Decarbonising Heating and Cooling Workshop

25 March 2019

Report on the Workshop Outputs

Aims

On the 25 March 2019 EPSRC held a Decarbonising Heating and Cooling workshop to address the following aims:

- Understand where future EPSRC focussed research can best add value to the landscape
- Scope ideas for a call in the area to be funded in approximately February 2020 (date to be finalised)
- The workshop will also give attendees the opportunity to feed into EPSRC strategic development for the area

Following this workshop two further workshops on 26 March 2019 were held focussing on interdisciplinary and international themes.

Format of the workshop

Following an initial introduction by EPSRC and a talk by Prof Goran Strbac of Imperial College to raise research questions the group addressed the following:

- Barriers to progress in heating and cooling
- Solutions (focussed on EPSRC research) to the barriers
- A review of current research mapped against the barriers
- A discussion around the nature of a proposed EPSRC call
- A debate on the best way forward

Barriers

The barriers identified by the group to decarbonising heating and cooling are described below. There is definitely overlap between the categories identified but the categories do give a loose structure.

Infrastructure	• Leakage in gas grid is significant • Integration an issue-demarcation between components not clear • Co-ordination of heating/electricity systems not understood • Lack of Infrastructure and service industry for emerging technology • Locked-in infrastructure, optimises over decades to status quo • Electricity grid needs major strengthening • Insufficient electricity generation to supply all electric heat/cool (+ electric transport + move)

	• Building stock (old)
Replacement of the gas grid	• Converting gas grid + homes to low carbon gas – s/m/l – building distributed gas generating facilities, proving network integrity, converting appliances • Incumbent technologies→vested interests lead to similar solutions • How to manage decline of the gas grid. Medium/long-large implications for gas network companies and consumer on a regional/national scale • How to convert existing gas grids for safe and reliable H_2 transport • Reusing pipelines from offshore sector/infrastructure • Some ministers believe that H_2 way to solve • Cost: significant; also geographical effects • Dangerous routes to pursue - therefore not enough understood, lack of feasibility studies etc.
Infrastructure to achieve replacement of the gas grid	• Limited capacity of energy vectors – elec/heat/H_2 • Electrification of heat – can we meet peaks and deliver flexibility? • Medium-long term system-wide. Very expensive if we get it wrong • Infrastructure developers – s/m/l e.g. heat + synergies networks • Lots of tech solutions make economic sense IF they are right • Connections/organisations to lead e.g. heat networks • Deep energy retrofits offers a way of reducing demand for heating/cooling, but there is currently no market for energy retrofits • Need to influence individual decision makers s/m/l • Competition between renewables • Infrastructure of the built environment – huge amounts can be done if retrofit carried out correctly • M→L systems effect. Take up is exponential • Needs strategic decisions • Big investment cost that gets recovered gradually • Backlog of buildings being built with old technologies • Big gap compared to other countries • Decommissioning existing infrastructure
Lack of data in real performance at scale	• Needs expensive large scale trials – esp for H_2 - £bn's • Absence of heat networks currently – med to long term to change this, high cost to step change to different delivery but essential for local/regional heat cool balance • No district heating and cooling networks • Engineering – we don't understand full cost of electrification costs

Complexity /Uncertainty	• Seasonal variation/peak demand • Focus on domestic • Diverse Market • Urban Heat Island –consumer + Customer Relationship Management planning driven • Size of problem – reducing demand • 'no silver bullet' / local solutions under national framework requires resource to understand the best choices for that place …how to address? • Lack of knowledge of opportunities • Uncertainty in cost and performance of different heat decarbonisation pathways • Uncertainty about long term (& medium term) costs – decisions without information • Complexity – too many technologies, all want to be used. Understanding such complexity is a barrier • Hydrogen – appliance change, safety issues, production cost, storage. • Confusion in market regarding 'best' solution undermines confidence e.g. in DH • What if Hydrogen doesn't deliver
Costs	• High cost of the low carbon heat options • Technologies too expensive for real life use: Particularly transmission & storage in limited spaces • Impact on fuel poverty – solutions, only well off can afford • Higher capex of most lower carbon options • Gas grid is too good. Gas is too cheap • Techno Economics: – sizing; capex; external system factors • Gas and elec heat pumps need to be lower cost, higher efficiency • Gas powered heating/ utility systems are too expensive • Gas too cheap • Existing technology too cheap – people know about it, who to call when it is gone. • Many technologies not available at scale • Mature conservative Industry driven by lowest cost • Low margins difficult to innovate • Current system is cost optimised. Any future change requires major capex • Cost of change, repurpose existing technology
Policy + Regulation	• Bioenergy – policy failure • "Heat" is not regulated (yet) • No benefit to builder/landlord to be more energy efficient • Cost –Incentivising the right people — challenge of landlords

	• Traditionally, heating and cooling are regarded as "low tech" areas until recently. Investment policy research doesn't keep with needs • Most new DH reliant on gas CHP, not consistent with CCC recommendations • Systemisation e.g. heat networks rolled out • LA Officer, Finance, elected members – lack of understanding from key decision makers
Human Factor / Consumer	• Customers interaction with smart systems • Low public trust in HMG utilities etc • BRAND – Heat Pump! Not attractive. • Potential lack of convenience • District heating not in your control – need resilience • Massive retrofit will be required → how to get public on board 10K incentive? • Lack of flexibility and performance of current solutions. Built in flexibility –heat networks DO offer flexibility • Understanding barriers/enablers • Consumer expectations and 'Adaptive 'expectations • Consumers want heating systems that deliver heat in the same way that their gas boiler does • Low awareness of non-gas powered heating technologies • Technologies too advanced themselves are a barrier as people are unable to follow – even to minor repairing • Rural/urban solutions need to develop solution that work for rural areas with low density, fuel poor homes – biomass • Most of the solutions tend to be supply side driven. What about addressing user engagement • Consumer concerns/resistance to signing up to District Heating • District Heating =long term investment perceived as risky owing to multiple uncertainties • High cost of low carbon heating systems – short-medium – implies big govt/tax payer costs – subsidies to bring costs down widespread – expensive • Public attitudes to thermal comfort. Lack of evidence and engagement with low C options. Medium (+short to) Needs large scale trials and engagement programmes – expensive • Benefits of providing local flexibility in terms of heating/cooling are not clear for customers
Whole Energy Systems / Managing Multi scale vectors	• Managing multi vectors at scale – car charging, elec heating, renew electricity • What can be done at an individual scale is different to a national model – don't have understanding across scales • Transport is key

	• Short term therefore seeing this more frequently, car charging patterns, usage etc • Lack of research done on whole energy systems relating to heating and cooling • Energy Vectors – Integrating H_2 across the energy system, including for heating and cooling • Importance and value of whole system approach to energy system decarbonisation not fully understood • How to integrate the best heat pump/Gas/storage technologies with controls that do Demand Side Mnaagement & keep consumer happy? • Integration between heating and electric networks • Future strategy driven by "known" technical solutions. Stifle innovation • Not just about CO_2 – other emissions need to be zero • Trying to decarbonise transport at the same time
Storage	• Technologies are geographically/geological dependent, making large scale production difficult • Wide seasonal(and location) for heating and cooling • Strong heat for a long time in a compact package is a) difficult and b) costly • Dislocation of thermal sources and demands for energy services • District heating temp of operation – lower T means more recovery, but in building delivery options possible issues – legionella etc.. • Storage crucial however current framework(s) doesn't reward heat storage
Efficiency	• Low Coefficient of Performance of Heat Pumps due to weather in UK • Need retrofitting solution - Building retrofit difficult! • Challenges unique to the UK : – old leaky stock • retrofitting listed buildings • demolish and rebuild? standards? • Gap between Engineering Potential and Building Industry Attainment • Building stock – poorly insulated and lacks space for stores e.g. HP • Role and value of energy efficiency and heat recovery not understood • Gas & elec heat pumps needed for higher temperatures to supply existing houses • Energy efficiency crucial – building fabric –need the buy-in of developers and construction industry

Non-Domestic	• High temp heat to industry from heat pumps (>150^{0}C) not possible at present • Business models for waste heat recovery →people want to sell heat but how? • How to get a market for waste heat • How to decarbonise heat in industrial sector? • Poor understanding of non-domestic, lack of statistics, high diversity • Payback period : Domestic < 7yrs, Industry < 2yrs
Skills	• Skills gap in terms of installing, commissioning, & controlling heating/cooling systems • Heat pumps collectively under perform • 'Advanced' heating/cooling storage is too complex for installers, specifiers • Lack of skills in industry to deliver non-traditional Heating Ventilation and Air Conditioning approaches • (e.g. early Ground Source Heat Pump failures) –twinned with lack of design and installation best practice/standards • Lack of people (capacity)

Solutions

Solutions were generated by the group and have these have now been mapped to the Barriers. A further category of Technologies has been added. Those with red ovals indicate preferred options by the group –the more ovals indicate the stronger the preference.

Infrastructure	• Solutions for off grid communities – Electricity supply often inadequate? • Building energy performance gap →Building regs part review in summer 2019 • Investigate alternative retrofit options role v value • Landlords and leaseholders → industry & domestic ++> incentivise? Unlock infrastructure • Challenge role focussed policies: - Installers - Developers - Landlords • Heat from sewage & mines & waste & industry → reuse existing repurpose infrastructure –domestic hot water heat recovery???  • Biomass – CHP close to consumer →integration with waste • Integrate heating/cooling and waste utilisation/management

	• Look to international (and domestic!) examples to figure out how to retrofit huge cities in old/inefficient housing stock

Replacement of the gas grid	• Renewable H_2
	• Managing/preventing H_2 leakage
	• Large scale trials of 100% hydrogen heating systems gas networking re-purposing
	- Addresses lack of data; consumer engagement and cost barriers
	- Short term
	- Costs will be very high £BN's
	- Broad approach to evaluation; technical; economic policy
	• Sort Gas Grid :-
	  • Assess existing gas grid →green gas potential (this and other solutions)
	  • Assess mini gas grid potential compare with other options to actually develop strategy
	- Increase the resilience for increased capacity
	- s-m term; arguably iterative
	- Structure & segmentation of national grid
	- Restriction: energy density of H_2 approx 1/3

Infrastructure to achieve replacement of the gas grid	• Short → long term Low value commodity therefore lack of investment and payback challenging Lower cost/storage transport options – longer term govt need to make it a requirement and encourage it • Integration of buildings, e.g. where tower blocks generate a large amount of heat • Be realistic! Need to propose practical & feasible examples of linking research & demonstration at different scales: Dwelling, District, University Campus, Industrial site etc.. • Define Infrastructure solutions: Different decarbonisation options have different infrastructure and regulatory challenges Evaluate these scenarios & redirect investment need/rationale to long term vision e.g. how to practically build the future • Unconvinced that we need to decommission yet • Trial Decommissioning of the gas grid (in a specific region?) • Maximise resilience of national gas grid to allow upgrade to semi H_2 and pure H_2 operation, address materials, safety metering
Lack of data in real performance at scale	• Exemplars, demonstrations case studies Good promotion – confidence

	• Barriers – confidence/cost demarcation → demonstrations→ benefits
	  ○ More demo projects to appreciate how real people do things (not how we think they do)
	• Linkage between EPSRC/IUK/BEIS to benefit from trials on decarbonisation heating/cooling→real data at scale
	  • s/m/l term
	  • Don't need to wait to start
	  • BEIS Innovation challenge currently will provide a lot of data
	• Need Time resolved data – need it at tight timescales→seconds/mins to see bottleneck in network
	• Prove local energy system integration under UK market conditions and UK mindset – local schemes power/demand management etc.. →how do you use it in reality?
	  →people – North & South difference in hardware mindset
	• Research & demonstration projects @ university campuses Promote 'disruptive side' pilots! E.g. deep geothermal heating and cooling
	• Research demonstrators (small) –digital twin
	• Convert some offshore Oil Marine and Gas installations to research and development projects e.g. for green H_2, integration with intermittent kind
	• Measuring and considering how to close the performance gap between what low-carbon heat technologies are capable of and how they actually perform in practice.

Complexity /Uncertainty	• Cost – introduce non-cost factors into heat decarbonisation assessments – health – house space –service quality- other • Carry out research and provide evidence to policy makers and industry regarding the role and value of different technologies and systems • Mapping innovation systems in heat technologies • Cost – long term – quantify techno – economic uncertainties of techs across the housing stock →insights into models • Understand potential regrets associated with alternative heat decarbonisation pathways • New paradigms & approach – short term – cheap real options and other analysis to inform strategic choices • Even out heats & trough in demand Thermal } Storage -electric} -Bio resources

	• Biomass as storage & flexible energy vector to manage Seasonal variation
Costs	• Addressing cost barriers to change (& Technical) • Cost reduction related solutions – development of low cost manufacturing, installation and operation technologies for low carbon heating/cooling related materials, components and devices • Carry out Innovation and demonstration projects to understand the cost of technical performance of different pathways • Economies of scale in social housing • Short payback period –cheaper technical solution to provide heat and cooling
Policy + Regulation	• Addressing the policy gaps b/n barriers and solutions • Better balance between top down/Locally researched solutions • Capacity/capability – adaptive approaches to decision making/planning in relation to energy infrastructure • Confidence – regulation to address lack of confidence and perception of risk in relation to HN development – BEIS looking at this • Develop policy that will align regulatory market framework with low carbon agenda • Regulation/tariffs/incentives/higher tax → consistency of political leadership • Policy appraisal for DH/HP – short term – cheap. Learn from other countries - we are NOT first movers
Human Factor / Consumer	• Involve public in development of preferred future technologies – name them better, e.g. not heat pumps but "comfort machines" • Deeper understanding of user preferences & expectations of heating systems and controls and comfort. Short & medium Term • Heat as a service: automated control - Customer comfort - Benefits for wider energy system
Whole Energy Systems / Managing Multi scale vectors	• Integrated industrial heating and cooling & dehumidification solutions • Transport and storage of chemical potential not heat -- improve network energy efficiency • Fully integrated electric heat pump, store, DSM control system to solve barrier of grid limitations/affordability/efficiency • Short term –Economy 7 • Medium term – DSM Tariffs • Long term– H_2 /Elec co-ordination

	• Solution to all barriers
	  • Understanding how effective multi-energy vectors/sources/technologies for achieving the needs from whole system point of view (in short/medium/long terms)
	  • These would provide guidance for focused technology developments in s/m/l term
	• Cost related solutions:
	  • Whole system analysis can give guidance to cost reduction routes
	  • Focused technology development based on whole system approach would reduce costs
	• Distributed zero emissions and integrated CHP/Trigeneration and thermal network with storage – medium/long term
	• Whole system modelling to understand trade-offs. Short to medium relatively cheap
	• Integrate heating and cooling where possible
	• Understand the impact of electrifying heat on the grid
	• Integration of technologies → need a heat network. Strategic investment e.g. Stoke council
	• Reduce 'Vector' demand by increased energy efficiency and local heat/power generation amongst end users
	• Energy retrofits that reduce demand for heating and cooling
	• Homes/communities with high levels of efficiency and heat storage – address barriers due to high peaks; consumer acceptance; costs
	• Short – medium needs to be socio-technical demonstration including evaluation. Combination of known/new techs
	• Analysis of heat loads to assess the flexibility for demand management
	• Integration and intelligent control of systems over time & scale to provide flexibility
	• Use research re. demonstration facilities
	  • UKGEOS (NERC) (UKGEOS currently not multi vector)
	  • INTEGREL (EPSRC CESI)
	• Demonstrate multi vector reality
	  • Many possible energy vectors
	  • Existing and future demand patterns
	  • Real users
	• Combine to see what multi-vector potential is at different scales and how to implement
	Too many technical options
	• Whole system models
	• Roadmap

	• Working with industry • Reward/finance projects that embrace complexity and work across multiple sectors • Modelling studies, possibly using heat world data • Identify 'no regret' innovations robust against broadest range of future energy scenarios • Hybrid gas HP/Elec HP for optimised/flexible energy vector use will solve the barrier of flexibility in mixed energy grid – longer to medium term • Whole system value of different technologies
Storage	• Thermochemical heat storage and /or transmission is a solution to poor heat/elec infrastructure short → long term • What is current storage capacity in the UK for thermal vectors? • Hydrogen compression lighter factories and carriers • Inter-seasonal heat storage – wide seasonal variation • Utilisation of solar thermal energy and seasonal storage • Understanding the system level requirements for optimal generating, transporting, transmitting, storing and using heat/cold in short, medium & long term(defining the envelopes) • Effective energy storage to address mismatch between generation and demand – for renewables etc. • Thermochemical heat storage • Quantify potential benefits of storage → to operators → to the system and to facilitate policy change (reward storage & flex) • Techno-economic appraisal of the potential roles of storage techs – on which ones should we focus? • Advanced (night) storage heaters (including integration and control systems). Work on electric storage heaters would also be valuable, as they could provide valuable system balancing if their quality of heat service could be improved. • Need to improve on basic hot water storage, from performance and cost perspectives.
Efficiency	• Demand reduction – building regs changes and retrofit to reduce use • Design policy for able to pay household EE retrofit • Efficiency – develop novel old building retrofit options • Efficiency – analyse & find solutions to plug the gap between actual and potential building performance • Efficiency enhancement – short term: reducing conversion, transfer, chains
Non-Domestic	• Heat recovery – reuse, integration. Industrial heat recovery → 2nd application • Increase temperature of low grade heat for use in industry

	• High temp heat pump to replace boiler for industry • Thermochemical heat transformers and stores for industry • Novel heat technologies for industry (e.g. high-temperature heat pumps).
Skills	• Capacity /capability – targeted skills/knowledge development
Technologies	• Short term - PCU based thermal storage technologies • Medium Term – Thermochemical storage technologies • Long Term – Hydrogen/ammonia technologies • Cold chain technologies – producing, storing, managing and using cold both stationary and mobile • Novel waste heat to power technologies, ORC etc • Waste heat powered cooling technology • Waste heat recovery For heating/cooling • Cost effective technology for heating/cooling in transportation sector • Potential benefits of micro – CHP, fuel cells or other technology • Solution needs all techno options. All need investment for efficiency and cost • High COP(>2)low cost heat pump using chemisorption cycle. Medium term (Gas), long term (H_2). Cost target approx. £3K domestic • New refrigerants & cycles for H.T. (up to 200^0 C) industrial heat pumps • Smart Integrated renewables and secondary heat - Seasonal thermal energy storage → balance supply & demand - Integrate with wider systems • Balance heating and cooling demand plus long term storage → cost→ infrastructure utilisation • Ambient loop → supply @ 30^o multiple facilities. Remove geothermal generation • Localised tech (non-specific)→ heat pump, air source, pre-heat boiler • Smart Hybrid Hybrid domestic systems (heating/cooling – maybe electric too)→best solution for different building stock→skills development for installation and maintenance • Smart systems – metering & apps → Incentives • Ultra low emission biomass heating, compact, clean, convenient → Integrate with electric gen & thermal storage → skills • Integration – multi-disciplinary, industry, demonstrations • Localised storage →Buried sinks→new materials • Solar Thermal. PVT → large buried thermal collector.

	• Reduce U.h.i. • Re-distribute heat • <u>Industry Decarbonisation & CCS Opportunities</u> - Integration and utilisation of heat - Co2 pipelines for large emitter • Adoption of CHP/Trigeneration + thermal network →close to demand • Combined heating and cooling. Engineering – potential for heating and cooling from the same system – Hybrid • Heating and cooling of transportation sector • Heat transport at low cost – thermochemical? PCM? • Understand why heat pumps perform poorly and improve efficiency • Low temp district heating networks. Better use of lower grade heat and waste heat recovery → needs network and low T appliances • Deep geothermal for heat. Cheaper drilling • Improve knowledge on less proven options – Hydrogen – demonstrate & improve evidence on cost/acceptance • Cheap production of Hydrogen – electrolysis + chemical/ccus • Improving performance and lowering costs of heat pumps. Hybrid heat pumps (include novel technology developments, sizing for different houses, and integration and control systems). • District heat.

Current Research

The group then mapped current research against the barriers. In addition to the barrier categories identified – 'Innovation' and 'Technologies not demonstrated at scale' categories were also used.

Infrastructure	• Energy Networks Hub • UKCRIC Buried Infrastructure • H21 Project - Global, strategic (large scale) Hydrogen appliances (Small Scale appliances) HY - NET (National) - Gap in medium scale • Japan is pushing forward in the H2 faster than others. Can learn from them - can't compete with home energy systems, transport, fuel cells (China too) • Netherlands alternate gas infrastructure ECN. Not going to keep pursuing @ same rate, therefore UK can pick up and continue • BEIS EINAS • EPSRC - Zero Hydrogen cycle emmission CHP (TR) • EPSRC- ABC • Industry - Segragated packed tool Themal Storage (TR) • CESI - Energy system integration modelling (TR)

Replacement of Gas Grid	• BEIS HY4HEAT • Domestic H2 appliances - recent BEIS appraisal • EPSRC - Seasonal storage of solar thermal energy (TR) • CESI • Integration of Hydrogen, electrical networks (TR) • LOT-NET 5th gen D.H. • Thermo chemical netwrosk (H - DISNET-EU)(TR) • Industrial Decarbonisation ISCF • BEIS Hy4 Heat • Ofgem H2 in networks
Lack of data on real performance at scale	• Non-open data • CIBSE/BRE : Building performance gap policy and verification • Learning from International experience of low carbon heat transitions - UKERC 3 - unconvinced that more needs to be done • IEA Annex 52 Heat Pump - UK participants but still quality data shortage • Leeds Citygate • H2 Grid …KEELE UNI --> Northern gas networks
Uncertainty	*No projects identified focussing on Uncertainty*
Costs	• BEIS - Thermal Innovation Challenge: Retrofitting domestic energy retrofit demonstrators for groups of homes ---> Newcastle did the same 15 years ago, EPS needs to extract learning from this • Cost studies: ESC, Natinal Infrastructure Commission, CCC (Committee of climate change) • UKERC • EPSRC Next Generation of Thermal storage technologies • EPSRC - Supergen challenge project - domestic storage heaters/coolers
Policy & Regulation	• BEIS & OFGEM plan (+ScotGOV) to regulate heat (networks) • Politics of heat transition: Role of Incumbents - UKERC 3 • Regulation & Governance of continuity and change in Energy networks including for heat! UKERC 4 • UKERC (T&A) IDLES •ESC
Consumers	• BEIS pilot projects to assess Energy Efficiency approaches across different regions & tenures • Demonstrators on incentivising efficent behaviours- private orgs - look at Network Awards nominations for egs • Energy systems catapult : - living labs -heat as a service -consumer attitides to heat choices • BEIS smart meter & technology integration: --smart controls -- load/demand shifting • Public attitudes to heat pathways - UKERC 4

Whole Systems	• IUK smart local energy networks • ETI/Catapult whole systems modelling (esme) CESI • Whole systems heat pathways for the UK - UKERC4 • Multi Vector local energy systems modelling - UKERC 3+4 • Flexibility of local energy systems for heat - UKERC 3+4 • Thermal energy challenge, thema pump project (ZY) • IDLES • CREDS - Energy systems catapult
Efficiency	• BEIS - Thermal Efficiency Innovation Fund - Insulation - Air source heat recovery • MHCLG - Building regs review (Part L) will look at energy eff/performance gap (summer 2019) • Green building council - 'zero carbon buildings' (summer 2019) • Integral development - open for collaboration but by existence, indicates a need • Local and smart energy systems: Energy Rev • OFGEM low carbon network fund: mainly electricity but minor amount on heat • BEIS/Warwick - Low cost, medium efficiency gas heat pump • CREDS • EPSRC- ABC • UKCRIC - PLEXUS pump priming heat from buried infrastructure • +LEEDS Fellowship (INSTEP) • Cmbridge UNI - City Scale Geothermal • NERI - Geoenergy observatories • DEPP Geothermal Durham, Newcastle etc.
Non Domestic	• BEIS low carbon heat for glass industry • 3D Stock model(UCL) - Industry low grade heat recovery and use (TR) • Data centre cooling (LEEDS) • VLSTER - H.T. pump • Warwick/TNO Industrial sorption heat transformed (PILOT Study)
Skills	• EU - Real skills refrigerants • Infrastructure: ABC Swansea • Gas Grid - Supergen Bioenergy Hub • LOT-NET: Low temperature heat distribution • Flexibility of local energy systems for heat - UKERC 3+4 • Gap of knowledge - NIC?

Technologies not proven at scale	• Thermal driven heat pumps -->not enough • BEIS - Energy Entrepreneur Fund • Cornwall - United downs project (EU & Cloud funding) Pilot with a view to become commercial - Geothermal • BEIS + Scottish Government looking at what can be learn't from international appraoches to regulation, consumer protection • Search for H2020 grants • Smart Cities (EU Commission) • Zero +(Zero energy settlements) - has heat in it. Settlements in York and other parts of Europe (5-6 million) • Netherlands - Greenhouses very far ahead • LSBU - Bunhill/Islington - Luster (T & L) • BEIS/CT Prisma • BEIS - Droplet programme
Innovation Process	• Bristol already researching international lessons for heat networks • Consumer ESC - heat as a service • UK-GEOS sites/demonstrators, will run for 15-20 yrs (NERC) - end target EPSRC targetting: Thermal Energy Research Accelerator - new technologies, Smart local energy systems - IUK Demonstrators - Hybrid trial, Wales + Cadent • UKERC • BEIS • EINAS

Discussion

The group had a wide ranging discussion concerning the scope and remit of a future EPSRC call. Notes of this discussion are below.

- Useful in the call if one wasn't too prescriptive but spelt out that some will be system modelling and multi-vector approaches, whilst others will be more cost-effective machines of one sort or another for conversion etc. This is perhaps a good way of grouping them to not exclude things
- Link short, medium and long-term. Looking at UK export economy etc. Scenarios of other countries. UK is strong in manufacturing technologies, we can all benefit from the research here for cost-effective reductions e.g. materials, insulation and operations
- Where might technologies be used, what are the longer term prospects for them, and costings. Part of any project as opposed to a standalone point. Link projects that have fairly detailed technology with higher level modelling – mechanism to do this. Funded projects could be a mini network
- Some of the barriers could be overcome with a bigger network that engages with industry. Innovation with Industry, International, Policy Advice?
- Required component to look at techno-economic appraisal of future options. What would be the additional and what are the unique aspects related to heat. Cost curves

- User experience is vital to deploy decarbonising heating and cooling strategies – preferences, expectations
- IRL: (integration readiness level) could be 1-2, even at high TRL levels. Perhaps need to mention this in the call
- How do we adapt models to just heating and cooling, and the impact of looking at different energy solutions in isolation from others
- Supergen for heating and cooling though already have 5 interdisciplinary centres that cover heat; a Supergen would arguably add little as it is already a crowded field. Any other systems studies need to be linked to new innovation and trials
- Address the amount one can reduce demand for heat – energy efficiency and human factors, amount of heat that can be produced locally and stored, and how much heat the existing energy vectors have to supply to make up the difference between local supplies and necessity (shortfall in demand). Any call that would inform the system level aspects should cover these 3 sectors. Separate projects that would address this but all covered – suite of projects
- Pull it back to the Clean Growth Strategy and the policy challenge that decarbonising heat represents, as there is no pain free way forward, there's a whole set of interdependent infrastructures, etc, therefore politicians keep pushing it into one side. Consortium need to discuss it in a rich manner, taking full account of what else has been covered, as we are not making the progress required to meet the carbon aspirations in the area
- Don't have a broad call with the option of 5-6 different themes; challenge to narrow down what really needs to be addressed
- Want a portfolio approach to the call to ensure that the top ranking proposals are not all in the same area, especially as one single thing has not been identified. Fund enough across multiple areas to address all needs
- Call suggestions:
    - Stakeholder Industry Involvement
    - Impact Plan → demonstrators → scale up
    - Link with Energy system catapult??
- Encouraging industry/academic relationship
    - Insist on an industry partner for projects? Or incentivise industry partner
    - Link whatever EPSRC are doing to (IUK)+ BEIS
- For the EPSRC call, I agree with others at the workshop that I would prefer several funding strands so all of the funding doesn't end up in one area, particularly if that area is heat storage. Given the broad range of topics, one approach would be to set up Supergen+ network with a number of ~£100k grants on specific issues and then a number of larger consortium grants.

Debate

A brief debate followed where 5 solutions were each championed by 2 members of the group. The 5 solutions put forward were:

- Seasonal thermal energy storage. Scale to make the difference, e.g. in Denmark cheapest energy storage around. Can integrate both heating and cooling in this. Use the cold in winter for summer and vice versa. Consider both heating and cooling. Problem lies because of the fluctuation between hot and cold regulation.
- Heating and cooling network. £8M is not a lot of money; if a small proportion was used to form a network can use to leverage for more money. Have not got a central voice with government which is lacking that the network could provide. Need to work with industry more. A chance to also have ECRs. Based on previous networks, most work for themselves. Having a voice that pitches for everyone would be extremely useful.
- Role and value of emerging technologies. How will they support the transition to a low carbon system, what is the business case for them. Provide cost targets for new technologies. Understand what the actual proposition of this is. Moving into a digitalised world where we need to understand the importance of this. UK will be facing this 10-15 years before mainland US, therefore have the potential to become a world leader in this. If we look at 1-2 technologies could be in trouble in the future as they may not be viable at that stage. Need to consider the short, medium and long term of these.
- Gas grid innovation. Over the next 20 or so years, the bulk of heat will come from the national gas grid for the majority of our needs. This will have to decarbonise which will impose system changes – at a transition point where power generation systems were at years ago. Many research items in the EPS sphere to address. Can produce low carbon gas but can do it in a better way if we want to understand the targets and investigate it from a pathways perspective. Look at underpinning technologies and the cost of bringing them down – the strategy. Huge amount of technology that needs to be evaluated at lower TRLs.
- Energy performance gap. Can directly address the barrier about having a lack of real data at scale – what is the expected performance versus that in reality. Develop feedback loops that have a real reduction in systems and can help to achieve the energy trilemma in reality. Need to get carbon reductions needs to be real. If we continue to model systems that give us theoretical reductions won't get anywhere. We hang assumptions on modelling that doesn't happen in the real world; don't empower the engineers who are good at the R&D side of this to solve the model versus performance gap.

In the voting - Seasonal Storage came out on top but closely followed by Heating and Cooling Network.

Conclusion

The area of Heating and Cooling is currently generating a lot of media and public interest. The call for participants of this workshop generated over 100 applications for just 10 places so it is clear the interest in this area from the research community.

The workshop has helped to demonstrate that although there are research challenges that spread across the remit of UKRI there are certainly significant challenges within the EPSRC space to warrant a call in the area of decarbonising heating and cooling.

Thanks again to all those who contributed to the workshop and we look forward to working with you again.

Gerard Davies

17/05/2019