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Looking forward to UK low-carbon heating

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Whilst the oil crisis of the 1970's brought renewed concern for delivery of energy efficient heating systems, the new millennium has seen a shift of emphasis to delivering systems that can be classified as 'low-carbon'. Accordingly, this means giving due consideration to primary energy sources and grid carbon intensities. In countries with moderate or cold climates like the UK, industry has been challenged to deliver heating systems and building designs that have significantly lower carbon emissions in the next few decades as part of national and international emissions reduction strategies. In what is the fortieth anniversary volume of this journal it is appropriate to take a look back at the application of heating technologies and also to ask if industry should be looking further ahead in order to meet the challenges that have to be faced?

Since the introduction of carbon emission based assessment of building designs came into effect in the EU in 2006, the choice of heating fuel and primary energy has had an effect on which forms of heating technology have been acceptable. For countries like the UK, where there has been a concerted effort to reduce grid electricity carbon intensity over the last decade, this has also meant that the heating technologies with the lowest annual carbon emissions have been changing. Whether this is properly reflected in the choices made at the design stage naturally depends on the data and methods used to make the carbon emissions assessments. Whatever is decided, the choice of heating technology will most likely influence the system emissions for a further thirty years or more.

The UK has looked to natural gas fuelled heating in housing and similarly fuelled CHP in district heating systems for a number of decades; chiefly for economic and supply chain reasons. The carbon intensity of UK grid electricity has been taken to be more than twice that of natural gas in the regulations that have been applied to buildings designed since 2006 and those that are being constructed now (0.519 $kgCO_2/kWh$ as opposed to 0.21 $kgCO_2/kWh$ respectively [11]). This has arguably made electric heating technologies hard to compete with conventional natural gas boiler solutions in terms of routes to compliant designs. Progression towards deployment of heat pump technologies has been corresponding slow [10].

In contrast to a slow rate of change in building and district heating design practice, the mix of primary energy sources in the national electricity supply has changed significantly in the last decade in the UK. The use of coal as a primary fuel has become negligable and a combination of large-scale deployment of wind power, PV and biomass

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power generation have contributed to total low carbon sources surpassing 50% of the supply on some occasions. Grid electricity carbon intensities now regularly fall below that of natural gas at certain times of day. It has been projected that UK average grid carbon intensity will fall below 0.15 $kgCO_2/kWh$ by 2025[4]. Given that median seasonal efficiencies of domestic heat pumps have been shown to be more than 2.65[8] the advantages in terms of annual emissions of heat pump technologies of natural gas boiler technologies is very clear; even using current values of grid electricity carbon intensity. This has been recognised in studies of national heating energy strategy[3] and consideration of long term carbon reduction over a 2050 horizon[2]. National heating strategy in the UK is accordingly focussed on long-term deployment of heat pump and district heating using heat pumps.

Given these recent and projected changes in grid electricity carbon intensity, we must return to the question of whether this is being reflected in the Building Regulations and design practice. At this time, the carbon intensities used in design calculations remain at high historic values. In view of the fact that overall carbon emissions targets are centred on a 2050 timeframe, and that nearly all the buildings designed in the last decade will still be operational, surely we should ask whether it is more appropriate to look forwards in any assessment of emissions, with reducing grid carbon intensities in view? This issue has been highlighted in past CIBSE Technical Symposium papers with respect to the design of individual buildings[6] and district heating[1]. This need for a more forward-looking perspective on emissions assessment is now set to change in the proposed revisions in regulations[11]. It is unfortunate that opportunities for developing buildings with more appropriate heating technologies have been missed in this last decade and that the changes in regulation are yet to come into force.

As the carbon intensity of grid electricity falls below that of natural gas, the question arises as to whether a preferable heating solution would be to opt for plain resistance heating. This option may, in fact, be suggested by the building carbon emissions rates predicted in the design process (calculation of EPC data) in certain circumstances. Electric resistance has been adopted in many UK apartment developments in recent years as heat losses have been relatively small and resistance heating is attractive in terms of capital cost. From a building developer's point of view this may be a preferred option but, from the point of view of national policy and long-term reduction in emissions, it is objectionable and should be guarded against.

The reasons for guarding against any move towards resistance heating in preference to heat pumps relates to issues that were raised in the early days of domestic heat pump development. John A. Sumner was an electrical Engineer working for one of the UK generating companies who developed a water-source heat pump in an office building in Norwich (1946) and a ground source heat pump at this home[12;13]. In the 1950s Sumner made the point to the Central Electricity Generating Board (responsible for UK power generation at the time) that much capital cost involved in building new coal fired power stations could be avoided if heat pumps could be adopted rather than resistance heating[5;13]. At that time, electricity boards were very much concerned with selling electricity and 'viewed with some disfavour a machine providing a unit consumption of only one-third of that required to provide a given amount of heat by normal resistance heating'[13]. His argument was not accepted.

There is a very similar point to be made at the moment when there is a need to rapidly increase renewable power generation such as wind power and national power demands are expected to rise due to electrification of transport and heat. Given the finite nature of the renewable energy resources that are available, and the need to implement increases in renewable generation rapidly, heat pump technology will make better use of these limited resources in providing heat than resistance heating. In simple terms, a heat pump can provide 3kW of heat for 1kW of wind power. Heat pumps should be seen as a technology that leverages the available renewable energy resources as well as providing economic heating to the householder. This requires a policy that considers both generation and building demand, not just what is favourable at the level of individual buildings.

The fact that heat pumps for domestic heating work more efficiently when heat is delivered at lower temperatures, is well understood. Widespread deployment of heat pumps consequently also raises the question as to what heating system temperatures should be used in design? This is also an issue for the long-term development of district heating networks. If networks are to be operated with lower heat losses and low enthalpy waste heat is going to be introduced, buildings with lower system temperatures are required. It is interesting to reflect on Swedish experience with heat pumps and system temperatures. In the 1980's a rule was added to the Swedish Building Regulations (SBN) that restricted design (peak) heating system temperatures to 55°C, irrespective of the heating source[7]. At that time, heat pumps were at the early stages of implementation. This measure had the benefit that, as the heat pump market developed, it became straightforward to retrofit heat pumps into existing properties so that by 2007 36.5% of homes have some form of heat pump system[9].

One objection to mandating lower heating design temperatures could be potential capital cost increases due to the need for larger heat emitters. It should be recognized that building space heating demands continue to fall as insulation standards improve so that conventional radiators are relatively small in current new UK homes. Hence, lower temperature heat emitters are likely to have little impact on future space requirements or capital costs. If natural gas condensing boilers are used, lower system temperatures will also be beneficial in promoting greater tendency for condensing operation.

The need for building design to be informed by long-term national energy strategies and carbon emissions policy seems more apparent then ever before. In seeking heating systems that are optimal from an energy and carbon emissions perspective, there is evidently a need to think ahead to assess the impact of choice of fuel and heating technology over building life cycles. This requires design and assessment methods that consider long-term decarbonisation of the electricity grid. Recognising the finite nature of renewable generating capacity should also lead us to guard against any movement towards electric resistance heating. If the cost and practical impact is negligible, surely mandating lower heating system temperatures in new buildings should be considered as a further measure to promote long-term uptake of low-carbon heating? Let us look further forward.

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