. However, community energy planning (CEP) is an integrated approach that focuses on smaller energy (electrical and thermal) solutions where infrastructure is shared and funded by those who benefit from it directly.

A district energy (DE) network can act as a central component of a community energy plan because it: addresses load growth at the source and can be expanded with new development; provides a fuel efficient platform for energy distribution and the economies of scale for future fuel switching; retains the economic benefits of energy expenditures within the community; and maintains reliability when faced with low probability, high impact events.

District Energy

Any DE network will have four main components: a central plant that produces thermal energy and, if it is a combined heat and power (CHP) plant, electricity as well; a network of insulated pipes to move the thermal energy (either as steam, hot water and/or chilled water) and wires for electricity; energy transfer stations, which are essentially heat exchangers, located in the connected buildings; and hydronic (water-based) thermal distribution systems in the building.

There are a number of ways that an integrated planning process can facilitate DE development, both directly and indirectly. For example, in considering the deployment of the infrastructure, rights of way must be provided for the distribution network and surrounding uses must be considered when siting the central plant. However, urban form, building uses and design are also critical factors.

For example, load density represents energy demand over a given area and it correlates positively with the density of built form. Therefore, as building density increases, energy density also increases. However, the customer rate for thermal energy from a DE network acts inversely and will decrease. Essentially, the marginal cost of extending a distribution pipe to a high-density building is less than extending to a low-density building because the costs are dispersed over more users.

Also, the profitability of a DE utility depends (in part) on consistent and continuous thermal load – in other words, the network delivers higher efficiencies when the equipment is operating steadily as opposed to cycling on and off. Where the two individual buildings – for example an apartment building and an office tower – might have very different peak load timing (maximum demand), on aggregate the load profile is steadier and thus better for the DE system operator. Thus, mixed-use areas, which are generally desirable anyway, can improve the feasibility of a DE system.

Finally, a prerequisite for connection of a building to a DE network is a hydronic distribution system. In such systems, water acts as the medium to distribute thermal energy throughout the building via radiators. Thus, in areas where a DE network is not in place, but is being considered for future implementation, specifying "DE-ready" buildings in area planning policy or zoning bylaws could facilitate future connection.

York University – Keele Campus

At 457 acres, York University's Keele Campus is arguably a city within a city and the challenges it faces are analogous to those of Toronto: growth pressure; aging infrastructure; constrained budgets; and significant energy use and greenhouse gas (GHG) emissions. The campus is set to receive a rapid transit connection in 2015 and available land will be leased and developed very quickly, which will have a significant impact on energy demand. A Master Plan has been developed for the campus and the Secondary Plan has been approved, but there is little reference to DE in these documents.

The existing DE network was originally constructed in the mid-1960s and grew as the campus expanded. It currently serves 90 buildings (7 million square feet) and is approximately 3.5 kilometres in length. The central plant houses four natural gas-fired boilers, 8 chillers and two 5 MW natural-gas fired turbines with heat recovery steam generation. The central plant meets all of the thermal demand and on average, approximately 60% of the electricity demand.

The campus concept plan identifies the potential for approximately 15 million square feet of new gross floor area (GFA), more than twice the area served by the DE network currently. While buildings developed by the university are typically connected to the DE network, the new buildings would mostly be office, retail and student housing developed by private entities. As such, there is no guarantee that the developers will connect to the DE network unless this is required in leases.

Analysis

The first step in the energy planning process is a qualitative assessment of the existing conditions and in this case, the buildings not currently connected to the network provided a starting point because they represent immediate opportunities for expansion. The basic metrics in the survey are: ownership and use; fuel consumption (obtained from utility bills); and space heating, space cooling and domestic hot water equipment.

Next, a series of coefficients (electricity and natural gas consumption, electricity demand and GHG emissions, all specific to building use and normalized to floor area) are multiplied by the estimated gross floor area of the potential new development in order to calculate potential energy consumption, electricity demand and GHG emissions for each building. Coefficients are generally derived from public databases, energy models of existing buildings and engineering rules of thumb.

The calculated energy consumption values can then be inputted into the RETScreen Clean Energy Analysis Software program– freeware provided by Natural Resources Canada – in order to generate building load profiles. While more detailed engineering analysis will ultimately be required to assess feasibility, the software can help generate figures that assist with further planning, such as estimating potential GHG reductions by connecting to DE and the possible capacity of a CHP plant.

Another way that this energy data can be used is by visualizing it in a geographic information system (GIS). When combined with the data on existing buildings it becomes a useful decision-assisting tool. “Spatializing” building survey data and energy and emissions calculations can assist with identifying opportunities for expansion by providing a sense of what and where the loads are (which can assist with locating infrastructure) as well as the possible physical implications of expansion.

Conclusion

District energy networks are commercially viable, shared energy solutions that can help address the economic, social and environmental challenges facing urban municipalities in Ontario. An integrated planning process can facilitate DE implementation by identifying opportunities for expansion. Campuses, whether academic or other, are ideal settings to explore expansion and provide an excellent training ground in which to develop interdisciplinary curricula and innovative planning practice.

David MacMillan (jdmacmillan13@gmail.com)
York University – Master of Environmental Studies (Planning Program)
Toronto, Ontario