Decentralising energy

Peter North

The Mayor of London's Climate Change Mitigation and Energy Strategy sets ambitious targets to reduce London's CO_2 emissions to 60% of 1990 levels by the year 2025. With 30% of the capital's emissions attributable to heating, mostly from mains gas, one of the greatest opportunities is to reduce demand for heat through building retrofit and low carbon, local (decentralised) heat supply by means of Decentralised Energy (DE[1]). Decarbonising the other big energy related emitter, electricity supply, is best placed as a national action through nuclear, wind and carbon capture and storage.

The Mayor recognises the importance of decentralised energy technology in contributing towards the carbon dioxide (CO_2) emission reductions and sets a further target of supplying 25% of London's energy supply from DE by 2025. Current Greater London Authority (GLA) planning policies require relevant developments to consider: a) connecting to local district heating networks and if not, then b) installing their own Combined Heat and Power (CHP), and c) meeting 20% of the site energy demand from renewable energy sources. The current uptake of DE falls short of the trajectory required to meet the 2025 target, yet work carried out by the Greater London Authority concluded that London does have the capacity to deliver the targets. So the market is failing to deliver the potential which Powering Ahead (Greater London Authority, 2009) estimated to be worth £5–7 billon of investment to deliver annual CO_2 savings in the range of 2.2 to 3.5 million tonnes.

During 2007, the London Development Agency (LDA), the Mayor's now abolished delivery agency, investigated the DE market failure as part of the London Thames Gateway Heat Network (LTGHN) project. It concluded that the largest quantum of CO_2 savings could be delivered at market competitive rates (i.e., without government energy subsidy) in dense urban areas through industrial scale combined heat and power involving extensive district heating (DH) networks. This role for DH networks is mirrored in the Government's Heat Strategy which also came to a similar conclusion following its own work. Published in March 2012, the Heat Strategy highlights

[1] Decentralised Energy – defined as the local generation of electricity and where appropriate, the recovery of the surplus heat (combined heat and power – CHP) for purposes such as building space heating and domestic hot water production.

How to cite this book chapter:
North, P. 2013. Decentralising energy. In: Bell, S and Paskins, J. (eds.) *Imagining the Future City: London 2062.* Pp. 63-66. London: Ubiquity Press. DOI: http://dx.doi.org/10.5334/bag.i

a potentially major role for networks in areas of high heat demand by removing carbon from commercial and domestic building heat supply.

A city-wide DH network such as the LTGHN could be viewed as creating a heat market, by providing a route to market for low and zero carbon heat suppliers (industrial undertakings such as energy from waste, combined cycle gas turbine plant and energy intensive industry), and to heat consumers for building space heating and domestic hot water (DHW) production and other heat requirements. The LTGHN project was estimated to cost £160 million (at 2008 prices), serve the equivalent of over 110,000 homes and principally involved the creation of a district heating network that would involve:

- The phased construction of seventy km of DH pipework over a ten – fifteen year period connecting private sector industrial plants to consumers (a small to medium sized system in European city terms)
- The buying of heat from industrial undertakings
- The selling of a secure[2] supply of heat to consumers in the form of hot water
- The operation and maintenance of the heat network
- The expansion and development of the heat network and new connections
- Where appropriate, the facilitation of the bilateral supply of heat between suppliers and consumers, by allowing system access and charging 'use of system' for the transfer of their heat.

The project development was suspended in 2010 following the failure of the private sector to respond to a formal invitation to negotiate heat supplies. Considerable strategic and technical know how and commercial principles were established that continue to be deployed on London's current DE developments. The LTGHN would in fact look very similar to the city-wide CHP district heating schemes that have been operating in Northern European cities for many decades. Most of these schemes were undertaken by the municipality for reasons of national energy security (Denmark), the most economic form of urban energy supply (Finland), or the efficient utilisation of energy. In contrast, the LTGHN project was predicated on CO_2 savings at market competitive heat prices. Despite being economic propositions, the delivery of projects on the scale of LTGHN could be greatly enhanced by the de-risking effect of initiatives from government to facilitate the involvement of local authorities in promoting heat networks at scale, to encourage connections of heat sources and heat loads to these networks and coordination between local authorities. The implementation of the Government's Heat Strategy therefore provides an opportunity to secure this.

The development of large-scale DE in London continues primarily through the activities of London Boroughs following a systematic methodology of local policy formulation and heat mapping to identify the most heat-dense areas, and energy master-planning to establish the evidence basis and high level costs of specific area-wide DH systems. Local authorities (LAs) are then able to deploy their powers to de-risk projects by requiring developments to investigate connecting to the DH network, require financial contributions from new developments and facilitating other 'buy-out' arrangements, bringing forward their own heat loads to secure long-term heat income for the project and possibly funding at public sector rates. Similarly, LAs may also have an interest in existing and proposed energy from waste (EfW) schemes and can require new energy developments to be built with heat off-take to supply local DH network. With a number of London's DE projects currently completing the feasibility stage and moving towards commercialisation, it will be interesting to reflect on the public sector role in their delivery.

The question has been asked, 'So what happens when the gas runs out and we're so efficient at recycling, there is no longer any waste?' By then, interconnected DH networks would have been established in the short-term from gas CHP, in the medium term larger schemes based on EfW and

[2] Heat is made 'secure' with the addition of standby and top-up heat-only boilers fuelled by mains gas in sufficient number and capacity to meet heat demands in the event of the industrial heat supply failing.

sources of surplus heat, and finally the networks interconnected to form city-wide systems with multiple heat suppliers. As DH networks have the simple role of circulating hot water as the energy carrier, they are heat-technology agnostic. They don't care where the heat comes from, so it is entirely feasible that when the gas runs out and there is no longer any waste, the future energy source will be electricity from nuclear power and wind, CHP would therefore be replaced by industrial heat pumps.

But there are other more efficient and effective possibilities. Further consideration of alternative city-level energy sources has found there to be considerable potential in low grade (temperature) surplus heat from the likes of data centre cooling, underground train ventilation, electricity substations, sewage works etc. Heat pumps can elevate this low grade heat to current day DH supply temperatures (70°C – 110°C), however the higher the temperature elevation, the lower the heat pump efficiency and there is a limit to the economics and what people are willing to pay for heat from such a system.

By way of example, the elevation of waste heat from an underground train vent (23°C – 28°C) would be limited to 55°C – 60°C using a heat pump so as not to exceed the market price of heat. This would relate to a coefficient of performance (CoP)[3] of around three. In fact, lower supply temperatures may be entirely viable if building heating systems could either accommodate the lower supply and return temperatures, or are designed for this from the outset. Taking this to a natural conclusion, why bother with the heat pump? Why not simply collect and supply heat to the DH network at low temperature and elevate the temperature to the end user requirements by a local heat pump at the point of consumption? Even the need for a heat pump for the user could be minimised or eliminated if the building heating system was designed for low temperature, ie underfloor heating or close-coupled wall heating. Or maybe the traditional wet radiator system operating at low temperature would be sufficient where properties are highly insulated following retrofit.

So the future London urban DH network will evolve today from natural gas CHP, energy from waste and surplus heat operating at higher temperatures, with the networks becoming more interconnected. The systems would mature into low temperature networks scavenging low grade surplus heat, minimising the need for primary energy input. The system will be very efficient due to the low system heat loss, and the local distribution legs to consumers will be cheaper because of less onerous pipe work material requirements, with any high temperature water requirement being met by a local heat pump. Regulation should require industrial and commercial cooling systems to be designed to connect to low temperature DH systems, and the use of air radiator/river water cooling discouraged. Inter-seasonal aquifer heat storage would also become a possibility. Such systems have already been thought about and exist as small campus-type systems where it has been possible to carry out the overall design and specification from production to consumption in a single system. So is this how a zero carbon London will be heated in 2062?

References

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[3] The coefficient of performance (CoP) of a heat pump is the ration of heating or cooling provided over the electrical energy consumed. The CoP provides a measure of performance for heat pumps that is analogous to thermal efficiency for power cycles. The equation is:

$$COP = \frac{Q}{W}$$

where Q is the heat supplied to or removed from the reservoir and W is the work consumed by the heat pump.