Response on Domestic Heating etc **Gordon Taylor** **2008-04-14**

Introduction

Climate change mitigation is urgent and requires a transition to sustainability. (Ref. Stern N., 2006, 'The Economics of Climate Change'. Executive Summary, Fig. 3. http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm). The impacts are already increasingly apparent. (Ref. Spratt D. et al, 2008, 'Climate Code Red'. http://www.carbonequity.info/download.php?id=6). To avoid continued and dangerous climate change impacts, the CO2 concentration should be reduced below present levels – from 385 to at most 350 ppm CO2. To restore sea ice to its area of 25 years ago may need about 300-325 ppm CO2. (Ref. Hansen J. et al, 'Target Atmospheric CO2: Where Should Humanity Aim ?', 2008-04-07, http://www.columbia.edu/~jeh1/2008/TargetCO2_20080407.pdf). Hence the Precautionary Principle requires the adoption of the initial target of at most 350 ppm CO2.

Moreover there will not be enough natural gas at affordable prices. Production peaked in the USA in 2001 and in Canada in 2002. Although Canada will still be an exporter for some years, the USA has joined the EU, Japan, China and India in importing increasing amounts of natural gas, including as LNG. Yet the capacity for gas production and especially liquefaction, shipping and re-gasification is severely limited. (Ref. Hughes J. D., 'Natural Gas in North America: Should We Be Worried ?', 2006, http://www.aspo-usa.com/fall2006/presentations/pdf/Hughes_D_NatGas_Boston_2006.pdf). Furthermore the coal resources are far smaller than previously thought. (Ref. Energy Watch Group, 2007. 'Coal: Resources and Future Production'. http://www.energywatchgroup.org/fileadmin/global/pdf/EWG_Report_Coal_10-07-2007ms.pdf).

In the UK the annual average gas efficiency of existing domestic boilers has been estimated as 65%. (This and other such values in this paper are expressed on the Higher Heat Value basis, as is usual in the UK). (Ref. PIU, No Date, 'Energy Scenarios to 2020', Footnote 15. http://www.pm.gov.uk/files/pdf/PIUe.pdf). The best efficiency of non-condensing boilers is about 82%, so the annual average gas efficiency of existing commercial and industrial boilers is probably about 75%. For gas condensing boilers without advanced controls, it may be 86%. (See Para 103). The gas and carbon saving for domestic boilers would be about $(1 – 0.65/0.86) = 24\%$ and for commercial and industrial boilers about $(1 – 0.75/0.86) = 13\%$. In principle solar water heating could give a further gas and carbon saving. However small systems for individual dwellings have money payback times of 24 to 80 years. (See Para 41). This implies that the Energy Return On Energy Invested (EROI) would be very poor. Even condensing gas boilers would be quite insufficient since climate change and fuel depletion require heat measures capable of carbon savings of 100%. New or refurbished buildings to the Passive House standard and biomass heating can achieve this. However it would be impractical to rebuild all our towns and cities to this standard and biomass supplies would be insufficient. The only measure that can achieve 100% carbon saving for existing towns and cities is District Heating with large-scale Combined Heat and Power, industrial reject heat, municipal waste, biomass, solar heat and geothermal heat. (This is shortened below to 'DH-CHP and renewables'). The evidence for this is given in my response to the recent Heat Call for Evidence. (Ref. Taylor G., 'Criteria and Heat Measures for Carbon Saving', 2008. http://www.energypolicy.co.uk/criteria_heat.htm).

For delivery of such a solution, Government should commission more detailed national-level studies from at least three consulting engineering firms, including two from the Continent, showing solutions for heat with a carbon saving of 100%. Government should then define a roadmap embodying the national carbon targets and dates and set up a framework of franchises in each energy market, such as each town and city. Then after making the engineering studies available, it should invite Energy Service Companies (ESCOs) to bid for the franchises, with each conditional on meeting the absolute Carbon Emission Obligations. Local and national government would have only to monitor the carbon emissions outcomes, based on fuel shipments. These are already measured in considerable detail in connection with Petroleum Revenue Tax and the returns of GHG data to the IPCC. More detail is given in two of my documents. (Ref. Taylor G., 'Criteria and Heat Measures for Carbon Saving', 2008. http://www.energypolicy.co.uk/criteria_heat.htm and Taylor G., 'Energy Solutions for 60% Carbon Reduction', Part II. 2002. http://www.energypolicy.co.uk/epolicy.htm).

Although this response addresses only the heat sector, in extremis - as in wartime or more recently the three-day week and fuel strikes - electricity and transport fuel use can be reduced drastically more readily than heat. However a consistent and coherent approach to carbon reduction for all three sectors is given in my energy study. (Ref. Taylor G., 'Energy Solutions for 60% Carbon Reduction', 2002, http://www.energypolicy.co.uk/epolicy.htm).

Comments on Chapter 11. **Improving the energy performance of domestic heating and hot water systems.**

Para 1. '..supporting delivery .. for sustainable consumption and production'.
This cannot be true since the measures mainly considered use natural gas, which is a depletable fuel. The only measures that can be described correctly as sustainable are those capable of delivering carbon savings of 100%. This excludes all those based on depletable fuels, both fossil and fissile. (See Introduction).

Para 2. ..including proposals .. to phase out the least efficient products'.
Since the target has to be 100% carbon saving, this has to mean phasing out all coal, oil and gas boilers in favour of biomass heaters (for rural buildings) and DH-CHP and renewables (for urban buildings).

Para 5. 'They are sold by different industries in competition with each other..'.
Not so. The gas is all the same and the difference in boilers is marginal. Real competition in fuel and carbon savings in the heat market requires widespread availability of biomass fuel and of DH-CHP and renewables. In Denmark, electrical heating is not permitted in new build, and there is a fund for conversion from electrical to either gas or district heating. (Ref. http://www.elsparfonden.dk).

'In particular, options that are attractive for new buildings may not be feasible in existing buildings'.
Not so. Both electricity and gas are too carbon intensive and depend on depletable fuels, while DH-CHP and renewables offers 80% and the prospect of 100% carbon saving for all urban buildings.

'A comprehensive review of all the options would require a large study and extensive research..'.
A wider review of the options is included in the recent Heat Call for Evidence. (Ref. http://www.berr.gov.uk/files/file43609.pdf). (See also Introduction).

Para 6. 'While there are alternative heating technologies that may ultimately displace them..'.
Because of climate change and fossil fuel depletion, heating technologies capable of carbon savings of 100% should be deployed almost immediately. (See Introduction).

'..the scope of this paper is limited to what can be done in the shorter term..'.
However both climate change and fuel depletion are 'in the shorter term', so 'limited' measures are quite inadequate. (See Introduction).

Para 7. 'Views are invited...to consider policies ..such as ..community heating...and heat pumps'.
However micro-chp units are not suitable since they use natural gas, which has a significant carbon intensity and is depleting fast. (See also Para 112). Heat pumps are not suitable since they use electricity, which has a high carbon intensity and will have for decades. The only options capable of 100% carbon saving for individual dwellings are biomass heating and for community heating heat from large scale CHP plants, waste, biomass, solar heat and geothermal heat. To meet the challenges of climate change and fuel depletion in time, deployment should start almost immediately.

Para 8. 'Changes ..have set a minimum efficiency standard...that is close to the practical limit'.
Yet this is quite insufficient to meet the challenges of climate change and fuel depletion. (See Introduction).

Para 9. (Figure).
Neither the Reference nor the P1 outcomes will be possible or acceptable, since climate change requires a rapid reduction in carbon emissions and the competition for imported gas is already acute. Indeed fast-rising gas prices will force a reduction, since the UK will not be able to afford to pay for imported gas on the scale implied here. (See Introduction).

Para 10. ‘By 2016 ..newly built homes will have zero net annual carbon emissions’.
Unfortunately this cannot be achieved by Government decree but requires engineering solutions. While technically possible, this has yet to be demonstrated in the UK and confirmed by measurements. Brenda and Robert Vale built the New Autonomous House in Southwell at a cost within the local authority guidelines. However, while electricity and water were metered, this house was never monitored, including temperatures. (Ref. http://www.abc.net.au/rn/science/earth/handouts/ukvillage.htm). Moreover experience from abroad shows that zero heating or zero energy houses limited to on-site measures would be prohibitively expensive. (Ref. Esbensen T. V. and Korsgaard V., ‘Dimensioning of the Solar Heating System of the Zero Energy House in Denmark’, 1971. http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=7212104 and Goetzberger A. et al., ‘The PV/hydrogen/oxygen system of the Self-Sufficient Solar House Freiburg’, 1993. http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?tp=&arnumber=346960&isnumber=8044).

The cost-effective solution for single and multi-family houses are the Passive House standards, which reduce the space heating energy by 90%, but still require a tiny post-heater and means of heating hot water. (Ref. Feist W., No Date, ‘Passive Houses from Pilot to Mainstream in Germany’, http://malmo.se/download/18.1f60430104c0456fc68000698/Feist.ppt). This may be provided by a biomass heater. Over 6000 dwellings plus offices and schools have been built, and their performance confirmed by many measurements. (Ref. Feist W. et al, 2001, ‘CEPHEUS – Cost Efficient Passive Houses as European Standard’, http://www.passiv.de/07_eng/news/CEPHEUS_final_long.pdf).

Para 11. ‘The P1 target is already ambitious... ‘.
However it does not end growth in demand let alone begin to meet the challenges of climate change and fuel depletion, which require 100% carbon saving.

Para 19. ‘Press for EuP measures to adopt ..in line with our published indicative standards’.
Why would the UK standards be best ? Do they meet the challenges of climate change and fuel depletion by requiring carbon savings of 100% ?

Para 25. ‘This paper is issued for consultation as part of an annual process..’.
Why not do it right once instead of frequently ? If the policy was science-based, it would not need to change.

Para. 26. ‘It shows that UK boiler sales are substantially greater than those in other EU countries’.
This is probably because other EU countries are using a significant and increasing proportion of district heating. The buildings – whether single- or multi-family - are usually fitted with pre-fabricated ‘consumer units’ consisting of one or more heat exchangers, a pump and controls. Moreover in Denmark, ‘Heat Planning’ means that heat supply is being progressively transferred from oil and gas boilers to district heating. (Ref. Dyrelund A., 2000, ‘Why Zoning? Why not just leave it all to market forces ?’, ‘News from DBDH’, 2/2000, Page 16). This is also true for over 1000 cities on the Continent. (Ref. DHCAN, No Date. ‘The Case for District Heating: 1000 Cities Cannot be Wrong!’. http://projects.bre.co.uk/DHCAN/pdf/PolicyGuide.pdf). Hence it is quite understandable that the sales of boilers in other EU countries are substantially less and declining with time.

Para 27. ‘Alternative heating systems ...such as community heating ..is likely to be small..’.
But such systems, supplied from large-scale CHP, industrial reject heat, municipal waste, biomass, solar heat and geothermal heat are the only measure that can heat our existing towns and cities with carbon savings of 100%.

Para 28. ‘This paper...considers only (measures to improve the efficiency of heat generation and delivery)’.
But it largely neglects the one measure that can make a real difference. The Danish Government has named DH-CHP as the most important single measure for fuel and carbon savings and even in 1998, it had reduced Denmark’s total (CO2) emissions by 10%. (Ref. Auken S., 1998, ‘CHP – an important contribution to solving climate changes’, ‘News from DBDH’, 1/1998, p 1).

Para 30. ‘It is imperative that they can do so easily and conveniently’.
In the UK Thermostatic Radiator Valves (TRVs) are often fitted at the bottom of the radiator, and thus out of reach. They should be fitted at the top, as recommended by Danfoss, who invented them and are still market leaders. Also when radiators are connected ‘top and bottom opposite ends’ (tboe), their output is increased by about 15%.

Para 36. '..modern types (typically with lightweight heat exchangers ...and lifetimes of around 10 years).' Many early UK condensing boilers were of very poor design, typically with cast aluminium heat exchangers. One such was the Potterton Envoy 40, which I had. This failed 16 times in under five years, when I replaced it. As a result of the very widespread failures, Potterton left the domestic boiler market, but sold the name to Baxi. My current boiler was designed and made on the Continent and has a tubular stainless steel heat exchanger. It has delivered very high efficiency with very high reliability and already lasted over seven years. (See Para 103).

Para 37. 'The principal controls, as required by building regulations, are a programmer or time switch..'. However the time constant for a typical brick-built house is probably around 40 hours, and for new, better insulated but lighter houses about the same. Therefore time control lowers the daily output capacity of the boiler and forces it to work harder when on, so lowering the efficiency. Continental practice is continuous heating, sometimes with night setback of 3 to 5 C. Indeed advanced controls such as outside temperature compensation assume continuous heating. (See Para 103).

Para 40. 'Work is under way to develop an authoritative evaluation model ...savings from controls'. I assume that this refers to the work done by ESRU. (Ref. Cockcroft J. et al, 'Development of a Methodology for the Evaluation of Domestic Heating Controls: Final Report – (phase 2)', 2007. http://www.sesg.strath.ac.uk/Downloads/Report_BRE_E302_040707.pdf). Figure 11 shows that due to the time control, the system has delivered a 'comfort deficit' for the first half-hour of each 'On time'. This period would be longer with lower outside temperatures. The effect would also be significant when comparing time controlled with continuous heating. (See Para 103).

Para 41. 'Solar collector systems ...to reduce the fuel demand for water heating'. However the money payback times are far too long. That for an electrically heated property would be around 24 years and for a gas-heated property 80 years (based on current energy prices). Moreover the cost would be £ 2500 to 4000 to save about 0.79 - 1 and 0.35 – 0.44 tCO_2/y respectively. (Ref. 'Microgeneration strategy and low carbon buildings programme: consultation', DTI, June 2005, Annex A. (http://www.berr.gov.uk/files/file13989.pdf). (The gas figures should be divided by the boiler efficiency of 70%). Assuming a lifetime of 20 years, the cost of carbon saving would range from £ 2500 x 3.666/(20 x 0.79) to 4000 x 3.666 x 0.7/(20 x 0.44) = £ 580 to 1166/tC/y. Thus as noted in 'BNDH21: Solar water heating for housing', solar water heating indeed has 'poor economics compared with better insulation and boiler replacement projects'. Higher energy prices would increase the value of energy saved but also the cost of the system, so the payback periods may be little changed. Hence solar water heating for individual dwellings would be a very bad investment from both the consumer (money) and national (carbon) viewpoints.

As with most supply measures, solar heating is much more cost-effective at large scale. The specific cost is lower and the performance is higher. It could supply district heating for towns and cities and industry. (Ref. Taylor G., 'Criteria and Heat Measures for Carbon Saving', 2008. http://www.energypolicy.co.uk/criteria_heat.htm).

Para 44. '..the Government said it would ..publish ..proposals for ..product standards'. However the measures mainly considered here would not meet the challenges of climate change and fuel depletion.

Q 1. Yes. The scope has been defined as not the building envelope but only the heating system. (See Para 28). Yet the most important development concerning the building envelope is the Passive House standard. Based on building science, this has been devised to have the best cost-effectiveness, typically reducing the annual space heating energy by 90% compared with current standards. (See Para 10). Although this can be achieved by refurbishment, it would be impractical to rebuild all our towns and cities to this standard. The only other measure that can deliver fuel and carbon savings of 80 to 100% is DH-CHP with renewables. (See Introduction).

Q 2. This graph should show the effect of the projected penetration of controls and solar water heating systems. However the graph shown under Para 9 shows the projected effect of all measures in 2020 as only 15 TWh in 415 TWh – i.e. 3.6%. This is clearly quite inadequate to meet the challenges of climate change and fuel depletion. Moreover on-site solar water heating for individual dwellings is very far from cost-effective. (See Para 41).

Para 49. 'This is our first annual consultation paper ..performance of domestic heating and hot water systems..'. Denmark defined a national approach to 'Heat Planning' in the 1980s. Along with considerable building energy refurbishment, this has lead to about 60% of building space and water heating being supplied by DH-CHP with renewables with (for the area so served) typical fuel and carbon savings of about 80% and potential for 100%.

Q 3. No. Figure 2.1 is quite inadequate since improved boilers cannot give carbon savings of 100%. Figure 3.1 is highly improbable because all are quite inadequate and solar water heating in particular is far from cost-effective.

Para 51. ‘The intention is to monitor progress..’.
However the current projection is quite inadequate to meet the challenges of climate change and fuel depletion. These would only be met in full by a carbon saving of 100%.

Para 53. Acknowledged risks. Weakness in knowledge about market and technology trends..’.
Government should commission suitable studies from consulting engineering firms. (See Introduction).

Q 4. Yes. As Para. 53.

Q 5. Yes. Re-training will be needed to support the switch to biomass heating and district heating. Government could commission the production of training materials for use via a web site and in courses.

Para 60. ‘The UK market differs notably from that of continental Europe’.
Not in any fundamental sense. The housing stock is being slowly improved towards Continental standards. Very many boilers and radiators and most pumps, valves and controls are designed and made on the Continent. Installation practice is slowly catching up. Usage patterns cannot be significantly different. The use of time control in the UK is due to failing to understand the significance of building time constants. For buildings with time constants longer than say 24 hours and condensing boilers or district heating, continuous heating – as used on the Continent - gives lower fuel consumption and carbon emissions. (See Para 37).

Para 63. ‘..so any final performance requirements should be fully harmonised..’.
The EU leads the world in climate change mitigation. It is also highly and increasingly dependent on imported fossil fuels. To meet the climate change and fuel depletion challenges requires carbon savings of 100%. This in turn requires Passive House standards and biomass heating for individual buildings outside the heat networks and DH-CHP and renewables for all towns and cities. Therefore the EuP process should include these measures.

Para 65. ‘Carbon emission factors ..changes in the electricity generation mix..’.
This is not relevant since electricity should not be used for space and water heating. It cannot deliver carbon savings of 100% because – even if all the fuel was carbon-free – the generation, transmission and distribution chain is far too energy intensive. Moreover the existing capacity is far too small for the heat demand. (See also Para 5).

Para 67. ‘At present, there is no European mandatory energy labelling scheme for gas and oil boilers’.
In Denmark gas and oil boilers are tested and energy labelled. (Ref. http://www.dgc.eu/pdf/product_sheets/labelling.pdf and http://www.dgc.dk/publikationer/konference/2006/kvf_labelling_wgc.pdf). Moreover the test data are published on the Internet. (Ref. http://www.dgc.dk/privat/kedeloversigt.htm and http://tools.sparolie.dk/positivliste.asp). When choosing my current condensing gas boiler, I was guided by the (then current version of the) Danish list.

Para 68. ‘The SEDBUK method is ..unable to take into account ..the electricity consumed..’.
The Danish test method includes the measurement of the boiler electricity, expressed as that used in a year. (See Para 67).

Para 70. ‘..these test standards do not produce consistent results..’.
The Danish Gas Centre carried out much of the testing for the BOILSIM project, which is the most thorough study of gas boilers ever done. (Ref. http://www.dgc.dk/publikationer/konference/jsc_igrc04.pdf). Moreover they participate in the LABNET project, one objective of which is improving the consistency of test results. (Ref. http://labnet.dgc.dk/news/article1202.pdf).

‘There is a concern that the contractual relationships that exist between laboratory and manufacturer..’.
Firstly these are professionals, not given to falsification of results. Secondly LABNET exists as a check.

Furthermore it is necessary to keep a sense of proportion. Even condensing gas boilers offer carbon savings of only 13 to 24%. (See Introduction). To meet the challenges of climate change and fossil fuel depletion requires carbon savings of 100%. This in turn requires Passive House standards and biomass heating for individual buildings and DH-CHP and renewables for whole towns and cities. Testing of biomass heaters is already carried out by BLT, Austria. (Ref. http://blt.josephinum.at/index.php?id=327).

Para 73. 'Solar heating systems could be more readily understood ...if there were a limited set of standard specifications'.
There are standard tests for solar collectors and thermal stores. In the UK one agency capable of carrying them out is the British Board of Agrement. (Ref. http://www.bbacerts.co.uk/). However solar water heating systems for individual dwellings are far from cost-effective. (See Para 41). Therefore they should not be encouraged – e.g. with grants - and thus there is no national need for testing and standards. This should be left to the Solar Trade Association. Larger systems would be usually be individually designed and supplied with a performance guarantee.

Q 6. The Government should require every local authority to prepare 'Heat Plans' after the Danish model, for carbon savings of 100%. These would require the assistance of consulting engineering firms with experience of Continental practice. They would designate (working roughly from the centre) areas for district heating, areas for gas heating with the prospect of conversion within say ten years to district heating, and areas beyond the planned heat networks. The first would be supplied by cogenerated heat from large-scale CHP plants (including existing power stations, after conversion), industrial reject heat, municipal waste, biomass, solar heat and geothermal heat. The last would be upgraded to Passive House standards and/or biomass heating.

Para 76. 'Guidance on energy efficiency and energy savings..'.
This should be expressed in carbon savings, with the expressed aim of achieving 100%. As in Denmark, this should encourage conversion of space and water heating from electricity, coal, oil and gas to DH-CHP and renewables. (See Para 5). Larger sites such as universities, hospitals and industry beyond the urban heat networks can be served cost-effectively by on-site measures such as CHP, municipal waste, biomass, and solar and geothermal heat. Small sites beyond the heat networks cannot be served cost-effectively by on-site measures other than biomass heating.

Para 79. 'Outcome-based specifications ..can help to minimise this'.
The national roadmap and milestones should be specified as outcomes – absolute carbon emissions by dates. So also should the Carbon Emission Obligations of the individual franchises, which would aggregate to the national targets. (See Introduction).

Para 80. 'The carbon emission factors ..may distort markets if they do not keep pace with changes in the electricity generation mix'.
The projected carbon emission factor for electricity already distorts the market for heat because the actual values are much higher. (Ref. http://www.defra.gov.uk/environment/business/envrp/pdf/conversion-factors.pdf Annexe 3). Also there is no seasonal weighting for heat loads. This is particularly important for heat pump and solar heating systems which often use resistance heaters for peak and backup respectively and thus have very high demands in winter. However space and water heating should not be electric or even natural gas since they cannot deliver carbon savings of 100%. (See Para 5 and Introduction).

Para 81. '..introduced new guidance ..based on ..targets for overall carbon emissions'.
In order to meet 100% carbon saving ('zero carbon') in both new and existing buildings, DH-CHP and renewables must be adopted throughout all towns and cities. Where new buildings are constructed beyond the heat networks, they should adopt the Passive House standard and biomass heating.

Para 86. Delivery of P1 targets may fail because ..enforcement ..may not be sufficiently effective..'.
This could be overcome by transferring the responsibility from the local authority to the ESCO that supplies energy services under a franchise agreement. (See Introduction). The ESCO would then implement a mix of demand side and supply side measures to deliver their Carbon Emission Obligations. For new buildings, they would probably insist that the developers or builders guaranteed their thermal performance. Local and national government would have only to monitor the carbon emissions outcomes, based on fuel shipments.

Para 91. The Energy Efficiency Commitment scheme puts an obligation on energy suppliers..'.
National targets are expressed as absolute carbon emissions, usually percentage reductions from a base year. Moreover the only way to guarantee delivery is to deal with relatively few large corporate entities who are subject to contractual obligations. These would be ESCOs holding franchises under a framework defined by Government. (See Introduction). This is the logical extension of the existing EEC/CERT schemes.

Para 93. ‘CERT is based on carbon savings... There is no guarantee that CERT will deliver..’.
This is the great advantage of the franchise framework and ESCOs subject to contractual obligations. The ESCOs would implement the necessary measures and Government would monitor the outcome, based on fuel shipments.

Q 7. As Q 4 and Q 6.

Para 97. ‘The overarching message of the new water strategy is the need for everyone to ..not waste it’.
In the UK the largest single abstraction of fresh water is for cooling in connection with electric power generation, amounting to 44% of the total. (Ref. http://www.parliament.uk/documents/upload/postpn259.pdf). When power stations are converted to CHP operation and the co-generated heat supplied to district heating, the towns and cities provide the cooling with no need for such water. Hence DH-CHP and renewables meets both the carbon saving and water saving requirements.

Para 99. ‘To promote awareness of domestic energy use..’.
I have a unit for the real-time display of electricity use. However the electricity demand varies very widely, so feedback on the aggregate consumption over a period is also necessary. In the UK the billing of electricity (and gas) for domestic customers is usually quarterly. From 1st July 2009, Sweden will require monthly billing of electricity for all customers. (Ref. http://www.powel.com/pictures/COM/Products/MeterData/MI 4 2006 - VATTENFALL PG 72-73.pdf). However electricity should not be used for space and water heating. (See Para 5).

Q 8. The real-time display of electricity use can be useful. (See Para 99). The remote management of boilers would only be useful if time control saved fuel and carbon emissions. However with buildings of time constants greater than about 24 hours and condensing boilers or district heating, this is not so. (See Para 37). Furthermore condensing gas boilers – albeit without advanced controls - offer carbon savings of only 13 to 24%. To meet the climate change and fossil fuel depletion challenges requires carbon savings of 100%. (See Introduction).

Q 9. Yes. Fuel depletion will force a change to Passive House standards and biomass heating for individual dwellings beyond the heat networks and DH-CHP and renewables for all towns and cities. (See Introduction). Hence planning and deployment should commence almost immediately. (See Q 6).

Para 102. ‘Electrical components can be designed with lower power demand and energisation periods minimised’.
For circulating pumps, ‘A-rated’ units such as the Grundfos Alpha 2 can use as little as 5 W. (Ref. http://www.grundfos.com/web/homeDK.nsf/GrafikOpslag/dkhomepage/$File/sehrgut.pdf). Hence when running continuously to save gas or district heat, the money and carbon costs can be minimal. For example, running for 8000 hours/y, it could consume only 40 kWh. (See Para 103).

Para 102. ‘Lower temperature emission systems ..such as oversized radiators..’.

Para 103. ‘Weather compensation controls, in conjunction with condensing boilers..’.

In my heating system five of the original radiators needed replacement and I chose new ones that were ‘oversized’. I chose the present condensing boiler which includes outside temperature ‘weather’ compensation control and sensor (as opposed to switch) control of DHW heating. The time constant of the house is probably around 40 hours and the heating is ‘on’ continuously. The boiler condenses year round. I have been logging data (14 temperatures and 8 counts at one minute intervals) for more than seven years. From this I have determined that the annual average gas efficiency is 96% on the Higher Heat Value (i.e. 106% on the Lower Heat Value). Moreover the emitters are conventional steel radiators all fitted with Danfoss TRVs, so are highly responsive. Therefore overheating is minimised and maximum use made of incidental gains from the sun, appliances and lighting and the occupants. In my house, which is of conventional 1970s construction – although well-insulated - such sources account for 26% of the heat. Thus the gas demand factor is (1 – 0.26)/0.96 = 0.771. The results for other systems and houses would differ.

The same gas condensing boiler without outside temperature compensation control might have an annual average efficiency of 86%. With a single room thermostat mounted in a hallway not subject to solar gains, all other rooms could overheat rather than making maximum use of the incidental gains. Thus the gas demand factor could be 1/0.86 = 1.163. Hence the saving due to ‘advanced controls’ might be (1.163 – 0.771)/1.163 = 0.34 or 34%. The results for other systems and houses would differ.

Para 103. ‘whole-house underfloor heating systems are recognised ..as a way of achieving higher seasonal operating efficiency’.
My system with outside temperature compensation control and conventional steel radiators achieves an annual average gas efficiency of 96%. I doubt whether whole house underfloor heating would achieve a higher efficiency. Moreover it would probably be less responsive, and so may make less use of the incidental gains.

Para 105. ‘Passive flue-gas heat recovery units can be fitted to boilers..
This must not be permitted for small domestic boilers due to the grave risk of flue-gas leaks into the building and possible poisoning by carbon monoxide. Even for large industrial boilers it is very doubtful whether such units would be cost-effective compared to complete boiler replacement.

Para 109. ‘Where mechanical ventilation is installed, heat recovery ..may ..reduce the boiler load’.
Mechanical ventilation with highly effective heat recovery is an integral part of the Passive House standard. The space heating power is reduced to 10 W/m2 and the annual space heating energy to 15 kWh/m2. (Ref. Feist W., No Date, ‘Passive Houses from Pilot to Mainstream in Germany’,
http://malmo.se/download/18.1f60430104c0456fc68000698/Feist.ppt).

Para 110. ‘It might be possible ..using ‘upgrade kits’..’.
(See Para 105).

Para 111. ‘Biomass community heating (without or) with CHP and gas community heating with CHP ...may be unsuitable for existing housing, and may not yet be cost-effective’.
Not so. For existing towns and cities, only these can deliver carbon savings of 100%. Since effectiveness is a pre-requisite, only they will be cost-effective when the gas price rises or availability falls. However it may take decades to deploy fully, so we should follow over 1000 cities on the Continent and start now. (Ref. DHCAN, No Date. ‘The Case for District Heating: 1000 Cities Cannot be Wrong!’. http://projects.bre.co.uk/DHCAN/pdf/PolicyGuide.pdf).

Para 112. ‘..different infrastructure requiring high initial investment, professional design, and continuous operation and management.
Thus heat would be supplied in much the same way as water, sewage, gas and electricity. However electricity and gas cannot deliver a carbon saving of 100%. (See Introduction).

‘Micro-chp ...can be used to replace single-dwelling boilers’.
The results from field trials show an average electricity efficiency of 7.8%, an average heat efficiency of 71.8% and an average overall efficiency of 79.6%. The Transmission and Distribution loss was taken as 15%. (Ref. E.ON UK Plc., ‘The Performance of Whispergen micro CHP in UK homes’, 2006.
http://www.micropower.co.uk/publications/eonfieldtrial260606.pdf Page 11).
Contrary to the statement in BNDH22: Micro-CHP performance measurement, the energy performance of all CHP is given by the ‘Thermodynamic Heating Efficiency’ (THE) of the co-generated heat. (Ref. Taylor G., ‘Criteria and Heat Measures for Carbon Saving’, 2008. Thermodynamics. http://www.energypolicy.co.uk/criteria_heat.htm).
THE of micro-chp is (Central El Effy x (1 – T&D loss)) x Heat Effy/(Central El Effy x (1 – T&D loss) - El Effy)
A central gas-fired CCGT power plant has an electricity efficiency of about 55%.
Hence for this micro-chp unit, the THE = (0.55 x (1 – 0.15)) x 0.718/(0.55 x (1 – 0.15) - 0.078) = 0.86 or 86%.
This is less than the heat efficiency of a good condensing boiler - say 90%. Thus compared with this, the carbon saving would be negative. Indeed this would be true for any micro-chp unit with an electricity efficiency of less than 20% and an overall efficiency of less than 80%. (See the attached spreadsheet).
Moreover any system that depends on a depletable fuel is not sustainable. (See Introduction).

Para 113. ‘Further research on ..alternative systems ...is necessary..’.
DH-CHP and renewables is current practice on the Continent and in many UK cities such as Newcastle, Nottingham and Southampton. In Denmark, some 60% of the space and water heating is supplied from DH-CHP and renewables. Moreover in Western Copenhagen, the carbon saving is already 90%. (Ref. Taylor G., ‘Criteria and Heat Measures for Carbon Saving’, 2008. Page 10. http://www.energypolicy.co.uk/criteria_heat.htm). Hence all that is necessary is for Government to commission national-level studies of at least three consulting engineering firms, of which two should be from the Continent.

Q 10. As Q 9.

Para 115. '..shorter boiler lifetimes leads to higher costs for consumers as boiler replacement is expensive'.
Another advantage of district heating is that the 'consumer unit' is relatively simple and has a very long service life. (See Para 26). Moreover no annual maintenance is required and there is no risk of gas explosion or poisoning.

Para 115. 'The costs and benefits of solar water heating vary with system capacity and hot water demand..'.
(See Para 41)

Para 116. 'Advanced controls, when their energy saving potential has been established..'.
The energy saving results from increased boiler efficiency and better use of incidental heat gains. For example, my heating system has a gas condensing boiler with outside temperature compensation and ten radiators, all fitted with Danfoss Thermostatic Radiator Valves. The annual average gas efficiency is 96% (on the Higher Heat Value basis) and about 26% of the heat comes from solar gain, appliances, lights and occupants. Thus the fuel and carbon saving from such advanced controls may be 34%. (See Para 103).

Para 118. '..moves towards biomass may be restrained in areas subject to smoke control orders'.
The emissions of small biomass heaters are falling. (Ref. http://www.tekes.fi/OPET/pdf/ssb_austria.pdf). However these should only be used for individual buildings beyond the heat networks. There is no problem with using municipal waste and biomass in large modern CHP plant such as Amagerforbraending and Avedore 2 in Copenhagen. These are fitted with highly effective fluegas cleaning and monitoring. (Ref. http://www.amfor.dk and http://renewenergy.wordpress.com/2008/02/07/worlds-most-efficient-chp-station-uses-biomass/).

Q 11. Yes. When choosing measures for carbon reduction, full account should be taken of the Energy Return on Energy Invested (EROI), energy services, limits, exergy, and scale and system effects. (Ref. Taylor G., 'Criteria and Heat Measures for Carbon Saving', 2008. http://www.energypolicy.co.uk/criteria_heat.htm).

Para 123. 'The prospects of further performance improvement ...auxiliary power (electricity consumption).
This is all included in the test method used in Denmark for the energy label for gas boilers. (See Para 67, 68, 70).

Para 126. 'It is assumed that 5% energy saving by advanced controls is achievable..'.
For my heating system and house I estimate that the outside temperature 'weather' compensation control may increase the annual average boiler efficiency from 86% (estimated) to 96% (actual). Moreover Thermostatic Radiator Valves on all radiators make best use of the incidental gains from solar, appliances, lights, and occupants and so reduce the heat demand by 26%. Hence the overall fuel and carbon saving is about 34%. (See Para 103).
However the results for other systems and houses will differ.

Para 127. 'It is assumed that each system installed saves 8.6% of the total energy for space and water heating..'.
My heating system is instrumented sufficiently to determine how much heat is required for the DHW. For a system with a DHW storage cylinder, this depends only weakly on the hot water usage, since the cylinder losses dominate. However with the DHW cylinder located inside, the heat leaks to the house, and is useful almost all of the year. In my case the average over three years of the 'DHW Coil Heat' (which includes the losses from the primary pipework and cylinder) is 1456 kWh/y. Compared with the 'Total Heat', (i.e. the gas-fired heat plus the boiler electricity) of 19555 kWh/y, this is 0.074 or 7.4%. So with a solar fraction of say 50%, the heat saving could not exceed about 728 kWh/y or 3.6%. However the results for other systems and houses will differ. (See also Para 41).

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