Evidence to Commons Select Committee Energy and Climate Change Committee

From AECB

26 April 2016

Energy Revolution:

What Could Change the Energy Sector?

1. Introduction and Summary

The House of Commons Energy and Climate Change Committee (ECCC) has launched an enquiry into disruptive technologies and innovation which could transform the energy sector. This is AECB's response to ECCC's call for evidence.

AECB maintains that the remit of the enquiry is a little misconceived, because it hints of seeking 'silver bullets'. In the energy field, no such thing is likely to exist.

AECB considers that the nearest we have had to a 'disruptive' technology emerged 50-150 years ago. This was the discovery of almost 'free' fossil sunlight in the form of oil and natural gas.

Spending one's time with a conviction that something big will revolutionise the energy field, but speculating or not yet knowing quite what it is, consumes too much scarce political - and financial - capital. The majority of it could be better expended as we outline in Section (5). Only a small proportion should be reserved for the long shots we outline in Section (7).

2. Energy Policy Failures

Despite high energy consumption and CO_2 emissions, the UK still fails to provide warm homes for all [1]. The means by which it could achieve this very basic aim of health and social policy have been clear for 40 years [2, 3].

Fuel poverty was supposed to be abolished by 2016. The reasons why the UK has failed to end it seem to be political and institutional, not scientific or technological.

Either the facts as outlined in this evidence are not known or conveyed to those who run the country; or they are known, but they are privately dismissed at higher levels of government. Is this because small projects are seen as 'boring' and pursuing 'silver bullets' is seen as 'more exciting'? We do not know. It would be helpful for the Committee to enquire further into this.

3. Past Revolutions

We have had several in the energy field. Early 20th.C oil and natural gas fields; e.g., Spindletop [4, 5], gave energy returns on energy invested (EROEIs) of over 100. Most experts consider high EROEIs to be crucial if a technology is to make a useful contribution to running industrial societies.

Oil and natural gas supplemented the energy available from earlier sources; i.e., coal and before that wood. The effect of the abundance of cheap energy was spectacular. Most US cars in 1910 were electric or steam and ran on coal. By 1920, most were liquid-fuelled and ran on oil and their numbers were rising dramatically.

What new energy supply system offers to be as 'revolutionary' or 'disruptive' as drilling in the ground and using the fossil sunlight which flows out [6]? The answer may be 'none of them' [7].

4. 'Least Worst' Options?

We face the most challenging energy transition in history [8]. Current policy is not addressing security of supply or affordability very well. Most new sources of energy supply cost significantly more than fossil fuels. Distributing energy to consumers in the form of electricity costs significantly more than distributing it as fuel and heat [9].

Given these difficulties, the 'least worst' policy centres on investment throughout the economy in improved energy productivity. But it is hardly 'revolutionary'. It is a world away from the usual UK meaning of 'innovative'; i.e., complex, 'exciting' or novel [10].

Any 'innovation' needs to be mainly in the processes and mechanisms by which proven technology is disseminated and/or rapidly scaled up for widespread use, and available capital; e.g., in pension funds, is reinvested in long-term, low-risk areas [11]. It needs technology transfer as effective as Canada's R-2000 Programme and new delivery mechanisms and incentives as imaginative as California's investor-owned electric utilities became at the peak of 'least cost planning [12].

The technology needed covers more than just condensing boilers, LEDs and A+++ 'cold' and 'wet' appliances [13]. These examples are not so much the 'low-hanging fruit' but the fruit which has fallen off the trees and is lying on the ground!

We have left it very late. Many priorities were visibly the same 35 years ago, especially retrofit insulation and double or triple glazing. Improvement before 2050 needs to be much faster than in the last 30-40 years [14] [15].

Government intervention is 'unfashionable' [16]. But the current 'market' is unlikely to facilitate a transition from extravagant use of fossil fuels to the more sparing use of renewables [17]. What we need can only be secured via technically well-informed and well-integrated policy making. We hope that the UK, the first country to move from renewables *to* fossil fuel [18], is up to the challenge.

5. Promising Technology

In Section (6), we express concern at the waste of taxpayer or billpayer funds in the pursuit of reduced CO_2 emissions. By contrast, here are some of the many energy resources [19] which might cut emissions and cost 'UK PLC' somewhat less than buying energy at today's prices.

Technology	Details
Energy-efficient coffee makers	Consume 90% less electricity *vs.* UK worst practice [20]
T5 fluorescent and LED lights	Can consume 90% less electricity *vs.* old halogen and fluorescent lights
Combine existing German and Californian technology	Cut a refrigerator-freezer's electricity consumption from ~130-250 to 80-100 kWh/y
Passive infra-red lighting controls using 0.01 watts	99.5% less than the present average of ~2 watts
Danish solar thermal technology with seasonal storage	Proven since around 2005
Danish-type heat networks	Could provide built-up areas with cheaper and lower CO_2 heat than individual electric heat pumps. Can make use of resources which are not available to electricity networks.
Passive solar in new buildings	Easy, low-cost, but unknown to some developers and architects who face new houses north.

It is rather like discovering a series of giant oil and gas fields. They are in our buildings, not off the North Sea coast.

Because the energy efficiency resource often takes the form of millions of small units, it needs different financing and delivery mechanisms from drilling the earth's crust for a few giant petroleum deposits; i.e., as we have been doing for the last 100 years. The 'upside' is that, unlike nuclear fission and most renewables, many energy efficiency measures look not dissimilar in cost to oil and natural gas, thanks to:

- their relatively high EROEIs
- their abundance - new opportunities often emerge faster than they are implemented and competition tends to ensure that manufacturers steadily improve on other manufacturers' products.

See; e.g., recent implementation in New York City and in California. These cover both a regulated/vertically-integrated utility and a more 'free market' proposal.

6. Questionable Investment

We recognise the challenge to prioritise the use of scarce resources. But under current policy, little investment and/or subsidy is going into Section (5). More is going into the examples below.

1. The proposed EPR nuclear power station at Hinkley, Somerset [21]
2. Solar PV roofs in districts where network capacity becomes insufficient and infrastructure must be replaced to avoid damaging consumers' equipment [22]
3. Many retrofit insulation projects [23]
4. Forms of bio-energy that do not reduce CO_2 emissions, especially wood combustion [24]
5. Electric vehicle (EV) subsidies [25].

They do not seem to deliver what we want; i.e., affordable, clean and secure energy. At worst, they divert resources from more deserving areas in Section (5).

7. Long Shots

7.1. Nuclear Fusion

Fusion seems a good case of a speculative long shot, perhaps the kind the Committee is thinking of. But it is almost irrelevant to climate change. If/when it succeeds, it is unlikely to constitute a fundamental breakthrough on a par with the revolution in Section (3).

40 years ago, the UK Atomic Energy Authority stated that fusion would probably be ready for use by the year 2000. In 2016, it is still thought to lie 25 years in the future.

If Hinkley C power station goes ahead, its cost is variously reported as £16, £18 or £24.5 billion. All these seem very high figures to spend on supplying 1% of the UK's delivered energy [26]. But fusion might prove more complex and capital-intensive than nuclear fission, giving even more cause for concern.

We can make or labour the point that there is already a fusion reactor in the sky called the sun. It has no maintenance downtime. It is located a safe and convenient 150 million km away. Why reinvent it?

7.2. Batteries

Lithium-ion battery 'breakthroughs' are reported regularly. They are invaluable for mobile devices like laptops, cameras and mobile phones. But even at £125 per kWh of capacity, lithium-ion batteries remain costlier than lead-acid.

A £1,000 domestic oil tank stores 20,000 kWh; i.e., 5p per kWh of energy storage capacity. Large heat stores cost 25p-£1 per kWh. Electricity storage remains costlier than storing energy as hot water [27] or fuel.

The lithium-ion battery is certainly approaching parity with lead-acid. But batteries cheap enough for long-term electricity storage; i.e., summer to winter, seem a more speculative long shot than nuclear fusion. There is serious confusion regarding this point among lay people, including journalists, due to their confusion between energy and electricity.

7.3. Photolysis of Water

Hydrogen from direct solar photolysis of water, sometimes abbreviated as solar fuels, remains the prime target of research in photo-electrochemistry. If the Committee is looking for the 'Holy Grail', this is the strongest contender.

A direct pathway from incoming solar radiation to hydrogen gas [28] would yield storable fuel; i.e., the relatively convenient, tradable form of energy that we have relied on since the Industrial Revolution. We are set to need stored fuel in the energy mix for the indefinite future. But solar hydrogen is unlikely to be as 'disruptive' as (3).

Notes

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1 http://www.bbc.co.uk/iplayer/episode/b0756g0x/panorama-too-poor-to-stay-warm

2 The government's Marshall Committee, in Energy Papers 35 and 38, 1977-80, plus the follow-up activity and feasibility studies 1979-85. The apt slogan 'warm homes for all with waste heat from power stations' was used. The UK still rejects 70 million kilowatts of waste heat from its gas and coal power plants, which is more than the gas delivered to the domestic sector.

[3] To accompany the publications in ref. 2, one arguably needs the UK book *Keeping Warm for Half the Cost* (1978), the Canadian government booklet to consumers *Keeping the Heat In* (1976) and Marbek Resource Consultants' report to the Canadian government on advanced retrofit of timber-frame homes (1984).

[4] Given the relative capital intensity of the plant and equipment needed.

[5] https://en.wikipedia.org/wiki/Spindletop.

[6] Nuclear needs large, complex components, made to ultra-tight tolerances. Sir Arnold Weinstock termed the UK's Advanced Gas-Cooled Reactors 'watchmaking by the tonne'. Solar thermal equipment has less exacting tolerances but needs large areas of metal and/or glass; i.e., 1 m^2 of mirror glass per peak kW(t) for CSP generating plants in the 'sunbelt'.

[7] One ‘energy revolution’ that seems not to have delivered is nuclear fission. The forecast of 'electricity too cheap to meter' was made in 1954. By 2016, nuclear fission supplied about 2% of world delivered energy and the proportions was not increasing.

[8] In the last 200-300 years, we have gone from more expensive and/or diffuse to cheaper and/or more concentrated energy resources. For more discussion, see *LESS IS MORE: Energy Security After Oil*, published by AECB in February 2012.

[9] Solar PV electricity may be generated in spring and summer for 8-9 p per kWh. But to provide electricity on demand, who pays for the seasonal storage, frequency control and other grid balancing costs? Compare unrestricted electricity at 14 p/kWh to oil at around 3-4 p/kWh. UK policy is to use more electricity. Germany's is to use less.

[10] Funders often insist on technologies being 'innovative'. Existing technology which is on the verge of commercial, but still too risky for private firms to adopt, 'falls between the cracks'.

[11] Easily satisfied, we suggest, via the regulated utility model and via pension funds investing in their long-term bonds.

[12] Also sometimes called integrated resource planning. California's investor-owned utility programmes peaked around 1993 when the system was still vertically-integrated. The state ordered the utilities to invest in negawatts on consumers behalf and allowed their shareholders to keep 15% of the extra net profits.

[13] These products are the main cause of the fall in UK domestic energy consumption, especially in electricity usage. See http://edit.eceee.org/all-news/columnists/Andrew_Warren/energy-consumption-in-the-UK.

[14] An estimated 1% of the UK's 'commercial' energy was from renewable sources 40 years ago *vs*. 5% now.

[15] The rate needed may not be institutionally possible in peacetime. Existing investments could have to be written off, an unwelcome prospect to investors unless someone else 'picks up the tab'. Even if we almost make a Manhattan Project of it, we may need some kinds of large-scale geoengineering; i.e., chosen from the safer kinds, to 'buy time'.

[16] Examples include Disraeli's nationalisation of the telegraph system in 1868, Baldwin's creation of the National Grid in 1926, the US government's 1970s R&D on aircraft fuel efficiency and the work it then funded at Lawrence Berkeley Laboratory.

[17] Consumers have minimal access to capital; de-risked utilities can borrow capital for 50 years at a rate of 1%/y; e.g., Severn Trent Water.

[18] That is, from wood to coal from about 1750 onwards.

[19] Mostly but not exclusively energy efficiency measures. $40/barrel for crude oil equates to 2.5 c per kWh or 1.7 p/kWh. A few measures may cost slightly more than this but would still be cheap enough to abate CO_2 emissions at reasonable costs in £/tonne, helping to safeguard the economy.

[20] The least energy-efficient coffee makers use electric hotplates to keep the coffee hot; more efficient ones store the hot coffee in an insulated jug. For best practice, see www.topten.ch.

[21] Large amounts of political (and financial) capital are set to go into a plant to provide 1% of our delivered energy.

[22] The national grid increasingly fails to supply electricity to consumers within its strict voltage and frequency limits. Matters could worsen if *ad lib* connection of solar roofs continues, forcing the grid operators to turn off coal- and gas-fired plants during periods of high supply and low demand in summer 2016.

This inability to store electricity, and policy makers' obsession with electricity, is leading to the paradox of 'too much' electricity in summer (from PV) and 'too little' in winter. It seems insoluble if policy makers continue to focus on electricity-generating renewables and storing renewable energy as electricity and not as fuel or heat.

[23] The levels applied can be too large or little. In an oil- or LPG-heated solid-walled house, 225-250 mm of EPS foam external insulation appears 'economic'.

It is not very relevant that 75-100 mm insulation, with a wall U-value of 0.30, technically meets 'Building Regulations'. The Regulations usually state a standard which must be met in the very worst circumstances, not the ideal to aim at.

30 years ago, some local authorities added levels of external insulation to their council house masonry walls that are now seen as inadequate. Redoing the work today doubles the cost and is very expensive in £ spent per kWh saved. We are disappointed that lessons were not learned from this past experience.

[24] Solid fuel causes worse levels of particulate air pollution than oil or gas combustion. The large particles are a greenhouse gas and the PM-2-5 particles are a health hazard.

[25] The EV subsidy is £5,000. We assume that an EV uses 10 kWh per 100 km versus an efficient liquid-fuelled car using 3 litres/30 kWh per 100 km. We assume that it is driven 16,000 km/yr and that emissions are 0.52 kg/kWh from 230 V electricity and 0.27 kg/kWh from liquid fuel.

The two vehicles emit respectively 1,300 and 830 kg/yr. If the subsidy is spread over 15 years, the government appears to be paying electric car buyers £600/tonne to reduce CO_2 emissions. However, because the Audi A2's liquid fuel is taxed at around 60 p/litre or 6 p/kWh; i.e., £288/year, the Treasury also loses £290/year of tax revenue. Overall, over 15 years, this amounts to a further subsidy of £15x290 = £4,300 = £500/tonne to the EV.

We would like to see a comparison of resource cost to 'UK PLC' of power-to-gas technology and today's most efficient liquid-or gaseous-fuelled vehicles, versus the current policy of electric vehicles and reinforcement of the national grid to carry the extra load. Most forms of transport cannot be electrified, so some form of power-to-gas will be needed anyway and the question is whether a £5,000 makes any sense.

[26] That is, 7% of its electricity. Under existing policy, electricity consumers will be asked to pay the extra cost *vs.* electricity from gas or onshore wind.

[27] Large-scale storage.

[28] Leaving the hydrogen to be converted to a more convenient fuel; e.g., methane, methanol, propane or di-methyl ether. The last three are liquids or can be readily liquified and stored in low-pressure containers.