Heat in Buildings

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/575299/Heat_in_Buildings_consultation_document_v1.pdf

Deadline 27 January 2017

AECB Submission to BEIS

1. Overview

The consultation document asks many pertinent questions. We try to answer them here reasonably briefly. However, the consultation is extremely long. As a result, so is this response.

We think that BEIS's very lengthy call for ideas/insights/information reflects UK low priority to such work since:

- BRE was privatised in 1997
  and
- the House of Lords Science and Technology Committee condemned the lack of funding for applied building research in 2005.

Low to zero public funding for pertinent work accurately signals the low priority given to it. It also leads to such knowledge as there may be being 'privatised'; i.e., more often treated as proprietary and kept within the confines of companies or other bodies.

There might be less need for long-winded consultations if BEIS would employ enough scientifically-qualified staff to maintain its own knowledge base. [1] Better still, the UK would return to funding relevant applied research. [2]

No reference is made in our response to domestic hot water (DHW). However, it is highly unclear whether BEIS intended to include or exclude water heating from its consultation. Distinctly unclear terminology has been used. BEIS may have thought it was including DHW. There are special issues for DHW which we do not go into here. If BEIS desires more information, would it please contact us, or re-issue the consultation with this point clarified.

2. General Response to Points in Consultation

Introduction

1.1. As the document says, UK homes are warmer than hitherto. It fails to note that they are still the coldest in northern Europe, except maybe for Ireland.

The estimated UK whole dwelling average in the heating season, say October to April, is 17°C. This compares to 22°C or more in Denmark and Sweden. In Denmark, the domestic average was 22°C in 1972!

BEIS and CIBSE are rather dated in regarding 20-21°C as 'good enough'. 20°C is certainly inadequate for sedentary individuals in winter. Some people who have experienced better conditions wish to continue with them. [3]

Perhaps the consultation authors should visit Scandinavia in winter and observe the higher room temperatures and superior controls. It seems a slight waste of effort for a document to aim at Scandinavian practice 20-30 years ago and risk needing to revise the UK specification in ~~ten~~10, 20 or 30 years' time. Please could BEIS consider this when formulating its policy.

Boiler Performance

2.11 is inaccurate. Few boilers last 25 years. They should do. Lifetimes as low as 8-12 years in normal use suggest poor manufacturing and/or installation.

2.19 shares the apparent poor awareness of other parts of this document. We are concerned at proposals to require time controls. They do not make physical sense in buildings with long cooling time constants.

All buildings with sufficiently high insulation, thermal capacity and/or draughtproofing behave this way. The cooling time constant of a building with characteristic UK thermal mass and say cavity wall and roof insulation and good-quality double-glazed windows is set to be ≥50-100 hours. High-mass buildings with very good insulation and draughtproofing can reach 500-600 hours. Can someone please prove that time controls then save energy? It appears mathematically impossible. [4]

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Some very energy-efficient UK buildings in the last 30-35 years were constructed with no time controls. New buildings have less incentive to fit them than recent buildings, assuming that Building Regulations continue to enforce reduced heat loss.

Time controls are virtually incompatible with weather compensation or similar controls. The latter *are* a very good idea. But as the document implies, the Netherlands, Denmark, Germany, Sweden, etc have long had them.

Even this proposal may be deferred if too many object. The answer is to educate and enlighten installers, not delay or suspend plans for load compensation. As it makes time controls almost superfluous, there is no need to make overall heating systems more complex or expensive.

TRVs on all heat emitters do not always make sense. Balancing a system room by room should be done by other means, as this consultation accepts.

TRV quality, and positioning, tends to matter more than quantity. 2-3 suitable TRVs in the most important rooms might outperform ten poor ones and cost less. The document could address this.

If in doubt, would BEIS like guided tours of some energy-efficient buildings constructed 25-35 years ago with TRVs in selected rooms only and measured gas consumption since then of ~35 kWh/m^2y for space and water heating? We could arrange if wished.

2.20 To make practical sense, this clause must retain the requirement for temperature controls and lose the demand for time controls. If BEIS and/or its advisers continue to demand time controls, they need to prove their worth, given the calculated cooling time constants of UK buildings and rising condensing boiler efficiencies as the heat load falls, e.g. Figure 1.

2.22 We deduce that BEIS has arrived at the right answer for the wrong reasons. In individual heating systems, TRVs on all radiators may not make practical sense. Without high-quality materials and installation, TRVs are likely to be problematic; e.g., bad installations give rise to noise problems under some conditions.

Innovative Solutions

3.22. This text reads as a wish list. But the priority is wider use of existing technology, not very recent or new inventions.

33 years to 2050, and its 80% CO_2 reduction target, is *very little time* to bring new inventions into mass usage. Look back 33 years and name important energy-related technologies widely commercialised since 1984. We would find it hard to list five.

One is T5 fluorescent tubes and their 'eco' version; i.e., a 1990s/2010s technology. Another is condensing boilers. They came onto the Dutch market in 1989.

Hundreds of pre-1984 technologies have since contributed to saving energy, though. Ground source electric heat pumps were trialled in 1912. Low-e window glass and thin films like Heat Mirror[R] appeared in the USA in 1978. The 'Passivhaus Standard', all except the low-e glass and heavy gases, was demonstrated in Scandinavia, Germany and North America by 1977. Switzerland had 'superwindows', complete with insulated frames, in 1982. Germany launched the world's first diesel passenger car in 1976. Geothermal district heating was used in France 600 years ago. Odense, Denmark began its directly-connected heat network in 1929. LEDs existed from the early 1950s and slowly advanced further. Compact fluorescent lamps came onto the Dutch market in 1980. Dr. Jorgen Norgaard and Dr. Arthur Rosenfeld proposed highly energy-efficient lights and electrical domestic appliances in 1975-77; California started implementing it from 1978.

At a guess, almost all the technologies to significantly improve UK 2050 energy performance exist and are demonstrated or widely used in at least one developed country. The challenge is *not* so much R&D but more the practical work, technology transfer and implementation. It is intensely disciplinary, comprising psychology and anthropology even more so than physics or chemistry.

Yet this consultation stresses 'innovative solutions'. We interpret them as technologies complex enough or emerging from recent enough R&D to be patented, guaranteeing the university/researcher/industrial licensor an income stream. They do not coincide with the answers to the question:

> 'what technologies are in the financial interests of UK PLC, post-peak oil and under pressure to reduce CO_2 emissions 80%?' [5]

The distinction has been pointed out *repeatedly* by those who are *not selling something*. We hope that those who read this evidence will take heed.

Technologies barely conceived now but likely to be in extensive use by 2050 are more likely to be those affecting small plug-in electronic devices, not heating or cooling systems or the building fabric. They would contribute to lower electrical loads more than lower heat loads.

Time and Temperature Controls

4.6. This discussion of time controls is fundamentally irrelevant as we explain elsewhere. The point in 4.8 about UK penetration of time vs. temperature controls illustrates the muddle. More dwellings have time controls, but in very many dwellings - at least, the ones which people seriously intend to heat - temperature controls would save more oil or gas.

Households using 'essential electricity' only, via highly energy-efficient appliances, obtain a negative net benefit from smart meters. Although £450-500/y is a typical electricity bill today; i.e., excluding space and water heat, a bill of £150/y plus standing charges, corresponding to 1,000-1,200 kWh/y, would be typical of a 2-3 person household using unusually energy-efficient lights and A++ to A+++ appliances. [6]

This consumption gives UK PLC and the occupants no case for installing smart meters. At £350, the meter cost outweighs the claimed savings of £3-4.50/year; i.e., 2-3% of electricity usage, by a factor of 100.

Even if the electricity saving were £5/y, this is a 1.4%/y inflation-adjusted return on capital. The Treasury Green Book suggests a return on capital of *3.5%/y* before projects should go ahead.

Smart meters may have shorter lives and higher operation and maintenance costs. Existing mechanical meters are pretty simple. That, after all, is why some of the technology is 100 years old, which the consultation views in a perjorative sense. To us, it is positive if a product can work for 50-100 years with not much attention or regular maintenance.

Spend the £17 bn saved, ~£350 per meter, on, say, incentives for households to buy the best A++ or A+++ appliances, not A. It only takes subsidies to retailers or preferably manufacturers. Resulting saving on a household bill: well above 2-3%.

The greatest benefits claimed from smart meters are apparently remote meter reading and remote disconnection for both gas and electricity. These facilities can be obtained by replacing existing meters on normal timescales; i.e. costing billpayers £0/meter instead of £350. We are unhappy anyway with remote disconnection; i.e., without visiting a property to check the occupants' circumstances. In winter, it poses a threat to life and health. [7]

BEIS seems unaware of its own statistics. Domestic electricity consumption has fallen by 14% since 2008, mostly due to EU legislation on domestic appliances/lights. The UK should aim to ensure that this trend continues. [8]

The estimated smart meter programme cost apparently dwarfs the environmental/CO_2 reduction benefits. It carries on under its own momentum, partly for fear of the embarrassment if someone calls a halt.

Germany, our largest EU competitor, cancelled its smart meter plans. An internal review of why two medium-sized industrial nations reached opposite conclusions would be valuable before BEIS allows continued spending of billpayer money on a seeming white elephant. [9] It would be less embarrassing to cancel now than continue until 2-3 M meters are fitted and the failings identified by IT experts become widely apparent. [10]

3. Responses to Specific Consultation Questions

1. Is a three month coming into force period sufficient?

Yes for mandating more efficient condensing boilers. Not for additions like outside weather compensation or room compensation.

2a. Do you agree the minimum standard for domestic boilers in England should be changed to 92% ErP?

Yes.

2b. If not, what ErP rating is appropriate for each fuel type, and are there risks?

N/A

2c. What can be done to further improve the efficiency of a boiler beyond 92% ErP and what are the technical and cost implications for the industry and the consumer?

The danger is of too much regulation of gas and oil boilers leading developers to fit electric resistance heating. In most flats outside London, and some rural properties without natural gas, they already do. [11]

Standard electric space and water heating emits 2.3-2.6 times as many kg CO_2 per kWh of heat vs. a well-controlled gas or LPG condensing boiler. See below.

Emissions in kg per kWh of heat:

Natural gas 0.23
LPG 0.26
Oil 0.31
Electricity
resistance heat 0.60
or air source heat pump (COP = 2.8) 0.22

Notes:
Electricity: our estimate for 230 V AC loads with network losses of 12.2% and 100% efficient conversion of electricity to heat. COP estimated at 2.8 for a typical air source heat pump.
Gas boilers: we assume 95% seasonal efficiency.
Oil: we assume 90%.

Having permitted excessive use of electric heat, UK CO_2 emissions are millions of tonnes/year higher than they would be, had it been more restricted. Some Building Regulations consultees in 2000 noted that it was unwise to permit electric resistance wires to become the default in flats; they would make it hard to change to other systems later. Also, the 'fuel factor' was too lenient. But outside London, this became a default.

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It is of doubtful worth. Gas and LPG boilers can operate at almost 95-96% seasonal efficiency with simple controls demonstrated *back in 2001*. Why wait?

A condensing boiler in a private house in eastern England reached 96% seasonal efficiency - on space heating - in 2001 with few cost implications. The performance was achieved with a new German-made boiler and integral compensation control, but the original panel radiators had already had good-quality TRVs added and they did not change. [12] The system still operates at these settings.

3a. Do you agree that functional timers and thermostats should be a mandatory system component when a boiler is installed?

Thermostats, yes. Timers, no.

3b. Will increased demand lead manufacturers to diversify designs to make it easier for consumers to find a product that suits their needs?

Probably. But carried too far, this level of 'diversity' causes confusion and ultimately higher costs.

3c. What would be the advantages and disadvantages of mandating that all relevant heating system components be capable of communicating using an open communication protocol (e.g. OpenTherm)?

3d. Do consumers engage effectively with installed timers and thermostats to maximise efficiency?

No. Many regard thermostats as on-off switches, as though a central heating system designed to keep a whole building always comfortable has changed in their mind to a woodstove or open grate which operates on demand to warm a single room briefly - or for one evening - leaving the building cold at other times.

Such behaviour appears to reflect inability to afford normal UK space heating bills, i.e. £600-750(800-1100)/y with gas (oil) in a low-rise suburban house. These 'normal' bills can also be observed in construction of the period 1980-2015, reflecting it is thought:

- Weak Building Regulations/Part L, with UK 2017 wall insulation being similar to Danish 1977-1980 wall insulation
- Loopholes in Part L
- Poor enforcement.

3e. Please provide any additional information to support your answers to questions 3a-3d. In relation to question 6, what evidence is there to indicate how engaged consumers are, and to what extent does usability present a problem for any consumers, particularly vulnerable and disabled persons?

See comments elsewhere.

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4a. Do you agree that weather compensation should be a mandatory system component when a boiler is installed in a domestic building in England?

Yes, or an equivalent room compensation system, the latter especially in buildings of lower heat loss.

4b. Are boiler installers qualified and confident to install weather compensators and set compensation curves?

No.

4c. Please provide evidence to support your answers to 4a and 4b. In answering, please consider:
What technical factors have the greatest influence on effectiveness?
The impacts on energy savings and costs of different types of device, e.g. sensor-based or internet-based
The significance of different types of boiler burner control
Specific circumstances in the home that might make a difference

4d. What alternative solutions can minimise return temperatures in response to variations in heat demand? Please provide technical details of how alternatives might work, alongside details of expected impact on heating system performance, equipment supply and installation labour costs.

Please see our comments elsewhere in this response or contact us if this is insufficient.

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5a. Do you agree that Government should explore options to incorporate these additional technologies into minimum standards?

Yes.

5b. Should the private rented sector be permitted to opt out of more costly policy options, if undertaken?

No. But do give it adequate/reasonable notice and provide ample briefings and background information to avoid the reaction being one of cynicism and/or hostility.

5c. If an opt out is offered to the private rented sector should a similar opt out be extended to the social rented sector?

Neither should have opt-outs. That would discriminate unfairly against owner-occupiers. But do see 5b.

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6a. Do installers have sufficient familiarity, training and experience to properly install each of the technologies listed above?

No.

6b. Can installers and consumers make confident decisions regarding which technology is an appropriate solution for a given household?

No. But it does not make sense to customise heating systems and controls. Owner-occupiers move every 5-7 years. Private tenants move more often.

The overriding objective is thermal comfort. It is not 27 million different control systems, one customised for each dwelling. That would force all new occupants and their installer to 'gut' a system after they buy a house so that the heating 'works for them'. Tenanted properties would be even more difficult, because the landlord would have to agree to 'customise' the controls for that tenant.

We have known what influences human comfort for decades. It includes adequate radiant temperature and air temperature, absence of severe draughts, no excessive radiative asymmetry, etc, etc. The findings are common to every human being on the planet, e.g. as in Fanger's landmark research 40 years ago. We cannot easily see a justification for more than compensation control of the circulating water temperatures, a few very high-quality TRVs and one thermostat that provides overriding control of the boiler.

We know too that there is a statistically normal distribution of preferred operative temperatures, for physiological and psychological reasons. Most highly-insulated dwellings monitored in Germany in the 1990s/2000s were kept between 18 and 26°C; not all were kept at 21.5°C. Cultural differences exist between countries, e.g. Norway and Sweden, and between households of the same 'ethnic group' and nationality, e.g. British-born Caucasian.

The focus should be on getting systems designed and installed correctly when a building is constructed or refurbished. The aim should be that this consultation does not have to be re-issued in 2027.

6c. Is there evidence to suggest that any of these technologies are incompatible with each other or with any of the technologies mentioned in this consultation?

See our reply elsewhere on the virtual incompatibility of compensation and time controls.

6d. Do consumers understand how to use TRVs effectively?

Very rarely.

6e. Are there other technologies that should be considered on an even footing with those listed above?

Yes. If BEIS needs further information please contact us.

6f. Please provide any evidence in support of your answers to questions 6a-6e. In answering question 6a please consider any practical barriers affecting any of the technologies, and any steps that could be taken to address those barriers.

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7. What evidence is there that TPI control can deliver energy savings in English households, and what is the range of energy savings (%) across various property types and circumstances?

8a. Do the functionalities of automation and optimisation effectively describe the 'smart' controls that offer the greatest benefit? Should there be greater focus on remote access?

Probably not. Most remotely-accessed controls are pursuing goals which are mistakenly allied to the myth that intermittent heating saves energy.

8b. In what ways could greater uptake of these functionalities promote smart control innovation?

We refer to our comments elsewhere and our concern that the consultation authors fundamentally misunderstand building dynamic thermal behaviour.

BEIS's attention in terms of 'smart' controls would be better directed to lighting. Control there *can* be instantaneous, with very positive effects on electricity consumption. This is because electric lighting systems have no thermal inertia.

8c. What evidence is there to indicate how long a smart heating control lasts?

We do not know but electronic equipment can be strikingly short-lived. Some mobile telephones dating from say 2000-01 are robust. Their 2015 counterparts have more to break down. But even 2000 mobiles still in use have probably been refurbished at least once in 17 years. Contrast this with electricity meters.

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9. *Is there demand for consumer advice, and how should it be delivered? What more can the industry do to encourage consumer engagement with heating controls and their heating system?*

There has always been 'demand' among a small minority who are able and prepared to pay design professionals to design a new heating system or pay a comparable expert to survey a whole building and advise on its overall energy performance, in terms of insulation, airtightness and heating controls. But many consumers have little idea if their controls are good, bad or indifferent and have little time or inclination to do much about it.

Experts as above are thin on the ground. We suggest that the government could reinvent successful programmes that it scrapped, possibly for ideological reasons, 20 years ago; e.g., the first Energy Design Advice Scheme (EDAS). EDAS was managed by expert yet disinterested [13] academics at several UK universities. In principle, it paid national experts 'the going rate' to give energy users advice on a particular subject, reflecting the value of saving many tens of percent of UK PLC's expenditure on gas and oil, i.e. several £ billion per year. Subsequent versions of EDAS were 'reorganised' and became apparently less and less successful. Later, the programme was abandoned.

Past government advice on intermittent heating and TRVs *has* permeated consumers' and installers' minds, leading to wide use of timeclocks and TRVs. But real understanding is close to zero. A 2013-14 EST survey showed that opinion was divided 50/50% on intermittent heating.

So far as we know, the UK's most energy-efficient buildings - judged by measured gas bills - *have no timeclock and few/no TRVs*. This consultation's apparent belief in weather compensation *and* time controls *and* TRVs exemplifies the misunderstandings.

If the compensation controls are well-adjusted, a hypothetical low-heat loss building might need radiator flow and return temperatures of 55/35°C at the design ambient temperature. These water temperatures would be adequate for the steady state, sufficing to maintain the internal temperature at say 22°C in the living room, perhaps a bit more in bathroom(s).

But intermittent heating or night setback must return the internal temperature promptly to an acceptable level after an unheated period ends, say a start-up at 5.00 h and reaching target temperatures by 7.30 h. That needs much higher water temperatures, maybe 80/60°C, which greatly reduce the efficiency of the boiler, heat pump or CHP system.

As Figure 1 shows, condensing boilers are more efficient at part load. At a return of 30°C, and 30% load, this particular boiler's efficiency is 11 percentage points ahead of the seasonal condensing boiler efficiencies in EST's 2000s tests. [14]

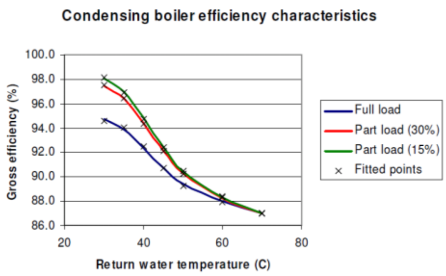

Figure 1. Example of measured gas condensing boiler efficiencies.

Source: Univ. of Strathclyde.

In our view, government, not industry, is responsible for issuing incorrect advice, especially at the time when condensing boilers replaced non-condensing ones and the standard efficiency curves radically changed.

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10a. Do you agree with our understanding of the costs associated with each of these technologies?

The document says:

> 'Costs are also likely to come down with increased demand and competition, as happened with condensing boilers last decade'.

If UK PLC policymakers consider a technology, it is incorrect to focus on costs in small volumes in an immature market. The average cost which UK PLC pays will be dominated by the later sales, in a mature market, at lower prices. These can usually be predicted by off-the-record discussions with the relevant industry.

10b. Do you agree with our understanding of the way costs may change, and the reasons why they may change?

No. See 10a) et al.

10c. Would consumers be willing to accept the additional upfront costs of technologies listed in Table1, on the basis of reducing their annual energy bills and benefiting the environment?

Probably very few at returns of 'only' 10-15% per year. Consumers apply high discount rates to discretionary expenditure. [15] But if measures are cost-effective to UK PLC, they should be part of the Building Regulations. Condensing boilers became part of the Regulations in the 2000s.

Weather compensation and other control refinements are likely to be more cost-effective than raising high thicknesses of wall insulation. Weather compensation in low-heat loss buildings avoids the cost of time controls, something BEIS has not yet realised.

10d. What evidence is there on the impact of each technology on the performance of domestic heating systems? How might this change with further innovation?

We refer to the broad conclusions of building research abroad for the last 40-50 years.

10e. Our Impact Assessment currently only considers natural gas. How might consequences be different for oil or LPG boilers?

LPG boilers would operate similarly to natural gas. Oil is a more common rural fuel. But arguably, BEIS should possibly be seeking to encourage replacement of oil by LPG, because:

a) CO_2 emissions in kg/kWh are 12% lower, 0.25 vs. 0.28 kg/kWh
b) the seasonal efficiency of a gas boiler can be 95-96% with best available controls, vs. perhaps 90-92% with oil, giving overall emissions 20-25% lower

c) LPG is unlikely to cause contamination if there is a leak
d) LPG burns with zero to extremely low PM-2.5 emissions, unlike oil, wood or coal.

Success in such shifts may rely on enforcing competition law. LPG can be priced at up to ~50% above kerosene, gasoline or diesel. We consider that bulk LPG prices should be regulated until the market is visibly working. [16]

10f. Please provide any further information to support your answers to questions 10a-10e.

We refer to worldwide research carried on by technological universities and building research institutions over the last 35-40 years, especially in the countries cited in reference 2.

11a. Do heating engineers share a common understanding of what hydraulic balancing entails, and is it undertaken regularly when a boiler is replaced or serviced?

No.

11b. What practical barriers might prevent a central heating system from being hydraulically balanced (e.g. system size)?

Mainly lack of knowledge and expertise on small or large alike, although more attempt is needed and is usually made to balance large systems. A totally unbalanced system has more dramatic and obvious effects, if it affects multiple dwelling units.

11c. What is the average cost to a consumer when hydraulically balancing a central heating system?

An author of this document once balanced a 14-radiator system in a 100 m^2 four-bedroom semi-detached house in 3-3.5 hours. The system was performing poorly, with some radiators too hot, remote ones giving too little heat. It appeared that the system had not been balanced significantly when new. After waiting for a cold, cloudy day and making accurate adjustments, rooms could aparently be heated to within ≤0.5 K of the design values. [17]

Industry trade rates can be used to come up with a ballpark cost for say 3 hours' work in an average-sized house of 10-12 radiators. Meanwhile, a 10-20% saving on a normal gas(oil) bill would be worth £70-140(100-200)/y.

11d. What evidence is there to demonstrate the impact that hydraulic balancing can improve the performance and/or carbon intensity of domestic heating systems?

There is work going back 30-40 years or more on balancing the radiator systems in blocks of flats in Sweden et al. The savings from hydraulically balancing a system that was allegedly 'balanced' when the block was new were sometimes many tens of percent. Temperatures were usually more comfortable/less variable afterwards too.

The process is simpler in a low-rise single-family house than a block of 100 flats with a central boiler. But because small UK systems are sometimes balanced to a poorer standard than flats, or hardly at all, our estimate is that the saving could still be 10-20% or more.

Such work has not generally been publicly-funded since last century - see **Overview**. Few or no public domain measurements exist.

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12a. What flow and return temperatures are typically set for a condensing boiler at the point of installation?

80/60°C is not unusual.

12b. Can lower return temperatures be implemented in the existing housing stock without upsizing radiators on a grand scale?

Yes:

- Adopt continuous heating. It lowers return temperatures and thereby increases the operating efficiency of i) condensing boilers, ii) heat pumps and iii) CHP systems.

- Assess the effect of the thermal improvements undertaken, like wall and roof insulation and double glazing, since fitting the original 1960s, 1970s or 1980s radiators. Oversized radiators permit lower temperatures. Anecdotally, flow and return temperatures of 55/35°C may then be feasible on a radiator system that originally operated at 82/71°C or 80/60°C on the coldest day.

12c. Should Government consider setting a maximum return temperature in the future?~~Yes~~.

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Yes. Sweden and Denmark apparently adopted flow/return temperatures of 60/40°C for individual heating systems in *1980*.

12d. Please provide any further information to support your answers to questions 12a-12c. Please consider what barriers might prevent lower return temperatures being set in the home, or which may prevent an installer carrying out a heat loss calculation.

One significant barrier is EST's advice counselling householders against continuous heating. Repeated surveys abroad have suggested that, with controls readjusted, continuous heating may use slightly less fuel than intermittent for the same thermal comfort. Its advantage increases in low heat loss and/or high thermal capacity buildings, because these are more thermally sluggish. We are moving towards these.

14. What action should Government take to reduce the use of coal and oil in buildings? Over what period of time should the transition occur? Which levers should be deployed to support homes that are harder to heat?

We do question the inclusion of coal and oil in the same sentence. This is seriously in error.

Coal should be phased out immediately, with grant aid considered. The invisible air pollution and visible soot from its combustion make it unacceptable vs. alternatives.

LPG, often mistakenly amalgamated with 'oil', is the lowest-CO_2 rural fuel, if burned in a condensing boiler. If it is stored and used to back up a large solar thermal system, it is about 40% less CO_2-intensive than an electric heat pump. [18] It does not threaten to overload the national grid, unlike mass electric heat pumps. Gas combustion produces few if any PM-2.5 emissions.

On measures to thermally improve rural buildings, maybe including ~~Enerphit~~ EnerPHit Standard retrofits, try low-interest loans like those offered by Germany's state housing bank over 25 or 30 years. These retrofits are likely to be viable at oil or LPG prices, if UK PLC costs them over the life of the insulation and glazing measures, typically 25-50 years.

Rural buildings are one of the cases where EnerPHit measures do appear viable. This reflects the lower cost of piped gas and other options in towns, also the lack of space for thick wall insulation in some districts where houses abut the pavement.

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15. What other innovative solutions or opportunities exist that may have a tangible impact on emissions from heat in buildings, either in the next two carbon budgets or out to 2050? Please provide any supporting evidence.

In a discussion of 'decarbonisation', we are surprised that this document cites heat networks just once. Its only mention of them is negative.

The UK discharges 68 million kilowatts (gigawatts, GW) of waste heat from thermal power stations, i.e., 24 hours/day, 365 days/year. This reject heat flow exceeds the rate of natural gas supply to the domestic sector for space and water heating!

The Netherlands has a more extensive gas network than the UK, serving approximately 99% of Dutch buildings. However, it proposes to replace gas networks by heat networks by 2050.

Denmark heats 65% of its suburban detached houses by heat networks, the bulk of the low-density areas having been connected since 1979. At £6,500 per detached bungalow, [19] Danish retrofit heat networks appear worthwhile if the 'civils' costs could be translated to the UK. This assumes that we pay for networks over their lifetime, using Green Book interest rates.

Denmark heats 15% of its buildings from piped gas. Many of these gas networks may be replaced by heat networks in the next 30 years.

Danish towns like Marstal, Gram, Dronninglund and Vojens are 50% to over 62% solar-heated. This step change from 0% to 50-60% solar almost overnight is available to countries and towns which have heat networks, but not to others.

Overall, district heating makes it somewhat easier to utilise renewable energy than electric heating does. Some renewable resources are very low-exergy. In Iceland, with possibly Europe's best per capita renewable energy resource, over 90% of the country and most of Reykyavik are on piped heat.

Since we are responding to a call for evidence, including negative and positive remarks, we should make our wider views clear, i.e. current UK practice on designed and installed heat networks and electric heat pumps is of abysmal technical/engineering quality. There are so-called 'insulated' pipes within blocks of flats that actually lose more heat (in W per m) than buried Danish district heating networks lose.

We hope that the government is willing to contribute to improving the situation, putting an end to a relatively arms length and deregulated economic and energy policy. Unless it is, the prospect of meeting future CO_2 reduction targets via either technology is relatively poor.

Glossary

References herein to UK PLC mean that the UK is viewed as a whole. Decisions on different technologies are discussed in terms of costs and benefits to the overall economy and the whole nation, not to particular individuals or groups.

Notes and References

[1] Also known as the Scientific Civil Service.

[2] The last programme was Partners in Technology, in the late 1990s. More satisfactory would be also to establish a UK instituion equivalent to those in other developed countries including Sweden, Norway, Denmark, Finland, Canada, and USA. This helps to bridge the gulf between academic institutions and commerce.

[3] Some clients for UK private one-off housing nowadays issue a brief, on the basis of experience, for a new dwelling to be designed for winter air temperatures as high as 22, 23 or 24°C in the living room and 24, 25 or 26°C in the bathroom(s).

Monitored Passivhaus Standard buildings averaged 21.5°C. These were a systematic selection of relatively energy-conscious, frugal households. It is thought that more 'normal' households might maintain higher temperatures.

[4] Given the interaction of building time constants and the lower efficiency of a derated condensing boiler, heat pump or CHP system if it operates 8-10 (e.g., 7.00-9.00 h, 17.30-22.30 h) instead of 24 h/day and so has to increase the flow and return temperatures.

[5] We would prefer a target modified so that it does not a) mislabel wood burning as 'LZC', b) omit the CO_2 content of imported goods c) reserve the right to 'outsource' emissions reductions to developing countries.

[6] Especially by 2020-25 as today's best available technology becomes more standard.

[7] Disconnecting the gas or electricity supply cuts off space heating to 95-97% of UK dwellings. Even dwellings heated by natural gas, oil or LPG need electricity for the pump and/or fan to operate. Some woodstoves can operate without electricity, but wood now poses a serious air pollution problem; see http://www.bmj.com/content/350/bmj.h2757/rr-1.

[8] Regrettably, the UK lobbied against some EU legislation.

[9] Surprisingly, UK policy is for consumers to pay the cost of 'smart meters' and for suppliers to reap most of the benefit; i.e., the remote meter reading and the remote disconnection.

[10] http://www.claverton-energy.com/smart-metering-is-fcuked-a-disaster.html.

[11] Although most rural properties have space to store LPG.

[12] www.energypolicy.co.uk.

[13] The academics were not engaged to do any of the consulting work, which would have been a conflict of interest. But they were knowledgeable of which consultants across the UK were experts in a field and they tended to help guide experts towards particular projects where they could be of most help.

[14] These were seasonal efficiencies. 86% versus 97% is a major saving, even if the 97% reduces to 95% in real,

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monitored systems.

[15] At another extreme, regulated utilities like Severn Trent Water can reportedly borrow at a real 1% per year for 50 years.

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[16] Given the lower volumetric energy density of LPG. The disparity can tend to make it cost-effective only in small buildings of low heat consumption; e.g., Passivhaus standard. LPG in other countries is priced similarly to oil.

[17] These help to control room temperatures in mild weather, though, if design temperatures vary between rooms.

[18] A heat pump of COP 3.0 emits 0.17 kg/kWh, using the SAP intensity of 0.52 kg/kWh, which we consider too low for assessing technologies which lead to a sustained increase in electricity demand. A 95% efficient LPG condensing boiler, backing up a system of 60% solar fraction, emits 0.4 x 0.26 = 0.10 kg/kWh.

We have not calculated the emissions of a heat pump plus solar. It does not make economic sense to superimpose one very capital-intensive £6-8k system on another capital-intensive £3-6k system. The solar system supplies most heat at times when the heat pump already operates at high COP; i.e., June to August, saving less CO_2.

[19] Figure from Danish DHA, 2011. Refers to areas outside the capital city. Quoted in *LESS IS MORE: Energy Security After Oil*, AECB, February 2012. Likely to be rather less in areas of semi-detached and terraced housing.