



**MEETING NOTE: PRIME MINISTER'S COUNCIL FOR SCIENCE AND TECHNOLOGY
- MINISTERIAL BRIEFING ON DECARBONISING HOMES**

Timing: 28th May 2020, 14:30 – 16:30

Attendees:

Name	Role	Organisation
Minister Kwasi Kwarteng	Minister of State for Business, Energy and Clean Growth	Department for Business, Energy, and Industrial Strategy
Professor John Loughhead	Chief Scientific Adviser	Department for Business, Energy, and Industrial Strategy
Professor Alan Penn	Chief Scientific Adviser	Ministry of Housing, Communities, and Local Government
CST Members		
Professor Julia Black	Strategic Director of Innovation	London School of Economics and Political Science
Professor Muffy Calder	Vice Principal & Head of College of Science & Engineering	University of Glasgow
Suranga Chandratillake	General Partner	Balderton Capital

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Professor Jim Hall	Professor of Climate and Environmental Risk	University of Oxford
Professor Max Lu	President and Vice-Chancellor	University of Surrey
Dervilla Mitchell (MEETING CHAIR)	Executive chair of the UK, India, Middle East and Africa region	Arup
Professor Paul Newman	Director	Oxford Robotics Institute
Professor Dame Nancy Rothwell	President and Vice-Chancellor	The University of Manchester
External Experts		
Dr Mike Cook	Partner and former Chairman	Buro Happold
Professor Peter Guthrie	Professor in Engineering for Sustainable Development	University of Cambridge
Professor Roger Kemp	Professorial Fellow	University of Lancaster
Professor Robert Lowe	Professor of Energy & Building Science	UCL
Dr Keith MacLean	Chair	UK Energy Research Centre (UKERC)'s Advisory Board
Dr Mari Martiskainen	Senior Research Fellow, Science Policy Research Unit	University of Sussex
Professor Tadj Oreszczyn	Professor of Energy and Environment	UCL Energy Institute
Professor William Swan	Leader, the Applied Buildings and Energy Research Group (ABERG)	University of Salford

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Professor Jeremy Watson	Chief Scientist and Engineer	Building Research Establishment
The Royal Academy of Engineering		
Keyne Walker	Policy Officer	The Royal Academy of Engineering
Philippa Westbury	Senior Policy Adviser	The Royal Academy of Engineering
Policy officials		
Olivia Absalom	Clean Heat Directorate	Department for Business, Energy, and Industrial Strategy
Damitha Adikaari	Director, Science & Innovation for Climate & Energy	Department for Business, Energy, and Industrial Strategy
Alex Lohead	Clean Heat Directorate	Department for Business, Energy, and Industrial Strategy
Elena Michael	Private Secretary to the Minister of State for Business, Energy and Clean Growth	Department for Business, Energy, and Industrial Strategy
Matilda Nekar	Head of Home Energy Retrofit Enablers, Energy Efficiency and Local Directorate	Department for Business, Energy, and Industrial Strategy
Daniel Newport	Heat and Business Energy	Department for Business, Energy, and Industrial Strategy
Victoria Tink	Building Environmental Scientist	Ministry of Housing, Communities and Local Government
CST Secretariat		

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Beth Hogben	Secretary	Government Office for Science
Rita Haddad	Head of Secretariat	Government Office for Science
Evie Ackery	Project Research Officer	Government Office for Science
Charley Lenton-Lyons	Project Research Officer	Government Office for Science

Introduction

1. Dervilla Mitchell opened the meeting by welcoming Minister Kwasi Kwarteng, Minister of State for Business, Energy and Clean Growth, invited speakers and officials. She explained that the objective of the session was to follow up on advice from the Council of Science and Technology to the Prime Minister on how the government could take a systems approach to achieving the target of net zero carbon emissions by 2050.
2. The Minister had requested a more detailed discussion of the latest scientific, engineering and technological thinking on retrofitting of homes and the development of a hydrogen economy, including key challenges, opportunities and prospects for success. This session would focus on retrofitting of homes.

A systems approach to retrofitting homes

3. Professor Jeremy Watson, Chief Scientist and Engineer at BRE, summarised the challenge. The UK needs to decarbonise 20,000 homes a week to meet the 2050 target. Government will need to set the boundaries for a retrofitting programme so that all relevant factors are included, as well as consider interdependencies between different factors.
4. He summarised issues that a systems approach to retrofitting should take into account:
 - a. Socio-technical factors: how users interact with technologies that would affect technology performance and socio-economic aspects.
 - b. Technologies will be needed for performance assurance, sensing and analysis of real-world impacts of retrofitting solutions.
 - c. The impact of retrofitting on wider infrastructure – an extra demand of around 70GW might be expected from retrofitting, which represents a doubling in necessary grid capacity¹. There are also implications for gas infrastructure and the potential use of hydrogen depending on the route the Government chooses to take. Local energy management, including local battery storage and autonomous local districts may have a role to play.

¹ GridCarbon Dashboard App

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- d. The cost of retrofitting and who will bear it. The Committee on Climate Change (CCC) estimates this at around £26,000/home retrofit. This figure is contested² and could vary significantly between different types of dwelling, but would certainly be a substantial investment for most property owners.
 - e. Further socio-economic factors, including: performance assurance for value enhancement and payback of the investment, acceptance of disruption; aesthetics;
 - f. Digital technologies will be important to underpin a retrofitting programme, including the assessment of needs and manufacturing bespoke parts off-site³, and monitoring of performance.
 - g. There needs to be monitoring for unintended consequences of some retrofitting approaches such as health impacts of condensation and mould.
 - h. Cultural changes in the building sector to develop the capability and skills for retrofitting: develop best practice, standards frameworks, monitoring and enforcement
5. Professor Watson proposed a 'What Works Centre' for Net Zero, with retrofit as the first key challenge.
6. Participants raised the following issues in discussion:
- a. There are important broader interdependencies between home decarbonisation and the wider energy and transport infrastructure. Government will need to identify these interdependencies and coordinate development of an integrated approach to optimise systems changes needed beyond the home. For example, re-laying cables for the low voltage network is a huge and potentially disruptive endeavour and will need coordinated management.
 - b. How to develop the UK's supply chain to drive retrofit? How to upscale capacity to meet Energy Performance Certificate (EPC) pathways? The UK's materials supply chain is both mature and robust. As there are 64 distinct types of houses that need to be retrofitted, a flexible manufactured system must be implemented to meet EPC pathways.
7. Participants discussed the different options for decarbonising heating:
- a. There are limitations in applying heat pumps with the current infrastructure. For example, heat pump technologies may be limited by the age and design of housing stock, particularly dwellings with limited external space. The quality of the appliance and installation are important - heat pumps can cause local electricity network flickering even if few are in use in any one area.
 - b. An alternative is converting the existing gas network to hydrogen for use with home boilers. This has the advantage that 85% of UK dwellings are connected to the gas infrastructure⁴ and boilers are a familiar technology. By 2050, the hydrogen delivered through this system would need to be zero carbon at source so finding more efficient methods of producing hydrogen from renewable energy directly into hydrogen is the long-term goal.
8. Further discussion touched on the necessity of co-development and testing of solutions:

² See additional note to CST: "The building decarbonisation transition pathways: Initial reflections", Robert Lowe and Tadj Oreszczyn, UCL Energy Institute, 12 June 2020.

³ BRE/ Construction Industry Hub work on this

⁴ [Sub-national estimates of households not on the gas grid, 2015 - 2018](#)

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- a. Technologies will need to be integrated into sophisticated, interconnected systems to provide satisfactory performance for the home user. Many appliances optimise performance as an individual unit rather than being designed to work with other appliances as part of an efficient system.
- b. Attendees commented on the importance of trials. Wales and West Utilities and Western Power Distribution have been conducting hybrid heat pump trials. They have been successful in lowering carbon intensity but require a strict management regime which limits user interference and choice.
- c. Integrated hybrid heat pump trials will be needed to develop our understanding of deployment challenges.

Challenges and opportunities for decarbonising home heating and cooling

9. Professor Tadj Oreszczyn reflected firstly on the importance of retrofit, as buildings are responsible for half of energy use during the UK's winter quarter.
10. Retrofit technologies range from energy sources, energy vectors, energy stores and conversion technologies, to heat demand reduction. R&D needs to bring together tools, existing research, and data to move rapidly into deployment of efficient, cost-effective systems. Deployment data should be monitored for unintended consequences to improve real world performance.
11. Heat pumps have some clear advantages, they potentially reduce energy consumed to as little as 30% of the current level. They also present challenges, including user behaviour and consumer acceptance⁵.
12. Recent developments will affect the relative advantages of different technologies including: the net zero legislation; the reduced cost of wind energy and storage (it is becoming more cost-effective to build more wind turbines than to install high levels of insulation in certain homes).
13. COVID-19 has produced a shift in domestic energy consumption and exacerbated fuel poverty. Measures to stimulate recovery from COVID-19 are an opportunity to refurbish.
14. Professor Oreszczyn noted the co-benefits of retrofit, including quality of life, health, comfort, and dispersed job creation. In contrast, unintended consequences are extremely complex, and at worst can destroy lives.
15. Whilst the regulation of efficient heating systems has caused a significant reduction in domestic energy use, a lack of long-term policy commitment in the housing sector has historically penalised early adopters. The UK is in a strong position to learn from previous regulatory experience and adapt. It was suggested that Government will need to demonstrate a clear, sustained vision and leadership to rebuild the sector's trust.
16. Discussion focused on the numerous challenges and opportunities of retrofit:
 - a. There was consensus on the importance of consistent and clear policy.

⁵ For additional information on the benefits of heat pumps versus hydrogen see additional note: "The building decarbonisation transition pathways: Initial reflections", Robert Lowe and Tadj Oreszczyn, UCL Energy Institute, 12 June 2020

DRAFT

- b. The existing energy efficiency ratings of a building will influence the most appropriate retrofit approach. For example, in lower consumption buildings, it may be uneconomic to install high capital cost solutions, such as heat pumps.
- c. Cooling challenges should also be considered and can be an added benefit of some options. However, the UK's demand will primarily be for heating over the coming decades.
- d. A British standard on refurbishment would be useful. Development of unique UK property datasets can assist with local authority planning and advising homeowners.
- e. Occupancy patterns and usage preferences mean optimal solutions vary even with technically identical properties. Decisions for retrofitting programmes involving multiple properties require consideration of social equity. While the average UK occupancy time is around 6-7 years, a significant number of households may stay in their home for much longer.
- f. Smart meter data provides more information on behaviour patterns and energy usage. Over recent decades, almost all households have moved to heating the whole house. University of Sussex research has highlighted that the UK homeowner prefers lower home temperatures to homeowners in other European nations.

How to strengthen innovation and implementation of research, education and skills into the built environment

- 17. Professor Peter Guthrie presented on some of the challenges around retrofitting. Installation, maintenance, and control standards are important, particularly as minor implementation errors produce huge efficiency losses and people may operate their homes in sub-optimal ways.
- 18. Dr Mike Cook commented on education and skills:
 - a. Looking across the system for retrofitting reveals a significant skills gap, especially digital skills.
 - b. Skills will be needed to design an entire home system, ensure different appliances and technologies are installed so that they work together and perform in line with the user needs.
 - c. Upskilling needs to extend to the suppliers, systems manufacturers, inspectors, householders, as well as people who will train the future workforce.
 - d. Solutions may involve building on existing apprenticeships and T-levels, local provision of training, and government-endorsed qualifications.
- 19. Attendees raised the following points around skills in discussion:
 - a. A large group of highly skilled people will be needed to plan and implement smart home hubs. Software advances could solve a lot of configuration problems, but installation skills will still be an issue
 - b. The impact of COVID-19 will be significant unemployment, including in sectors beyond construction. Is there an opportunity to support people to develop skills needed for the future?
 - c. How can government incentivise businesses to upskill for retrofitting needs? The structure of the industry in the UK - highly fragmented with a relatively high proportion of self-employment and small and micro businesses - makes business investment in higher level skills challenging. Supporting connection or integration of businesses with complementary skills could be one

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approach. The government should produce a certification system, or an accreditation scheme for specialist fitters.

- d. Economic history shows that government struggles to predict specific future skill needs. Any national programme to develop future skills should support adaptability and encourage professional development to respond as technologies and needs develop.

20. Further discussion centred around regulation.

- a. One retrofit solution for government is to update building regulations to raise performance standards. Industry is extremely responsive to regulation, though enforcement is also key.
- b. Regulation to exclude the most inefficient options from the market could also be effective. For example, UCL produced analysis on the potential impact of condensing boiler regulations on UK gas consumption.⁶
- c. On financing retrofitting options, there is much to learn from the experience of implementing the Green Deal. This charged investment to the 'property' but home owners viewed this as a liability, rather than an asset.

Socio-technical perspectives on public acceptance and technology uptake

21. Dr Martiskainen spoke of the socio-technical aspects of technology uptake:

- a. Research by the University of Sussex shows that over 80% of people in the UK are satisfied to very satisfied with their home heating and hot water system⁷, so creating demand for retrofit and low-carbon heat is key.
- b. The Government's Net zero ambition is an opportunity to better communicate the wider benefits of retrofitting, including health, energy efficiency, and reduced bills, as well as reduction in fuel poverty.
- c. Popular design features in UK housing stock, such as period features, can make retrofit harder to install. Aesthetic changes to the property from retrofitting may also be unacceptable in some areas (e.g. those with Conservation rules).
- d. Home ownership is decreasing. This trend could alter attitudes among property owners who make decisions on retrofitting. For example, social housing landlords are more forward looking than owner-occupiers
- e. To be socially acceptable, retrofitting needs to be affordable, competently delivered, and easy to achieve. People will need access to finance, help choosing the right technology, and trusted suppliers.
- f. A key solution is knowledgeable and trusted intermediaries^{8,9}, between householders, suppliers and financiers. They will have local expertise and knowledge of local building materials.

⁶ <https://www.sciencedirect.com/science/article/pii/S0301421515300641?via%3Dihub>

⁷ Sovacool, B.K., Cabeza, L.F., Pisello, A.L., Fronzetti Colladon, A., Madani Larijani, H., Dawoud, B., Martiskainen, M. The demographics and geography of decarbonizing household heat: Reviewing low-carbon heating purposes, preferences, and practices in five European countries. Paper under review.

⁸ Kivimaa, P., Martiskainen, M., Brown, D. 2018. Towards low energy homes: Intermediaries supporting the market for energy efficiency. CIED Policy Briefing 10.

<http://www.cied.ac.uk/publication/intermediaries-energy-efficiency/>

⁹ Martiskainen, M. and Kivimaa, P. 2018. Creating innovative zero carbon homes in the United Kingdom — Intermediaries and champions in building projects. Environmental Innovation and Societal Transitions, 26: 15–31. <https://www.sciencedirect.com/science/article/pii/S2210422416301277>

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22. Professor Swan presented on Great Manchester Combined Authority's (GMCA) Retrofit Accelerator Framework activity, part of the local authority's commitment to achieving net zero carbon emissions by 2038.
 - a. There is a long history of collaborative retrofit projects and a strong community of practice connected to the research base. GMCA retrofitting systems have tried to 'knit together' various aspects of the systems approach to retrofit.
 - b. The Retrofit Accelerator Framework looks at the trusted offer, available finance, driving performance, and sustained demand. One of the least understood areas is the owner-occupier as a demand driver. Market research may help explore this further.

23. Discussion highlighted that almost 70% of UK homes are owner-occupied although the proportion has dropped in recent years. Around half of these are mortgage free. This has a significant influence on occupants' attitudes to debt and ability to raise additional finance for retrofitting with long term payback on energy bills. Behavioural science research will be important to help shape appropriate policy and communications.

Discussion

24. Participants made the following points in open discussion:
 - a. Could digital twinning be applied to help test different approaches to a retrofitting programme? The concept is already well established at a building level to build a digital representation of physical infrastructure and use data from sensors to understand performance. GLA has developed a digital twin of the whole of London. Government data can help provide insight into performance under different policy conditions. Developing this approach could allow personalised advice to home-owners, but also help with planning at a district or city scale. The UK has significant capability in this area to build on. Government should consider how to overcome barriers to data sharing, including between different parts of the public sector.
 - b. There are skills challenges with increasing reliance on data and computational modelling. This approach works better when the workforce who uses it are highly trained, and there is a big challenge to provide the right information, via high quality case studies, into AI in the first place.
 - c. Early piloting of public-sector sponsored retrofitting approaches was strongly recommended. It was suggested that initial programmes should focus on small-scale, high-quality outcomes with inbuilt evaluation and learning to identify critical factors that drive efficacy and value for money, before scaling up.
 - d. Tailoring solutions to housing stock will require local knowledge and insight.
 - e. Energy passports for buildings could provide a record of real world performance from retrofit. BEIS SMETERS programme measures the performance of a building from central data collection, and can give an indication of quality of retrofit. Understanding underperformance tends to require onsite investigation.

Conclusions

25. Professor Alan Penn, MHCLG CSA and Professor John Loughhead, BEIS CSA provided some concluding remarks including areas for their departments to focus in future.

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26. Professor Penn noted that:

- a. There are no silver bullet solutions. The housing stock and industry are heterogenous which necessitates multiple different ways of doing things, to the maximum extent we can, to ensure we reach net-zero.
- b. Our national mindset on housing stock should be shift from profit and return on investment towards considering long-term asset value including the value of sustainability. In other sectors, there has been a shift towards selling services over products (such as buying mobility rather than owning a car). This could also affect the domestic housing market.
- c. Private capital will be needed to fund retrofit. There is a need to design a funding mechanism around the property owner.
- d. Of all potential decarbonisation measures, retrofit offers the opportunity for creating new forms of employment. It provides opportunities to level up across the UK, to stimulate economic recovery after COVID-19, and to support people in low skilled areas to retrain in areas which could be more widely applicable for the future economy.

27. Professor John Loughhead provided further comment:

- a. The government should not plan the systems answer to the challenge of retrofit as factors change. Instead, there is a need to develop a programme that states the initial steps along the road and can be evaluated and adapted as we learn from deployment.
- b. Behavioural drivers are important. Property owners will decide between available options on the basis of personal convenience and capital costs at the time.
- c. GMCA's experience reveals that approaches to retrofit require a strong local element.
- d. Our approach to using the existing infrastructure could depend on technology development. Direct hydrogen production through solar would offer new opportunities for using the gas infrastructure.

28. The Minister thanked participants and noted that discussion will be helpful to inform development of a new Heat and Buildings Strategy, which BEIS is planning to publish in due course. Given the scale and complexity of the problem, there cannot be single solution and Government will need to work with industry to develop a flexible and adaptive plan. The Minister would like to explore the opportunities to upscale hydrogen production and use the existing gas network infrastructure. This will be the focus for the second session on 18 June.