

# Optimisation of Operating Temperatures and an Appraisal of the Benefits of Low Temperature District Heating (1999: T1)

One of the most fundamental decisions to be made by a designer of a new district heating system is the selection of design operating temperatures. Lower operating temperatures will reduce the cost of heat production from CHP plant but to achieve lower temperatures requires additional investment in the heating systems within the buildings. The cost of the district heating network is reduced if the temperature difference between flow and return is maximised. There is therefore a need to establish the optimum design temperatures to achieve the most cost-effective scheme.

In order to identify the optimum design temperatures, a series of case studies based on notional groups of buildings were developed and comparative economic analyses produced. The case studies comprised combinations of:

three types of built form: apartment blocks, row houses and commercial buildings;  
two sample climates : London and Toronto;  
three types of CHP plant: extraction-condensing steam turbine, back pressure combined cycle gas turbine and spark-ignition gas-engine.

The analysis of the heating systems within the buildings was carried out by CANMET who developed simulation models using the Simulink software. This enabled hour by hour heat demands, district heating flow rate and return temperatures to be calculated for each case. These heat demand patterns were then used as the basis for the spreadsheet models developed by Merz Orchard to simulate the operation of a CHP plant over the year and hence calculate the cost of heat production. Designs for the district heating network were produced using System RORNET by Merz Orchard and the capital cost was estimated. Finally, costs were obtained from manufacturers for district heating substations, radiators and air heating coils required within the buildings. All of these cost elements were calculated

for a range of design operating temperatures, from 90°C to 70°C flow and from 55°C to 30°C return.

The results are presented in a series of graphs for each case study analysed showing the cost of heat against the design temperature difference for different flow temperatures. It was found that, for all cases, it was not worthwhile to reduce the design flow temperature below 90°C as this leads either to a smaller temperature difference and therefore higher network costs or, if the temperature difference is maintained, additional costs for larger radiators. Both of these cost penalties are more significant than the small reduction in heat production cost obtained with using lower flow temperatures.

For a peak flow temperature of 90°C the optimum temperature difference was found to be about 35°C (55°C return temperature) in all cases, although the cost curves are relatively flat and a variation in return temperature of +/- 10°C about the optimum resulted in a cost variation of less than 3%.

There are many other potential benefits from using lower temperatures, in particular the ability of the district heating network to utilise low grade heat sources available from industry, solar heat and heat pumps. The cost penalty from selecting a 70°C temperature instead of 90°C was found to result in an overall increase in the cost of heat of between 4% and 6% of a typical heat selling price. It is possible that, in some circumstances, this relatively small increase is justifiable given the potential environmental benefits in the longer term of maximising the use of waste heat and renewable energy by means of district heating. However, in many cases, the low grade heat sources will contribute only part of the energy supply and will effectively pre-heat the return water. A reduction of return water temperatures will therefore be the more important requirement.