



Report of the ERP – ETI – RAEng Heat workshop 22 January 2009

Introduction

The Energy Research Partnership, Energy Technologies Institute and Royal Academy of Engineering jointly organised a workshop to examine the role of heat in the UK's energy system. It took place in the afternoon of 22 January 2009 at the home of the RAEng, 3 Carlton House Terrace, London.

The workshop was designed to raise the level of thinking on heat as an issue, help guide ETI's future work on heat, and inform participants' responses to the Government's consultation on the Heat and Energy Savings Strategy, which was subsequently launched on 12 February.

Over fifty energy professionals attended, with almost half from industry, and an even split from academia and the public sector (including policy makers and funders). A series of presentations set the context, covering technology, policy and the whole systems approach, followed by an interactive panel discussion, with senior figures from private and public sectors.

Participants were asked to consider the demand for, and supply of, heat in the UK's energy system, now and under scenarios which put the UK on a path to 80% reduction in CO₂ emissions, with an emphasis on how new technologies and wider innovation in our use of heat can help achieve these emissions targets.

This report summarises the views of the speakers, and the discussion that followed. During the event, participants were asked a series of questions, to gauge reaction to key issues for heat, some of these responses are also given. The full set of presentations is available on ERP's website: www.energyresearchpartnership.org.uk/heat.

The organisers thank all those who participated in the workshop, in particular the presenters and members of the discussion panel. Special thanks go to Jim Skea, Research Director of the UK Energy Research Centre, for chairing the event.

The Energy Research Partnership is a high-level forum designed to give strategic direction to UK energy research and innovation activities. It brings together key funders from government, industry, academia and other interested bodies to identify and work together towards shared goals. www.energyresearchpartnership.org.uk

The Energy Technologies Institute has been established to accelerate the development, demonstration and eventual commercial deployment of a focused portfolio of energy technologies, which will increase energy efficiency, reduce greenhouse gas emissions and help achieve energy and climate change goals. www.energytechnologies.co.uk

The Royal Academy of Engineering brings together the country's most eminent engineers from all disciplines to promote excellence in the science, art and practice of engineering. Strategic priorities are to enhance the UK's engineering capabilities; to celebrate excellence and inspire the next generation; and to lead debate by guiding informed thinking and influencing public policy. <http://www.raeng.org.uk/>

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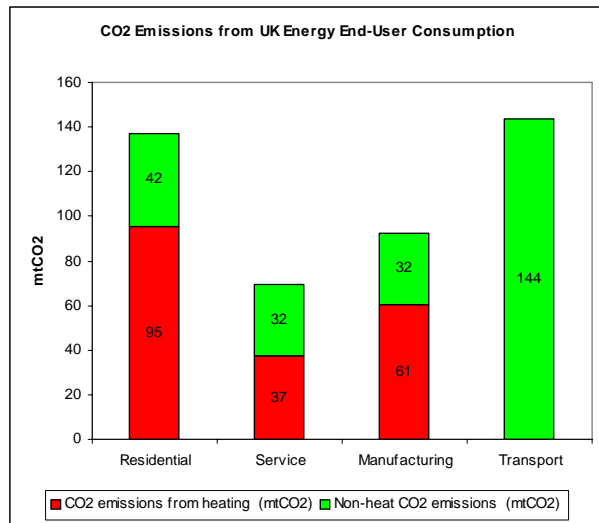
Jim Skea, UKERC

Setting the context

Whole systems

(i) Bryan Silletti, Caterpillar & ETI Strategic Advisory Group on Heat

To set the stage on the importance of heat, the annual UK energy consumption to provide heat is 70 Mtoe, and it is a significant contributor to CO₂ emissions:



Let's break these numbers down:

Mtoe	Space heating	Water heating	Low temp process	High temp process	Cooling
Residential	26	11	1	0	N/A
Service	9	2	2	0	1
Manufacturing	6	N/A	8	5	N/A

System level optimisation will require significant change in terms of how things are done. Heat and electricity have been decoupled, but are integrally mixed, we need to re-engage that mix.

For the domestic load, the question is not necessarily about heating or cooling, but how we provide a system that allows people to be comfortable more efficiently. Improvements from new build are coming through, but 70% of 2050's housing stock has already been built. This can be tackled through decarbonising the supply or retrofitting energy saving technologies.

In the near term we should use heat more effectively, such as through integrated controls and insulation. Longer term we can look at how to deliver and use space and water heating more efficiently.

There are many options for decarbonising heat supply. One is to consider the large amount of wasted heat from production from various different systems, much from electricity generation. This table looks at the technical feasibility of doing this, not the economics:

Mtoe	Gas	Oil	Coal
UK total wasted heat production *	23.9	5.3	34.9
Power Stations Approximate technical potential estimated for a generic multi-stage steam turbine power station. Detailed and site level analysis has not been performed	20 (16 Million Homes)		
Refineries Available for use as low temperature heat source with a viable heat sink from 60-120°C	2 (1.6 Million Homes)		
Other Industry (> 20MW) Technical heat recovery potential at temperatures up to 1500°C with commercial technology	1 – 2 (0.8 – 1.6 Million Homes)		

The Danish Energy Authority has done a great deal of work on heat networks, utilising heat and making the systems much more efficient. Starting with natural gas they achieve a 30% reduction in CO₂ intensity, which is diversified with the inclusion of biomass and waste heat, then renewable firming to continue decarbonisation. Nine heat networks in the UK are already established or expanding, so there is a financial model by which they are working here and is efficient.

There are other key enabling technologies which exist to help us get greater efficiencies, including heat storage and heat pumps. But we need to understand how we can integrate those systems to use energy efficiently and integrate into a broader segment to reduce CO₂.

A combination of demand management and decarbonised supply is critical to reach emissions target. The sequence of deploying technologies and managing demand is a debatable point, but there will be a time element and a capacity element. What we really want is affordable comfort with a low carbon system and secure supply.

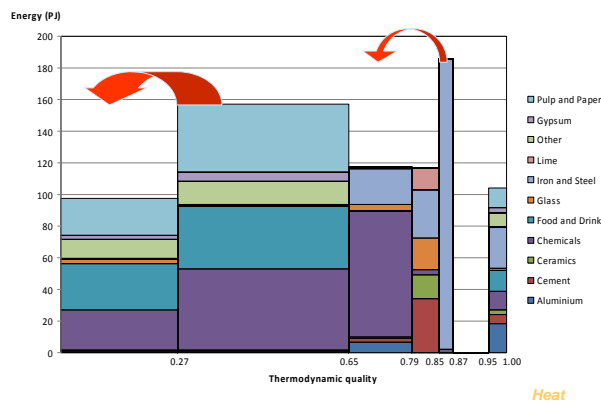
(ii) Geoff Hammond, University of Bath

Over the last 30 years, there has been a gradual growth in energy demand in both domestic building services and in the commercial sector. The area that has been the greatest success story has been the reduction in energy use in industry because of greater price sensitivity and a move in the UK from heavy to light industry together with a switch from coal and oil to gas and electricity.

We have used a portfolio of thermodynamic techniques, include ones that just look at the *quantity* of energy but also others that look at the *quality* of energy. In the UK, we have rather lost sight of thermodynamics, when those constraints underpin the whole of the energy system.

The most important point is that there is more than one law of thermodynamics and, if you just use the first law, you get this idea of the quantity of energy, what we call enthalpy. If you use the first and second laws, it comes to a measure of a property which is commonly called exergy. You can use these ideas to gain different insights into an energy system. If you just analyse the energy, it tells something about what you must conserve. Exergy is about the efficient conversion of energy into work, but not into heat. If you are using it to analyse heat networks, for example, you can sometimes be misled.

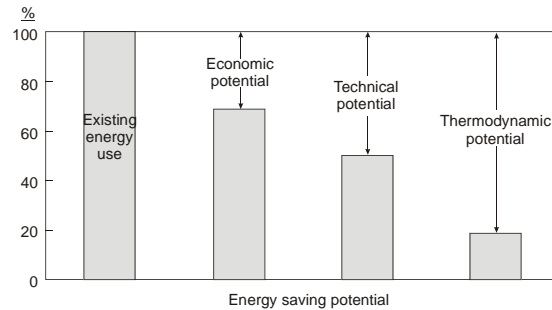
Exergy analysis shows how to optimize the use of energy at different levels of quality – if you like, different temperature levels. That leads to this idea of energy or heat cascading. We have been looking at how we could develop heat networks which optimize the use of this heat cascade at the different temperatures; just to see what would be possible in terms of utilisation of energy, particularly in the industrial sector:



At the highest levels of thermodynamic quality is electricity use, below which are high temperature processes, and down to low temperature uses.

Electricity is a high grade energy source, which we should use for high grade applications. It is inefficient to use electricity, at least with the current network, for space and water heating. However, under a series of projections of energy scenarios to 2050, we find that roughly 50% of electricity is used for power applications in the home and roughly 50% for heating applications.

There are a number of barriers to improving energy productivity in industry. For technical reasons we can only get to about 80% of the thermodynamic potential. In recent work we have done for the ETI, we have a range in industry of 11 to 22 TWh of heat recovery potential. However, in practice, you could probably get about 50% and, if you take account of economic factors, perhaps only 30%:



Heat

It is important that we use these ‘whole systems’ ideas – this idea of sustainability assessment. Thermodynamic concepts are very important but we have to use them in the right way. There are some cases where they can give you misleading results and we need to take account of both the quantity and the quality of energy if we are trying to optimise an energy system.

We also need to test to what extent we have lower hanging fruit, particularly in industry. If industry has been so successful already in reducing its energy consumption, and it is price sensitive, then how much is there left to do?

Policy

(iii) Hergen Hays, Department of Energy and Climate Change

It is fair to say that, in energy policy making terms, electricity always had centre stage and heat has been like the Cinderella of policy making. However, I am very pleased that there has definitely been a shift within government departments and also among ministers, increasingly to note the importance of heat and therefore the policy levers that we should consider putting in place to enable carbon savings from heat where possible.

A decision that we have taken in the Department of Energy and Climate Change is to bring energy saving and heat together as policy drivers. We believe that the best heat is the heat that you do not need to generate and so energy saving and energy efficiency policies are an important component of any over-arching heat policy.

What is certain is that if we want to meet our 2050 targets in renewable energy and 80% CO₂ reduction, then we need radical reforms: incremental step changes will not ensure that we actually meet these targets.

What we really want to see is what I would classify as a whole-house approach, rather than a piecemeal approach. A question is whether there is a need for a more co-ordinated,

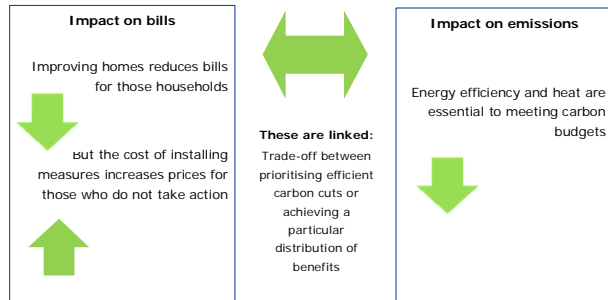
holistic, advice service, driven by an expertise to advise the home owner on a range of solutions from energy efficiency to the installation of heating or micro-electricity technologies. Also we have to ask whether the plethora of instruments for financial support - obligations and incentives - work effectively together? And do our ambitious targets require more direction through regulation in the future?

One of the questions we are grappling with in terms of policy making is whether we want to see more district heat networks. In Denmark, there was no gas system in place and they used heating oil. The local government decided that three-quarters of Copenhagen should have district heating and there was no choice, while one-quarter was connected to the gas mains. It was a very directional approach and one that was very much facilitated by the oil crisis in the 1970s.

In urban areas in the UK, we are now mainly on a gas grid, but do we want a further heat network installed, with all the prices and capital investment that is required? There could potentially be 5.5 million properties within the UK that could be connected, sensibly, to a district heating network, compared to currently about 2%.

In terms of industrial heat and CHP, there is again a set of policies already largely in place. The question for us is whether there are too many, should we streamline them, and are they the right policy instruments?

Our policies will have to consider bills and carbon emissions – and these impacts are related:



On the one hand, improving energy efficiency or installing heat technology will reduce residential or business bills, but someone has to pay for that, so there are winners and losers. The message is that those who do nothing will be paying for the benefit of those who will take up these measures.

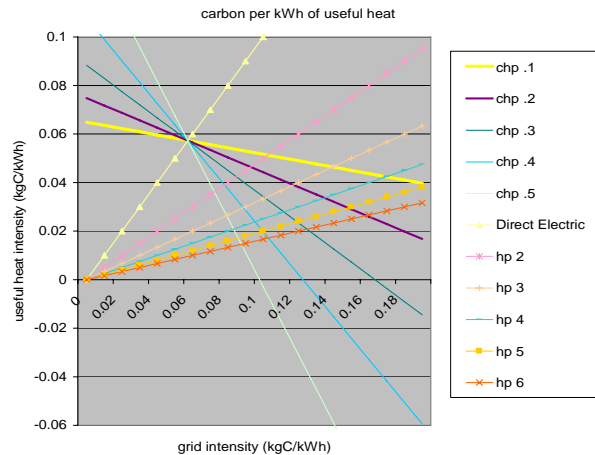
There is also an issue of distribution, and distributional impact, for policy makers to consider: whether we need some policies that are directly targeted to ensure that these new technologies and the energy efficiency measures reach not just a certain strata of society.

(iv) Nick Eyre, University of Oxford

Meeting energy security and carbon goals with respect to heat in the UK can now only be achieved by using less energy or

shifting to renewables. The constraints for heat are the competitiveness and affordability goals. Heat is a low-value energy demand which people are not prepared to pay for in the way they pay for electricity or transport fuels.

There are three scales at which you can think of low carbon heat. The large scale is to decarbonise electricity and use electric heating. This graph looks at how the carbon intensity of heat depends upon the carbon intensity of the electricity grid:



Direct electric heating has a slope of 1, which heat pumps can improve on, with lower gradients. CHP technologies with different electrical efficiencies have negative slopes, because the more carbon intensive the grid is, the bigger the benefit of generating electricity from gas-fired CHP.

At the moment grid intensity is about 0.15, and a gas boiler is about 0.06. At the moment, both heat pumps and gas fired CHP are therefore good for carbon, compared to a boiler and direct electric heating. However, when we get to about half the current grid intensity, or rather when the marginal plant on the system (likely to be gas or coal at the moment) at the time when we want heat is half the current grid intensity, heat pumps are very good and CHP becomes bad. I submit that that is quite a long time away, and there is a generation of CHP technology that can be put in before you run the risk that you are damaging your overall carbon economy.

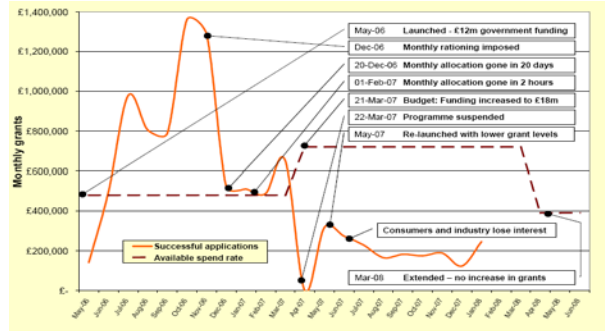
On the medium scale, district heating is only low carbon if it is fuelled by biomass or CHP. It remains an open question whether it makes sense to put in a heat system in low carbon developments. However, it is not a general panacea.

The micro scale, where fuel is turned into heat at the point of use, or close to it, will go on being important, and the most important for the foreseeable future, so we should be focusing on those technologies.

Is current policy working for heat? The price for carbon in current policy instruments is about £10/tCO₂, about an order of magnitude lower than the market price for carbon in gas.

So the instruments are probably not affecting behaviour and the fuel mix. That is not to say they are bad – if you use the money raised in a sensible way, that is effective.

The one thing you want from support for innovation is consistent policy. This graph shows the level of support provided by the Low Carbon Building Programme, and one thing it is not is consistent:



What is needed is something like a feed-in tariff or a renewable heat incentive which operates when there is a consistent price, and people know they can get it.

On buildings and behaviour there is a better story to tell, and the Government is doing quite a lot in this area. The regulations that made condensing boilers mandatory was excellent, and CERT has done its job really well. However, for the future, policy instruments may deliver 30% reductions in emissions, but reaching 80% will mean a fundamental reconstruction of the building stock.

To conclude, in the short term the priority is to use less heat, and remember that the second law of thermodynamics exists. Longer term the struggle will be to use more renewable fuel, requiring significant incentives to develop the supply chain.

Technology

(v) Dennis Loveday, Loughborough University

There has been a growth in the demand for heat domestic sector over the last 30 years despite better efficiency measures on insulation and heating technologies. It may well be because people have more disposable income and wish to spend it on being warmer: there has been a general increase in indoor temperatures, and the number of rooms being heated. There has also been a 40% increase in the number of households.

It is interesting to look at market penetration of home energy efficiency measure:

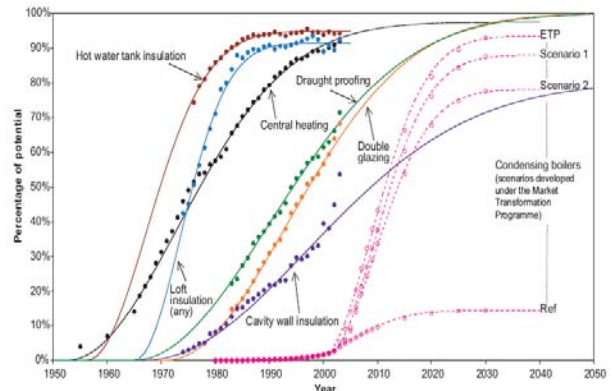
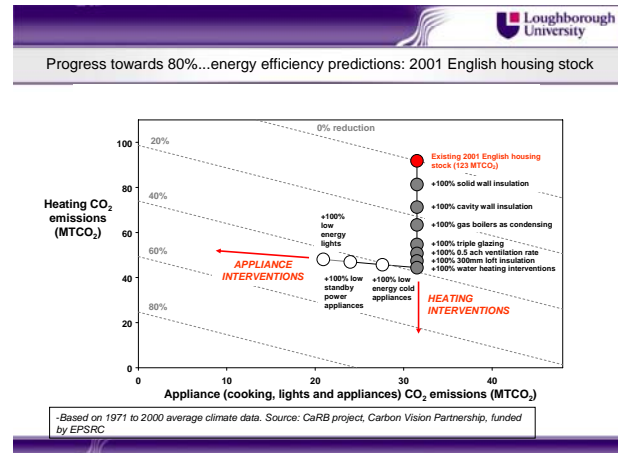


Figure 1 Market penetration of home energy-efficiency related measures

You can see that to reach saturation takes quite a long time – several decades in some cases. Considering 100% interventions in insulation and other energy saving technologies to the existing English housing stock, the following graph shows we would make it to about 40% carbon reductions. So there need to be quite radical other interventions to get to the 80% target for the built sector. Or if you don't meet it there, the onus goes on other sectors like transport.



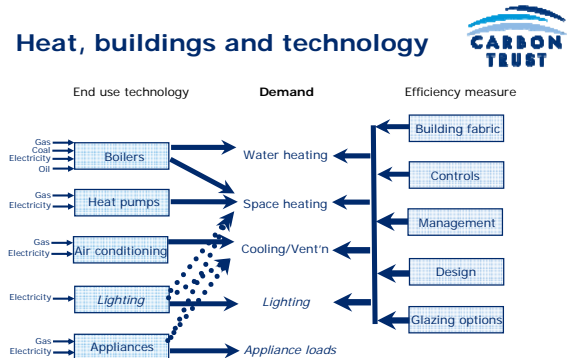
An estimated cost for further fabric interventions is around £20k per house, that's a £400bn across the UK which may very well be a worthwhile investment compared to recent others.

Some of the more advanced demand reduction technologies in various stages of development include advanced window systems (triple or vacuum glazing and aerogel replacements), vacuum insulation panels (which can improve by a factor of ten the insulation of standard fibreglass constructions, though have limited lifespans) and super insulation, such that internal gains are sufficient to keep people thermally comfortable.

A particularly interesting issue is the technology/human interface, with significant scope for self-learning, predictive/optimal, systems to give better control of heating systems. Advanced controls have been reported to offer 20% savings, with good retrofit potential.

Human thermal comfort will be important to consider in a changing climate: will we be prepared to accept warmer conditions, or are we used to having air conditioning at work and in cars we will demand it in the home?

There is no magic-bullet technical solution, and we should not lose sight of the fact that many of these issues revolve around socio-technical/socio-economic factors, together with the skills base, supply chain and infrastructure required to deliver them.



(vi) Garry Staunton, Carbon Trust

As we hear “heat accounts for approaching half the UK carbon emissions” yet traded heat – heat for which money changed hands – is tiny:

kToc	Coal	Gas	Elec.	Heat
Industry	1,173	11,760	10,123	692
Domestic	487	30,090	9,893	52
Public Admin	5	3,834	1,879	376
Commercial	4	3,091	6,469	9
Other	4	1,662	329	0

So the question arises: what do you do to measure your heat and heat use? Underneath this is also the idea of sub-markets and social technology options.

Successful innovation is a complex blend of things. The technology which emerges and saves you lots of carbon and money has to be housed within a company or organisation which is capable of marketing it, selling it, servicing it and supporting it – and of actually financing it in getting there. We need to look at the challenges within the innovation context and the regulatory framework underneath it needs to be neither too complex nor too negative to get in the way and, eventually, you want it to have no dealings whatsoever with you.

One of the key elements that makes electricity different from heat is that the electricity is the ultimate undifferentiated commodity at point of use. All electricity is the same, but not all heat is the same: from cooling at -25°C to processes at 800°C. So do not forget that this issue about the market is there: segmentation and market and matching the technology become even more important.

We have this thing about condensing boilers but let us not forget that it is not just a boiler, it is about design and integration at all sorts of levels. The work that we have been doing on our CHP field trial shows that what really cripples devices, from condensing boilers through to CHP, is actually the return temperature which, can be a function of Byzantine plumbing in houses, so that perhaps only half the potential benefit is delivered.

We are institutionally designing commercial building spaces with very light thermal mass and very high solar gain which overheat, and with a rise in temperature from climate change, this will get worse and not better. So there is a question about how you access thermal mass. How do you access passive design features in those structures that are there? How do you retrofit them? These become technology challenges.

Lighting and appliances are not heat technologies *per se* but they generate a good deal of heat and have an impact. So one of the questions about a super-insulated house is, with just the right lighting, can you do away with the heating system for space heating? Or do you start to be overheated simply because you are over-lit?

Process development is an efficiency technique and technology, but it is not often seen as such. Most process engineers do not set out to design it to make processes as inefficient as possible but they recognise that if they design it sufficiently well, then they can learn from it. That, quite often, is efficiency technology but part of it is also about intensifying and finding uses for heat that are nearby. Take a food factory for example, which is a modular process with a cooking step and a chilling step. You have one side of a wall kicking out heat, with the other side demanding cooling, and no one thinks to put it together. So there is a great deal that can be done about process design, which can save heat – although how you execute it is a different matter.

At lower temperature usage, similar things come into play. Drying and separation is a key issue. At a certain point, getting rid of water becomes a real problem because you actually need a temperature of above 100°C (or a vacuum) to

do it effectively, when most of the heat that people want to get rid of is below 100°C, and that is a challenge.

Perverse as it might sound, managing away high temperature heat is easier than low temperature heat. Cooling something at 80°C is more difficult than cooling something at 200°C. As an example, when you open the bonnet of a fuel cell Mercedes A Class, it is all radiator to cool an 80°C PEM fuel cell. If they could have a 120°C fuel cell, the cooling would become easier and it would cost them less.

Heat is expensive to buy or produce in financial and carbon terms, and so of course saving heat can save money and carbon. However, it is also difficult to get rid of and so the question becomes, how do you open up new markets for technologies which either deliver what you want at a lower cost, or are able to utilise or upgrade something which someone else does not want? How do you turn a waste, which you have to pay to dispose of, into an asset?

There are hundreds of different heat-efficient technologies out there, and many more are coming through. The point is that, to come through and to succeed, they have to enter a complex market which has very high entry barriers to it. When we look at heat, how we incentivise and develop it therefore, we need to think about how to address the market challenges and the company challenges, as well as the technology challenges.

Discussion

The discussion period was wide ranging and provoked much debate on how heat would fit into the UK's future energy system, the role of different technologies in that system, and what policies would be required to bring about the necessary changes to meet carbon emissions targets.

The purpose was not to reach consensus positions on issues, rather to articulate what the key issues were, and the range of views that existed. A number of themes emerged which particularly engaged the workshop:

- Whether a more established vision of what the future energy system will be should be agreed, so that the appropriate technologies, or development of them, could be put in place now.
- How new business models, which value services (such as providing thermal comfort) rather than selling commodities, could be a potential mechanism for delivering CO₂ savings.
- The need for large scale demonstration trials of retrofit energy saving technologies to inform policy decisions.
- That there is a general lack of data available on energy use at household level, which could be used to improve understanding of consumer behaviour, and allow the development of innovative business models and policies.

The summary of the discussion below is divided into broad sections, though it is of course impossible to disentangle some issues. Each paragraph represents a view that was expressed, either from the panel, or the floor. The discussion was held under Chatham House rules, so speakers are not identified.

Whole energy systems

Whatever the answer to reducing CO₂ emissions from heat demand, how it is managed is absolutely central to all other decisions about the UK energy system because of the interlinkages that are implied, particularly by the strategy on combined heat and power, and the level of penetration of district heating.

Until decisions have been made on whether to utilise heat from electricity generation, we don't know where to build the power stations and how to integrate them into the heat system. It is as simple as that. It is too important to keep saying that we will do a bit of this and a bit of that, and that is an opportunity. We need a much more systematic view as to how the future will unroll. We should not be put off by all these little difficulties that we are having at the moment, but we need to think ambitiously, otherwise we will not deliver the target.

We have to spend somewhere £30 to £50 billion a year over the next 40 years on the whole energy system, to deliver 80% CO₂ reductions. But it is not economically optimal for each piece to get to 80%. With the efficiency savings, I do not see how we can economically and practically get to an 80% or

even a 60% reduction in heating on the total housing population.

Storage is an incredibly important property of any system where there is variability of demand and variability of supply. The only reason why we have not paid more attention to storage in the UK is because we have had a model which says that you must have the capacity to supply demand. We have had very cheap energy and we have gone for the lowest possible capital conversion prices. We have many very efficient forms of storage that we do not notice, such as a half-full tank of petrol in our car. This will not work in future, however, because this system needs much more thought about embedded storage. The systematic thinking about this is very weak. People seem to think that storing close to the point of supply is a good idea – which it is, if the connection from the point of supply through to the transmission system is very expensive, because then you can optimise that connection. But actually, storage close to the point of demand is best of all, because then you can use the whole system to get the energy to where you want to store it and it is ready when the user needs it. Once you start to have the interchange so that you are connecting the supply of electricity and the supply of heat, and you are cross-connecting at different places in the system, then you can start to think about what form you want to store the energy in. As is most obvious, the really expensive bits of kit in the system should be running all the time and you need some cheap bits of rapid load following kit to take it from the store and turn it into the service, like a gas boiler.

If we look at the system that provides the comfortable environment for us to live in, it comprises the structure of the building; the insulation; the glazing; the device that provides the heat; the ventilation; the device that distributes the heat, and the system that controls all of the bits and pieces. On the whole, each one of those components of the system is supplied by a different organisation which is very keen to promote the performance of their component. We have very, very little information on the performance of the whole system and how the various components interact with each other. We need to do far more monitoring of existing retrofitted houses than we do new installations

District heating and CHP

District heating is not a panacea, and not viable in low-rise when too much heat is lost. Even in multi-rise, if installed incorrectly, losses can be as much as 25%. Gas-fired CHP maybe not the long-term future, but is an enabler that is available now.

Putting in a heat distribution system has to be an important part of what we do. There is nothing difficult in the technology to decarbonise the heat supply and make buildings more energetically more efficient. Difficulty is in the implementation: why is it that there is so much resistance in the UK to heat distribution? There are cultural barriers, and a renewable heat incentive is required.

If the grid is decarbonised through CCS, there would still be an important role for CHP because that would reduce the amount of electricity capacity that would need to be produced for heating. Electricity for heating will be much more expensive than people are used to, perhaps by a factor of three or four by the time we have added in the decarbonisation costs.

There is not necessarily a resistance to heat distribution, but a lack of awareness. One of the things we should challenge ourselves about is whether people will turn round and say, 'If you had only told us that there was this solution out there, we would have loved it.' People have said that district heating is expensive but solar thermal or ground source heat pumps or biomass boilers, are even more expensive. When you go to upgrading existing homes for £20,000 to £30,000, that is much more expensive than a district heating solution for most buildings.

The real issue is the cost of networks in the UK. The reason for that is the availability of competent contractors to install the pipe. To install pipework costs £1500 a metre, of which £300 is pipe supply, £200 is pipe installing, and £1000 is to open and close the road. The civil engineering industry in the UK just does not have the necessary contractors available to install the pipework.

There is good evidence from Nordic cities which are using heat pumps to pump heat from the waste water system into the heat distribution system. The heat distribution system in Copenhagen is about 30 kilometres across. In Gothenburg the new CHP plant is on the other side of a major river – one of the biggest in Northern Europe – to apartments and the heat losses from the distribution system are about 4%, which is about half the losses from the electricity system.

Business models

We need to be clever as an industry, as a society, as policy-makers and as financiers about finding ways which avoid the capital aversion of consumers to write cheques. Consumers hate capital expenditure typically discount to zero any operating cost savings. We need to find relatively simple ways where the cost of deployment, whether that is on or off balance sheet, is done by largely big companies with big balance sheets, who do ROI calculations. They can make more profit because there is energy saving is profitable to do as opposed to costing money. They give a proportion, perhaps even a small proportion of that energy saving to the consumer in terms of lower overall energy bills and you amortise the cost of the kit over a said period – and it does not matter who is living there, because you still do the same thing – in a way that drives uptake potentially dramatically.

Even though the part of the abatement curve which shows positive returns from energy efficiency measures, it is giving a return which is lower than that of customary, moderate risk industries, and there are consequences of that. Will society be ready to pick up lower returns for investment? We will have to resolve that issue, and we will have to take the bottleneck

out of the customer demand, which seeks to minimise the capital layout today.

There is almost a fundamental misalignment between societal need and the revenue model where, if you sell more stuff, you make more money. If you are a gas or electricity supplier or whatever, you make more money by selling more and that, by definition, locks you into more revenue equals more CO₂. If you can flip the model, from being a service-backed commodity supplier to being a commodity-backed service supplier, then fundamentally you can align interests between society, energy suppliers, consumers and other people. Doing this is not difficult, because the product can be owned and operated by the utility in your house – therefore gas is a cost to the operation of that highly efficient device. So they have a direct incentive to maximise the efficiency of the device, to sell you a service of thermal comfort and lighting, as opposed to a commodity of which they want you to buy as much as possible.

Changing the culture of utilities to make them operate more in terms of delivering service has been coming through in ministerial speeches, but there is scepticism that this will actually be delivered. However, it's not clear that were it to be delivered, and if there were to be some sort of cap on the energy or carbon emissions from supplied electricity and gas, which would reduce over time, that that would actually give the driver to the change in the business model.

There have been many business model changes in history. But let us not forget that many of these companies go down the drain – or actually have first an advantage because they take a bigger risk, and then they iron out the inefficiencies. An inevitable question is, who will make the first move when we are running out of time. We need to create an environment and policies that will push industries and players in the direction to think seriously about what they are actually doing for customers. Industry innovators will not do this on their own. There is the chicken and egg: let us create frameworks, so that we can really push innovation. Step-change is needed, but, with 'business as usual', incremental stuff will not happen either. We first need to decide what energy system we want in 20 years' time or 50 years' time because innovation will happen around that, and we do not want to have the wrong type of innovation.

The discussion about energy retailers becoming energy service companies is not a new one in this country. From everything that we have seen over the last nearly 20 years now, they have tried but they have failed and they have fallen back to being essentially an efficient wholesale purchaser and a call centre. Government policy has tried to turn these organisations into energy service companies but they do not fit the requirement at all. We have to change the framework and get it right, and we should admit that we cannot decouple in a system that has no price regulation.

In the UK, the energy services business is about 5% of the size that it is in France. People often talk about Scandinavia but there are equally large district heating schemes just over in France. They fall off their chairs with laughter about the fact

that the utility companies should even want to enter the energy services business and wonder why the Government is trying to drag them along to enter it. They are completely different organisations: utility companies are utility companies, and they are involved retailing massive amounts of energy, while energy services companies are there running hundreds and thousands of little schemes delivering localised energy. They are a completely different model, organisation, type, smell and shape.

In Ontario, almost every single gas appliance is rented to the consumer. It is owned and operated – the asset is the utility's owned and operated asset and it just happens to be sitting in your house, so there is an alignment of interest to maximise the efficiency of that sort of thing. You will end up with those kinds of structures and possibly even with these kinds of things being part of a regulated asset base, whether it is a national grid or somebody else.

Consumer behaviour and available data

Despite standards required in building a sustainable community such as the Greenwich Millennium Village (GMV), with sophisticated heating controls, a lot of windows are open simply because people like fresh air.

Consumers are very likely to be service averse, because they have all undergone recent experiences over the years where the levels of service that they expect from banks, insurance companies, telecommunications providers and so on have plummeted.

As an industry, we need to get more people in who understand consumer segmentation, customer needs and so on. One of the reasons why we provide a poor service is simply because we do not know what it is that consumers want, and we fail to measure the enormous amount of value that we are giving away by providing a crap service.

A lot business models are based on incredibly incorrect energy data. The published data on individual electricity consumption for a two-bedroomed flat in the UK was rubbish when we went and measured it. Utility companies do not really look at that kind of level and it is only when you are selling to 300, 400 or 1,000 houses that you become quite motivated about what an individual house is using. In GMV there are 1100 homes and the heat take ranges from around 4,000 to 20,000 kWh/year, with the overall average being 6,000 – 7,000 kWh. So what the heck are those other people doing and how are they misusing their systems? Should you have quite restrictive controls to shut the heating down?

The kind of accurate, rich, granular, highly segmented data store that we could actually believe in would be absolutely a gold mine for many companies. If you go to a more distributed world, with lots more transactions and smaller bits of data, then suddenly the data becomes a valuable resource and the transactions become millions of them instead of just a few big lumps. I think the whole system of data management, and transactional bit of energy, which historically has been pretty

irrelevant, will become massively relevant. There is opportunity in that data, telecoms, IT space – whether it is British Telecom, Cisco, Google or Intel – and these people should see energy as a major opportunity for growth for the future. I don't think they get it yet.

It is a systematic problem that either the data is not available, or it is not validated, or it is not available in the right form, or you have to pay large sums of money for it. You can obtain a set of conclusions based on it, but you cannot have the data, so the conclusions are useless because you do not know how the data has been treated. Nowhere is this more true than in buildings. A group from the Carbon Trust, the Technology Strategy Board, the Department of Communities and Local Government, the Energy Trust Board, have got together and agreed that this is a problem and that we need to do something about it. We are not quite sure how much of the data actually already exists, which seems extraordinary, given the very high level of metering we have in the UK and an enormous amount of information. However, some of this data is not available at the level of granularity that it is particularly important, because it matters whether your house faces north/south or east/west, as to whether solar thermal on the roof is possible, and it matters not per postcode but per building.

What makes people change and willing to spend money is crises, and really expensive stuff. Energy, certainly in the last couple of decades, has been too cheap, too available and too reliable. Energy is finite and it should be more expensive. Its reliability should not be taken for granted.

Technology demonstration and deployment

If we simply implement current technologies, we will not be going far enough. We need the Energy Technologies Institute, the Carbon Trust, EPSRC and the Technology Strategy Board all to encourage the development and deployment of new technologies in this area as well.

There is no silver bullet in here: we cannot have a major technology that is not deployed, and we cannot have renewables not going forward and maturing so that they become commercially viable. We should think in these terms, that time does make a difference, and we cannot prioritise, even in a large country like ours.

Housing associations would be a fantastic test bed for technologies, if only certain things could be sorted by the relevant government departments. The split of initiatives and issues between different government departments is one of real concern. We need a 'Decent Homes' mark 2 to upgrade social housing to a much higher standard. The rigid rent policy on funding for upgrading properties prevents this happening now.

We need to get on now with some serious, large scale trial applications on existing houses. We think we can get certain CO₂ reductions with the established technologies but we are not sure how far we can go. Some of us believe quite

strongly that that is actually nowhere near enough and that we need R&D to produce some new ideas and technologies, but we are still not sure which is the best way and where are the areas to put serious money. Large scale trials, which would be relatively easily implemented in the public or social sector, rather than the private sector, would get us a long way in clarifying the issue.

We are falling behind in terms of implementation, even on the most obvious pieces for demonstration. We need to have demonstration pieces put in on the ground, so that industry and customers can become comfortable with what they see. It is pretty much bread and butter stuff.

Policy/regulation

We will not get to a cost-effective solution without having between us some shared view about the best way forward and that view will have to be based on some evidence concerning economics, technology and business models, otherwise we will continuously argue. The challenge for us as a community is to develop that shared view and to think about it over time, and to think about the implementation issues.

It is probably not a good idea just to start doing things now and assume the market will sort it all out because the assets that we are talking about are very long-lived and the costs are enormous

There is no single instrument that works for every single circumstance, and this is a fairly complex scene. The supply side markets should somehow do their trick. In housing, there is much room for standards. An interesting example would be the recent decision on putting a large sum of European money in place for CCS and new technology perhaps is a good way to help something there in the cost curve which otherwise might never happen

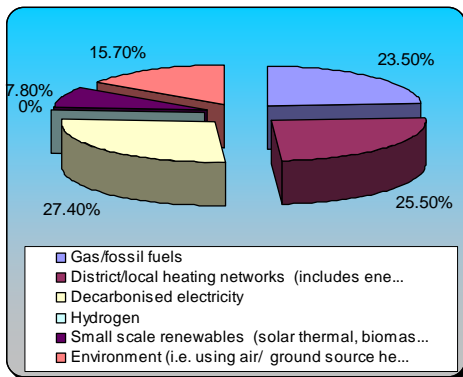
If you are looking at the long-term to 2050, we should have the appropriate policy which encourages long-term investment, so that long-term investment is the current business model. It must change from short-term returns to very, very long-term returns.

Questionnaire responses

Participants were asked to respond to a number of questions on heat, put at the start of the workshop, then again during the panel discussion. Though not in any sense a robust survey, it is interesting at least to note the views of more than 50 energy professionals. A selection of the responses is described below.

The majority believed greatest improvements in the way we use heat (and associated CO₂ emissions) would come from the demand side, specifically from existing buildings (with insulation a priority). A significant minority thought that heat networks, and the use of waste heat would deliver the greatest improvement.

There was a consensus that fossil fuels (and boilers as the technology) would dominate heat provision in 2020. There was no such consensus on the 2050 timescale:

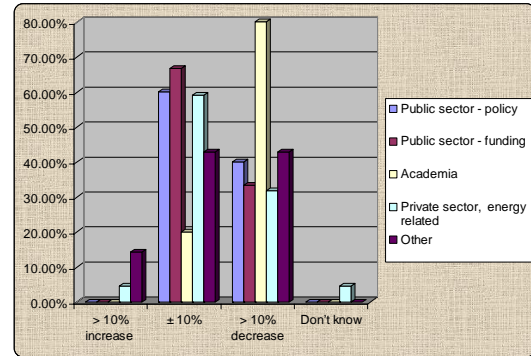


Over the course of the workshop, those thinking that heat networks would dominate the provision of heat in 2050 increased from 25% → 56%. Those thinking fossil fuel would dominate fell 24% → 7%.

Asked to prioritise areas for RDD&D funding, half voted for domestic buildings, one-third said heat networks.

When asked what the barriers to deployment of new approaches to supplying heat, half thought capital expenditure, though significant minorities thought regulation and social inertia. Availability of technical solutions was not seen to be a barrier.

There was an even split between those who thought residential emissions of CO₂ would see no change or large reductions. This was strongly influenced by academics who voted 4:1 believing large reductions would be seen. Participants from the private and public sector thought 60:40 no change.



Chair's conclusions

There is a good deal of consensus about what needs to be done in the short term with a strong focus on energy efficiency. For the existing residential housing stock there was a great deal of emphasis for the 2020 timescale.

For 2050, it was a rather different perspective. We think that things will be different, and ought to be very different in technological terms by 2050, but we do not really have a consensus about what that would actually look like. The weight of opinion shifted somewhat as a result of the discussion, with heat networks definitely coming more to the fore, but there were still people who were interested in decarbonised electricity, and microgeneration was still in there.

Interestingly, that slightly contrasted with a point that was made from Shell in the blueprint scenario, in that there is a value to having a sense of coming together to decide where you want to go. That point is clear but the trouble is that we do not know which particular option we want to go for. That has interesting implications for organisations such as ETI, thinking about R&D portfolios.

Another theme that came through was the importance of enhancing knowledge in this area. There is clearly a view that the heat network issue would be helped if there were more analytical thinking done about where the future could go. That thinking at a systems level is something we need to do.

In terms of knowledge, there were two further points. We clearly identified the need for better data, bringing things together. Another interesting point, which will affect people's lives over the coming decades, is that communicating that knowledge and information to wider society will be quite important, to get a kind of buy-in as to whether people will accept the kinds of changes that are possible in the future.

The final point is the general set of issues about regulatory frameworks, business models and institutional design and capabilities. There was a strong view that what we have at the moment is not fit for purpose if we have big ambitions for the long-term future. So there are ideas there that we may need to change the regulatory frameworks and, if they are changed, they may allow different business and service models to emerge, which was seen to be very important.

We have also identified a number of barriers that need to be dismantled. Some of the institutions and capabilities that we have are really not up for that kind of change yet. We need new skills and capabilities, and we need institutions to interact with each other in different ways. That is where there is a role for bodies like the professional institutions, like the Royal Academy of Engineering and so on, to take these discussions forwards.