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the sustainable building association

AECB RESPONSE TO DECC CONSULTATION DOCUMENT on RENEWABLE HEAT INCENTIVE

Background to response, evidence, and preferred alternative approach

April 23rd 2010

1. OVERALL APPROACH

The RHI proposes to pay revenue support at a uniform 12% per year. This amounts to subsidising the least cost-effective technologies the most. A rational policy usually subsidises the most cost-effective the most.

Revenue support, rather than capital grants or long-term low-interest loans, biases the program towards helping rich people who can afford the initial capital payment. This is not a good approach on social policy grounds.

Grants or loans would induce more investment in a technology and do so at less cost to HM Treasury. Private individuals apply much higher discount rates to the future (often 20% to 100% per year) than HM Government or "UK PLC" does (real discount rate = 3.5%/yr in Treasury Green Book for projects lasting up to 30 years).

The proposed support is subject to step changes; the support may drop sharply or disappear above a certain size threshold. This guarantees a system which is full of anomalies and opportunities to 'game' the system. One cannot understand how a system so full of flaws has progressed as far as a published Consultation Paper.

The proposed program pays no attention to energy efficiency. This introduces anomalies and an inevitable waste of resources. The proposed separate program for energy efficiency takes a totally different form.

It is unfortunate to be told that time is so urgent that DECC cannot wait to spend money, no matter how wastefully. Given the UK's dire economic situation, it is essential to make the best use of scarce resources.

2. CONFLICTS BETWEEN TARGETS

In case of conflict, the UK's GHG (mainly CO2) targets must come ahead of and take priority over the renewable energy RE targets. If RE is allowed to dominate over CO2, the result will be so nonsensical that it may be subject to ridicule around the world.

The present UK target is an 80% reduction in CO2-equivalent emissions by 2050. This is in the interests of getting climate change under control. This possibly entails returning atmospheric CO2 to 350 ppm and thereafter to 280 ppm.

The UK target is *not* numbers 1,2,3 ... of installations of technologies X,Y,Z... If such a target has been formulated, it is purely as a means to the more fundamental GHG goal. Policy should not be distorted this way.

3. PHYSICAL/LEGAL DEFINITIONS OF RENEWABLE ENERGY

Heat pumps running on a fossil fuel electricity system which is supplied ~80% by fossil fuels, 15% by nuclear and 5% by renewables can be no more renewable than CHP plants running on the same electricity system. Insofar as the CHP plant has a higher COP than the electric heat pump, and/or needs less backup or peaking plant on the consumer's premises, it has a lower environmental impact and emits less CO2 than the electric heat pump.

In November 2008, the Advertising Standards Authority found against Danfoss Heat Pumps Ltd. The ASA held in its judgement that it counted as misrepresentation for a seller to claim that a heat pump installation relied on stored, renewable solar energy.

The heat pump supplier pointed out that other sellers, and the government, were making the same claims. But they lost the case on all counts. Are further cases needed?

The heat in the ground is at ambient or near-ambient temperature. It has little or no exergetic value. Either heat pumps should be redefined as non-renewable energy, or heat from fossil CHP plant should be redefined as renewable energy.

Our understanding of long-standing UK government energy policy is that it aims to level the playing field in pursuit of the over-arching goals of energy security and decarbonisation, not to tilt it towards one/some commercial interest(s) and against (an)other. So we trust that this anomaly and others will be corrected.

4. TECHNOLOGIES OMITTED

1. Geothermal heat. Used on a small scale in Southampton. Available in other UK geothermal aquifer regions but not used; needs district heating (DH) systems. Quite widely-used in Germany, its use is spreading in Denmark.

   Please note that ground source heat pumps are *not* using geothermal energy. Geothermal comes from radioactive decay in the earth's core.

2. Large-scale solar heat. Not used in the UK. Widely used in Denmark, Sweden, Canada, Germany and Austria. Needs DH. See http://www.solarthermalworld.org/node/766. Said in Denmark to be potentially four times cheaper than solar thermal on single buildings and, given a heat main, a profitable source of renewable energy without further subsidy (unlike DECC's proposals).

3. Industrial or commercial waste heat. Needs DH. Less CO2-intensive than producing renewable energy from most sources listed here.

4. Large-scale heat pumps (which can use more stable heat sources, benefit from scale effects and use multiple-stage refrigerant cycles to improve the COP). Needs DH. See Denmark, which is planning to use spilled wind energy from the electricity system and store it as heat for use in DH systems.

5. Passive solar (new buildings.) Scope to provide ~2,000 kWh/year of heat in a typical new large detached house. Especially attractive on lower-density sites and in new developments which are laid out to optimise winter solar gain. Entirely renewable and resilient, and no running costs.

6. *Daylighting (new, especially non-domestic, buildings). Scope to displace 50-60% or more of electric lighting, depending in detail on design and controls. Passive solar energy used as light is more valuable than the same energy used as heat, since it displaces electricity, not heat, which in the UK is mostly derived from gas.*

7. Solar thermal systems for single buildings designed for a high solar fraction, supplying ~80% of DHW and possibly 25+% of space heat, typically 60% overall. Equipment mostly imported from Germany, Austria and Switzerland, hence costly. Applicable to low-density buildings that back up solar in mid-winter by a stored fuel; e.g. LPG or biofuel condensing boiler.

8. Gas CHP heat. It is illogical to support heat pumps running on a fossil generating system and not to support fossil-fuelled CHP via the *same* program. If the UK believes in energy efficiency, it needs incentives to use biomethane sent into the gas grid in CHP plant than in heat-only boilers - *not* the opposite.

   A separate support system for biogas CHP, versus natural gas CHP, will lead to waste of energy; it will lead to biogas being burned in small, less efficient plants. We remind DECC that it is more energy-efficient to use gas in large electricity generating or CHP plant than in micro-CHP plant or heat-only boilers.

   It is easier and cheaper to transport gas than either electricity or heat. The national interest would sometimes be best served by sending biomethane through the gas pipes to conveniently-located CHP plant, whose heat output displaces the combustion of gas in inefficient heat-only boilers (they are inefficient because they degrade high-grade energy; e.g. at a flame temp of >1000 degC, to low-grade heat at 30 or 60 degC). DECC's proposal does not contribute well to this.

5. NEW TECHNOLOGIES?

Air source heat pumps (ASHPs) existed 50 years ago and were assessed by the Central Electricity Generating Board and Central Electricity Research Laboratories. They are a mature technology with many limitations in the UK climate as the 1950s work showed.

Technological developments since then have been modest. The COP still drops sharply in cold weather and most ASHPs are supplemented by peak resistance heating. Even if not, at typical COPs 2.5-2.7 for space and water heating combined they save no CO2 versus well-controlled gas condensing boilers. It is irresponsible to support them.

Condensing boilers are a newer technology than air source heat pumps and are a more cost-effective way to reduce CO2 emissions. Making correct controls - as in continental countries - compulsory on all new condensing boilers could save ~15% of the resulting gas, oil or LPG consumption and give seasonal efficiencies nearer ~95-97% than the ~85% currently measured. See; e.g., www.ecotechnicians.co.uk. This appears to be a larger impact than is foreseen from this entire RHI program, but no incentives are yet available for such technology. Nor does this document propose to support condensing boilers which back up a large solar system providing most of the DHW and some of the space heating, solar fraction ~65-70%. Yet this combination emits less CO2 today than a heat pump in 2020 would be likely to emit.

Solid fuel boiler plant is not new. Pellet boilers are relatively new but do not deserve support unless/until the plant can match the emissions levels of oil boilers.

6. HEAT ZONING

In urban areas, with political will, DH systems could be developed and make most of the proposed installation(s) on individual buildings superfluous. In Denmark, electric heat pumps and biomass boilers are not normally permitted in areas where piped heat or piped gas is available. The UK needs a similar approach. Such coordination and zoning considerably reduces consumer costs versus the scenario of:

- a heat main
- a gas main
- a wood pellet lorry
- an oil/biofuel lorry
- an LPG/biofuel lorry
- and
- reinforced 3-phase supplies - to cope with large heat pumps

- all down the same suburban street.

None of DECC's proposed technologies compete on cost with the cheaper technologies available to DH systems.

7. PUBLIC HEALTH

Large advances in public health have occurred in the last 50-100 years. Some were fortuitous, but they are no less valuable for that. They are thought to have contributed to the significant rises in human lifespan since 1900.

One trend in developed countries is a move to **cleaner winter country air**, relatively free of smoke. Most rural buildings that burn fuel in winter have moved from solid fuel to oil or LPG boilers over the past three decades.

Another principal trend is towards **cleaner urban air**. Not only did small-scale solid fuel combustion become less common, but almost all suburban dwellings that had oil boilers 15-25 years ago have changed to gas. While the particle emissions from oil boilers are merely very low compared to solid fuel boilers, those from a gas boiler are extremely low.

DECC proposes to allow wood-fired heat-only boiler plant with particle emissions of 3 g/GJ or 110 mg per kWh. A rural detached house using 35,000 kWh/yr of heat will then emit 380 g/yr of particles, or over ~1 g/day.

The emissions of a domestic condensing oil boiler appear to be ~10-20 mg/kWh, or 90 % less than many wood-burning pellet or chip boilers. **This prospective rise represents an unacceptable increase in rural air pollution.**

As a web search will establish, there is a large amount of ongoing litigation against emissions from wood burning in US Canada, Australia and New Zealand. Under common law, solid fuel combustion by specific individuals is increasingly being banned or restricted to safeguard neighbours' health. The highest damages awards, in the case of prolonged exposure to a neighbour's smoke, have been several hundred thousand dollars. Many local governments are also legislating to ban or restrict solid-fuelled heating systems.

The health case against particulate emissions is as proven as the case for anthropogenic global warming (AWG). It is set out in many EU and national government reports, which analyse the number of premature deaths and the average shortening of life from breathing in sub-micron particles. Unlike the case for AWG, we are not aware that the case against particulates has ever been challenged. DEFRA set out the situation in its 2007 Air Quality Strategy.

Based on this scientific evidence, in built-up areas solid-fuelled plant on individual buildings should not be supported. It cannot match the emissions from other technologies suited to such areas, whether these be individual gas-fired boilers today or town-wide district heating systems tomorrow. Neither piped gas nor piped heat emit any major local air pollution.

Outside built-up areas, solid-fuelled plant should only be supported which has emissions in mg per kWh no higher than:

1. the mix of oil and LPG heating which is displaced,
2. the average of the best three new condensing oil boilers on the market,

- whichever is the lower.

The EU has cleaned up emissions from diesel cars greatly in the last 15 years. This began with the awareness that diesel particles are very harmful to health. Under the forthcoming EU6 limit, from 2014 a sub-2.5 tonne diesel family car may not emit >50 g per 10,000 km. There have been models on the market since 2003 which emit <30 g per 10,000 km.

We tolerate diesel cars mainly because they save so much fuel and emit so much less CO2 versus petrol cars. We cannot see such a redeeming feature for individual solid fuel boilers.

Why does the UK propose to apply directly the opposite principles to energy and to heating systems? The particle emissions from wood-fired boiler plant, in kg/yr per installation, are typically ten times more significant than the emissions from a new diesel car, driven for 20,000 km.

It is not as if it is necessary for the UK to accept increased air pollution to meet its CO2 goals. Many technologies could be encouraged, or supported financially, which would reduce CO2 emissions *and* reduce air pollution. See sec. 11.

8. COMBINATIONS OF TECHNOLOGIES

Only combinations of technologies which conform to sound engineering commonsense and good practice should be supported.

Solar thermal “backed up by” an electric heat pump is an anomalous combination. Both technologies are highly capital-intensive.

The main impact of solar is to reduce the load factor of the residual electricity demand and impose a “needle peak” on the grid. This transfers costs to the grid operator, who must retain generating plant and grid capacity “just in case”, but sees his/her load factor drop.

Bivalent heat pumps have been proposed, with a gas or other boiler used to lop the peak. But consumers do not normally want complex multiple heating systems. Most want “fit and forget” simplicity. Gas and oil condensing boilers can provide all a household’s heat, as can district heating.

Heat pumps in towns, backed up by gas boilers, would transfer the peaking problem from the electric grid to the gas grid. The UK gas grid had two near-emergencies last winter.

Many heat pump proposals implicitly only cover the space heating and quote a COP for that. Either the DHW is provided by the existing fossil fuel boiler system, if there is one, *or* it is covered by electric resistance heating. We consider the CO2 emissions in the latter case and for a fairly low-energy house.

An electric air source heat pump provides 5,800 kWh/yr of space heat @ COP 2.9. Electric resistance water heating; i.e., COP 1.0 is used for a DHW load of 2,000 kWh/yr.

This combined system uses 4,000 kWh/yr of electricity and provides 7,800 kWh/yr of heat. In other words, it has a combined seasonal COP of 7,800/4,000 = 1.95. The annual average GHG emissions in a domestic building are 0.61/1.95 = *0.31 kg CO2 per kWh of heat*.

Source for 0.61 kg/kWh: the SAP-2009 national average figure of 0.59 is corrected for the average T&D losses to domestic premises at 230V, which are 11%. On recent data, the annual average may be lower than SAP-2009. However, to compensate, the generating plant in use to heat buildings in winter is considerably more CO2-intensive than the annual average.

This *0.31 kg/kWh* can be compared to some present-day alternatives for heating a house and its DHW:

- Natural gas condensing boiler (assuming 94% seasonal efficiency) = 0.206/0.94 = *0.22 kg/kWh*
- LPG ditto (95%) = *0.26 kg/kWh*
- Oil ditto (97%) = *0.29 kg/kWh*
- Oil with 30% biofuel content (0.05 kg/kWh) = *0.22 kg/kWh*.

So, compared to new condensing boilers with compensation control, an air source heat pump used for space heating and with electric resistance water heating appears to make climate change worse.

9. UNCOUNTED GREENHOUSE GAS EMISSIONS

Significant uncounted GHG emissions are possible/likely from the technologies that DECC has put forward for support. In particular, wood combustion emits soot. Climate scientists consider that soot has contributed to the recent pace of Arctic warming.

Soot emissions are virtually inevitable from solid fuel combustion plant. They cannot be reduced to the almost negligible level of natural gas, LPG or biomethane combustion plant unless the solid fuel is burned in very large plant which can afford to fit stack devices such as electrostatic precipitators.

Before DECC subsidises the technology, could it please quantify how black carbon detracts from the expected CO2 savings and what it plans to do to combat this.

10. ENERGY SECURITY

The electric grid came close to failure in winter 2009-10. Much coal and nuclear generating plant is due to be closed in the near future, making margins tighter. Power cuts are perceived to be a risk in the period 2015-20, even before adding new peak loads. If a few million domestic heat pumps are installed, this could add 10 GW to coincident peak electricity demand in 2020, posing additional difficulties. This assumes a peak COP of ~2.

The concern is greatest with ASHPs whose COP falls sharply in severe weather. It is inappropriate to spend public funds on worsening the UK's energy security. Gas CHP by contrast would improve security, since it would displace gas otherwise used in heat-only boilers. CHP plant could change to a storable fuel at times of peak gas demand.

11. OVERALL INVESTMENT COST

The document suggests a subsidy of ~£1,400/yr to a suburban semi-detached house if it installs a wood-fired boiler and solar water heat. By implication, the subsidy to a large detached house with a 45 kW(t) heating system - the proposed limit to the subsidy - could be up to ~£5,000 /year. This is on the basis of a heat consumption for such a building of ~70,000 kWh/year and a payment of 7.5 pence per kWh for 18 years for an ASHP.

The net present value (NPV) is ~£20,000 per house for the standard-sized semi-detached house. For the large detached, it is ~£90,000. As pointed out, the planned support is likely to appeal mainly to semi-detached and detached house owners who have access to investment capital.

The document suggests a scenario of 2M dwellings fitting the favoured measures by 2020. It appears that this could be equivalent to a total NPV of at least £50 billion, if the average claimant receives support of say £25,000.

There are far superior ways to spend £50 billion to cut UK GHG emissions. Given the installation costs today in Denmark, Germany and Finland, this sum could pay to extend heat mains to ~10M dwellings.

Or £50 bn could part-fund heat mains and part-fund retrofit insulation and airtightness. The rest of the capital cost could be paid back by consumers as loans tied to the building. We could easily arrange for loan repayments to be lower than consumers' current expenditure on energy. So 100% grants would not be needed.

The same scarce resources cannot be spent twice. Spending on cost-ineffective measures makes climate change worse versus the option of devoting it to effective measures. It is not the duty of the UK government to order taxpayers' money to be spent ineffectively and thereby make climate change worse.

12. PREFERRED PROGRAMME

Urgency

Given the short timescale to 2020 or even 2050 the UK must spend scarce resources in a way which delivers reduced GHG emissions and/or increased CO2 sequestration

- predictably,
- economically, and
- fairly rapidly.

There is no real place pre-2020 for untested technologies. Nor is there room for technologies which could have serious and undesired - but not unforeseen - side-effects. We have already put some of our concerns on record as regards undesired but foreseeable side-effects.

DECC's proposals for air source heat pumps and solid fuel boilers do not contribute very constructively towards the above goals. They look more like an expensive and risky way to make climate change worse.

We summarise below a program which *could* contribute cost-effectively to a UK goal of lower GHG emissions.

Technologies

Support for the following principal technologies, which reduce heating GHG emissions, on an integrated basis. To have two to three separate programs is unsuitable. It introduces clashes and/or inconsistencies and wastes scarce resources. Currently the UK appears to have over ten programmes.

Built-up areas

1. Retrofit insulation, cheap window improvement options (e.g. replacement sealed units, leaving the frame and sash intact)
2. Ditto airtightness
3. Mechanical exhaust-only ventilation (MEV) systems (often the most economic and least obtrusive option; few retrofitted buildings can easily or cheaply achieve the Passivhaus standard of 0.6 ac/h @ 50 Pa but can often reach the Swedish standard of 1977, namely 3 ac/h @ 50 Pa. Without Passivhaus airtight standards, heat recovery ventilation is not really effective)
4. Natural gas (generally) and/or biogas CHP with backup fuel storage
5. Solid-fuelled CHP (on large plant where the emissions can be cleaned up) I assume biomass not coal here?
6. Large-scale solar arrays as at http://www.solarthermalworld.org/node/766
7. Large, efficient (high COP) heat pumps supplying DH systems and helping to keep the electric grid stable as windpower's contribution increases
8. Heat mains as per today's Danish best practice. Given inter alia their use of twin pipes, direct connection and efficient means of pipe installation, this diverges significantly from the DH options analysed for DECC.

In gas grid emergencies, CHP plant as in (4) above can switch to using the stored fuel. It becomes an interruptible load. This provides us with improved energy security versus the existing situation of individual gas boilers. It is agreed that the UK has too little gas storage; gas CHP would provide a surrogate for gas storage.

Low-density areas (no gas or other grids)

1. Very high insulation, often Passivhaus levels, replacement windows when possible (worthwhile because of the much higher marginal cost of heat available to such buildings)
2. Airtightness
3. MVHR or possibly MEV systems
4. (a) Ground source heat pumps and/or (b) solar on single buildings providing a high solar fraction plus backup boiler burning LPG or oil, mixed with compatible biofuels.
5. CHP systems as/when applicable, usually large buildings only.

In rural areas, the above combinations (4) (b), (c), (d) of solar thermal and stored fuel all have a CO2 intensity of about 0.10 kg/kWh. They impose no peak demand on the UK's fragile energy distribution systems; all winter backup is from a stored fuel. After retrofit insulation, the existing oil or LPG tank lasts two or three times longer.

Overriding Principles

1. Support to be directed to the most economic technologies on the basis of £/tonne CO2 equiv. at TGB real discount rates and life-cycle costing. This procedure is well-established and is used to set the insulation levels in Part L of the Building Regulations.
2. No step changes in support as the size of mechanical plant changes. Only sliding scales, in order to avoid anomalies.
3. Support to take the form of either a subsidised 100% loan covering all measures, with a legal charge imposed on the building until it is repaid, or a partial grant. The choice between these on a particular building might be left up to consumers, or might need to be decided by government. 100% loans have the merit that they give most consumers of limited means a positive cash flow from day one.
4. No public funding for measures which emit more GHGs and/or cause more serious air pollution (PM-2.5s and/or PM-10s, PAHs, NOx, CH4, benzene, etc) than the current UK energy supply & use system.
5. For space and water heating, the current default system to be be considered as a gas condensing boiler within the gas supply area and a mix of oil and LPG condensing boilers in the countryside, supplying all space and water heating.

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