Response to call for evidence on smart flexible energy systems

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Chapter 4: a system for the consumer

Before answering these questions, it is worth emphasising the uncertainty attaching to (a) definitions of the term 'smart' in relation to appliances and their control and (b) the actual performance of smart/automated products and services, as opposed to their estimated potential.

The consultation document identifies smart appliances as those that can support demand-side flexibility because they can be set up to respond to signals such as price information, or to direct (remote) control signals. This covers a wide range of possibilities, from the freezer enabled for fast frequency response or the smart-enabled washing machine that can be programmed to switch off at times of high demand to the highly-instrumented 'smart home'. In the latter, potential 'lifestyle benefits' are likely to be the main attraction, but network/demand response benefits are still uncertain while overall demand reduction will be highly unlikely, given the level of additional consumption associated with additional services and standby demand from the sensors and control system. As the consultation document acknowledges, consumers will need clear information on smart appliances and how to use them; this also applies more widely to the policy and research communities. At present, the 'smart appliance' debate is often muddied by associating benefits from *particular* applications of ICT in energy systems with anything that has the term 'smart' attached. It is important to be specific about just what technology configurations, activities, service expectations and (tested) costs and benefits are associated with a particular smart appliance or service.

The second area of uncertainty, relating to performance, comes through clearly in the reference cited in the consultation document (the 2015 Frontier Economics study for DECC). More generally, there is a striking difference between the thousands of research papers that estimate potential benefits from smart appliances/systems on the basis of simulations or trials in carefully-controlled lab conditions and the handful that report on performance and acceptability in real-life conditions. A default position of skepticism when viewing the claims made for smart appliances is therefore called for: for each case, questions need to be asked such as how they operate in real-life conditions, who is involved in making them work reliably and what knowledge and skills are called for, how financial and other costs and benefits are distributed, what the range of possible outcomes is and whether any are unacceptable, which conditions are most conducive to good outcomes and which potential side-effects need monitoring and guarding against.

28. Do you agree with the 4 principles for smart appliances set out above (interoperability, data privacy, grid security, energy consumption)?

Interoperability

For products to be truly interoperable, energy management systems require data to be shared between different technologies. Yet there is little interoperability as yet between smart home devices, with one recent study finding only 12% of smart home technologies compatible with other devices[1]. The smart appliance market is changing rapidly with multiple home network protocols (ZigBee, Z-Wave, Wi-Fi) in competition. This is confusing to consumers and likely to slow down adoption of smart home technology, due to unwillingness to be tied to a single suite or products or fear that their hardware may become inoperable if the related software is pulled from the market.[2] Interoperability may well require regulated open standards, although this could reduce incentives to firms to innovate and enter the market, particularly if smart appliances are bundled with services. For example, a battery sold alongside a service may be sold to a household at a reduced price in exchange for a commitment to use that company's service.

It is worth noting here that several 'smart' applications require very little in the way of interoperability and that these may well have the most to offer both networks and customers: for example, smart charging of electric vehicles with a combination of direct load control and a smart tariff; fast frequency response for electric water heaters and for space heating or cooling equipment; localized use of batteries and thermal stores to utilize locally-generated electricity. [3]

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[1] Ford, R., Karlin, B., Sanguinetti, A., Nersesyan, A., & Pritoni, M. (2016). Assessing Players, Products, and Perceptions of Home Energy Management. San Francisco, CA: Pacific Gas and Electric

[2] for example, Google and the Revolv home automation hub, https://arlogilbert.com/the-time-that-tony-fadell-sold-me-a-container-of-hummus-cb0941c762c1#.l3bzw2l6o

[3] for example, Boait, P.J.,Snape, J.R., Darby, S.J., Hamilton, J. and Morris, R.J.R. (2017) Making Legacy Thermal Storage Heating fit for the Smart Grid. *Energy and Buildings* 138, 630-640

Data privacy

In an increasingly interconnected world, more and more data is being collected by smart appliances and sophisticated energy management systems require data to be shared between different technologies. However, companies may not be willing to make this available, due to commercial incentives to protect their data assets. It is also not clear who owns the data, and whether it belongs to the customer or the manufacturer. The evidence also suggests that privacy is one of householders' key concerns regarding smart technologies[4]. Given recent hacking incidents, security is likely to become a major source of concern also.

Regulation and legislation to protect consumers in an increasingly data-driven world are lacking, and very few people, consumers or otherwise, have the skills or knowledge required to develop robust arrangements for data privacy. There is a need to better understand how customers both perceive and engage with smart home technology with regard to data privacy issues. In the meantime, a cautious approach is called for. For example, the current arrangement by which customers have to opt into sharing their smart meter data on a half-hourly basis and can opt out of the default sharing on a daily basis is worth maintaining. We entirely agree that 'consumers must be in control of any data exchanged with third parties arising from the appliances with clear consent procedures that will ensure they are able to make informed decisions regarding data sharing.'

Grid security

Smart appliances may or may not be more energy-efficient than the appliances they replace, and they may represent net additions to the stock of appliances. There is therefore a risk of increased overall demand on the grid arising both from added energy usage of smart technologies themselves as well as increased consumption as a result of altering user-technology interactions through smart control. For example, many smart appliances enable users to remotely or autonomously control their appliances to provide additional comfort or convenience.

The additional risk of simultaneous remote activation of loads also needs guarding against, as stated in the consultation document. Given that smart appliances and could represent a risk to security of supply if they add new or undiversified loads to the grid, a cautious approach is in order: smart appliances and controls need careful assessment to identify how far they contribute to, or detract from, national

[4] Wilson, C., Hargreaves, T. and Hauxwell-Baldwin, R., 2015. Smart homes and their users: a systematic analysis and key challenges. Personal and Ubiquitous Computing, 19(2), pp.463-476.

objectives of energy security and sustainability. These assessments should provide evidence to support specification of the criteria for the regulation of smart appliances. Where a smart technology or configuration does increase consumption (ie, it decreases *end-use* efficiency), then this negative should be proven to be outweighed by benefits elsewhere (most likely to be an increase in *system* efficiency).

Energy consumption

This is a major consideration. Smart appliances are typically designed with two main aims in mind: load-shifting (with potential benefits for the grid); and an enhanced service to the customer (for example, by allowing remote control or being part of a system that offers home security services). While smart appliances allow for the shifting of demand in time, offering the prospect of network benefits and (in conjunction with dynamic tariffs) reduced bills, they do not necessarily lead to overall demand reduction: the limited evidence to date suggests that overall electricity demand will be more likely to increase than decrease following the adoption of smart controls for heating or cooling systems[5], while. This point about limited evidence is worth emphasizing: there is a startling contrast between the number of research papers estimating benefits from smart appliances and systems and the number that offer evaluations of their actual performance. Post-occupancy evaluation in buildings tells us repeatedly that technologies rarely perform to expectations.[6]

While the additional energy consumption from individual appliances arising from their ability to respond to signals may be very slight, we should not conclude that additional consumption from integrated smart homes with many sensors and associated hardware will also be negligible. The evidence to date is far from reassuring on this point – home automation systems typically involve a range of sensors on permanent standby[7,8]. Looking at the overall potential for demand

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[5] for example, Yang and Newman (2013) Learning from a learning thermostat: lessons for intelligent systems for the home. Proceedings, UbiComp '13, pp93-102; Robinson J (2016) Impact analysis results for BGE's wi-fi thermostat pilot (generic version). Report for EPRI.

[6] for a summary of the issues, see Bordass and Leaman (2005) Making feedback and post-occupancy evaluation routine 1: a portfolio of feedback techniques. Building Research and Information 33 (4), 347-352.

[7] see http://edna.iea-4e.org/tasks/task2 for recent IEA report on standby consumption implication of the Internet of Things

reduction from smart appliances, even a study estimating the 'theoretical savings that could be achieved if [connected thermostats, window covering/lighting controls, occupancy sensors etc] were adopted by the entire portion of relevant homes' finds no more than 1-5% 'technical energy savings and points to the need for field studies.[9] Furthermore, the energy consumption principle described in the call refers only to one factor within a smart appliance's overall life cycle impact. There are other ways in which smart appliances and controls can have a significant impact on the environment. [10]

The priorities should be to assess where energy efficiency/demand reduction and demand response are most needed, to consider where ICT can contribute to either and then to evaluate what a specific development contributes in real-life conditions.

In summary, given the risks outlined above it is important that smart appliances are subjected to comprehensive and proportionate assessment to identify the extent to which they contribute to, or detract from, national objectives of energy security and sustainability. These assessments should provide evidence to support specification of the criteria for smart appliance regulation.

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[8] Louis, J-N., Calo, A., Leiviskä, K. and Pongracz, E. (2016) Modelling home electricity management for sustainability: the impact of response levels, technological deployment and occupancy
Energy and Buildings 119, 218-232
[9] Urban, B., Roth, K. and Harbor, C. (2016) Energy savings from five home automation technologies: a scoping study of technical potential. Final report to the Consumer Technology Association. Fraunhofer USA Center for Sustainable Energy Systems.
[10] Louis, J-N., Calo, A., Leiviskä, K. and Pongracz, E. (2015) Environmental impacts and benefits of smart home automation: life cycle assessment of home energy management system. IFAC -PapersOnLine 48-1, pp. 880-885

29. What evidence do you have in favour of or against any of the options set out to incentivise/ensure that these principles are followed?

We favour Option B, taking the view that smart functionality should be regulated and optional. It should be optional given that householders have varying priorities and limited budgets. For example, they may wish to prioritise energy efficiency over smart functionality, an outcome that can also be beneficial to the system as a whole. (LED lighting offers a striking example of this.[11]) Regulation to remove non-smart appliances (Option C) from the market is not recommended as there is a risk that appliance costs are increased and end-use efficiency is sacrificed to smart capability.

There are risks of 'getting it wrong' that are particularly associated with smart appliances, related to security and sustainability: hence the need to smart appliances to regulation that is at least as comprehensive as the testing and labelling regime for appliance efficiency .

Trade-offs between overall demand reduction and flexibility need careful and continuing assessment as an integral part of the development of smart systems. Smart technologies should be regulated in the same way as energy efficiency, where there is a high level of scrutiny and an onus to demonstrate effective at demand reduction. Smart technologies should be subject to a similar level of scrutiny and government support should only be given to those smart appliances that are proven to be most effective *in use*. This 'in use' stipulation is crucial: smart systems work through a combination of technological innovation and human activity, machine and human intelligence. 'Technical potential' assessments are inadequate as a metric for effectiveness: there is no substitute for careful trialling in real-life conditions over an extended period – at least a year.

Regulation is also needed to ensure that appliances sold to consumers on the basis of being smart meet minimum standards in terms of performance and interoperability. If an appliance is smart (i.e. communications-enabled) then it must meet certain criteria including minimum levels of flexibility to ensure it acts in the best interest of the grid. Regulation is also necessary on the basis of consumer

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[11] Boardman, B. (2015) Low-energy lights will keep the lights on. *Carbon Management* 5 (4), pp. 361-371.

protection, as the term ‘smart’ in appliances is used frequently and with varying meanings. There is evidence that a single ‘seal of approval’ style label which is backed up by government can be effective at influencing consumer demand[12]. This approach is taken with other successful consumer labels such as the certified organic, free trade and marine stewardship council (MSC) labels. For this reason we recommend a new flexibility label combined with efforts by government and other agencies to educate people about the environmental, network and cost-saving benefits of flexibility.

30. Do you have any evidence to support actions focused on any particular category of appliance?

Battery storage systems should be required to be smart (Option C). There is a significant risk to grid security if they are not regulated. The majority of domestic battery systems currently sold in the UK go to homes with rooftop solar installed. These have an incentive to maximise self-consumption and minimise imports, whereas the grid and network operators have an incentive to reduce peak demand and promote load-shifting to minimize network stresses. Regulation and possibly an incentive scheme are needed to align these incentives and prevent risks to grid security.

From a system perspective, the primary purpose of a battery is to provide flexibility and batteries provide flexibility at the expense of some efficiency loss – the additional energy consumption to enable flexibility is not negligible. Accordingly, batteries need to provide additional benefits to outweigh the costs. If flexibility is ‘bought’ from batteries when otherwise it would have been bought from new, possibly more efficient, appliances, then arguably it is better to be prioritise appliances over batteries as a source of flexibility. If the benefits from batteries in one dimension (security) are gained at the expense of another (sustainability) then there may still be an argument for continued support along with minimum efficiency requirements in order to qualify for battery subsidies or special tariffs. This again brings us back to the need for independent assessment of the costs and benefits of smart technologies, based on empirical in-use data.

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[12] Banerjee, A. and Solomon, B.D., 2003. Eco-labeling for energy efficiency and sustainability: a meta-evaluation of US programs. *Energy Policy*, 31(2), pp. 109-123.

31. Are there any other barriers or risks to the uptake of smart appliances in addition to those already identified?

A few further comments:

(a) Evidence from attempt to develop and market the smart home concept over the past half-century indicates that fully-integrated smart homes are far from being an inevitable development: the technical, operational and legal risks are still considerable in relation to projected benefits, and even more so in relation to any realised and measured benefits. This is widely recognised. For example, a recent study found that, although the concept was appealing to almost three-quarters of those surveyed, a third thought that smart home technology makes simple tasks unnecessarily complicated[13] (a conclusion reflecting the material that can be found on many smart tech. user websites and in consumer publications). There is little in the way of a value proposition for many smart technologies and often a particular product has to resonate with customers before they warm to the idea of purchasing smart home technology. Research also suggests that customers may fear losing control of their appliances if subject to direct load control, worrying that their electricity provider may behave as “big brother”[14,15].

(b) The EU referendum result has increased uncertainty in the area of appliance standards and labelling, given that many of our standards and labels are regulated at EU level. The EU has also traditionally been willing to regulate to ensure interoperability and competition in new technology areas, notably in the antitrust case against Microsoft regarding the preloading of browser software in the Windows operating system[16].

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[13] Krishnamurti, T., Schwartz, D., Davis, A., Fischhoff, B., de Bruin, W.B., Lave, L. and Wang, J., 2012. Preparing for smart grid technologies: A behavioral decision research approach to understanding consumer expectations about smart meters. Energy Policy, 41, pp.790-797.

[14] Verbong, G.P., Beemsterboer, S. and Sengers, F., 2013. Smart grids or smart users? Involving users in developing a low carbon electricity economy. Energy Policy, 52, pp.117-125.

[15] Balta-Ozkan, N., Davidson, R., Bicket, M. and Whitmarsh, L. (2013) Social barriers to the adoption of smart homes. *Energy Policy* 63, 363-374

[16] Antitrust: Commission fines Microsoft for non-compliance with browser choice commitments, EC, 2013, http://europa.eu/rapid/press-release_IP-13-196_en.htm

(c) Smart appliances present risks to cyber security in addition to grid security, but security on smart appliances has been weak thus far, notably leading to the hijacking of 'internet of things' devices in the attack against internet infrastructure provider Dyn in October 2016[17].

(d) Household battery storage is not likely to be the most efficient storage technology from the perspective of the grid. The evidence suggests that battery technology is not yet a profitable investment for households, either[18].

32. Are there any other options that we should be considering with regards to mitigating potential risks, in particular with relation to vulnerable consumers?

The above considerations concerning risk apply to vulnerable consumers, but with added force. Vulnerable consumers, by definition, are likely to have fewer resources with which to address risks to affordability, energy service reliability and operability. They are also less likely to have access to microgeneration[19], in-home batteries and highly-efficient or smart appliances; to be taking an active interest in energy markets; or to belong to well-developed social networks to assist them in adopting and using new technologies. The considerations relating to vulnerable customers set out in the review of early learning from smart meter rollout are valid for smart systems more widely: vulnerable customers are likely to need more support and guidance in choosing and using new technologies; there will be specific design needs for some customers in order to make the technologies usable; and a need to open up opportunities to share safely in benefits from microgeneration, demand aggregation and changes in tariffing.[20] As discussed above, a prime consideration has always to be the value of any particular 'smart' development in a given situation, and how that value is to be realised.

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[17] https://www.theguardian.com/technology/2016/oct/26/ddos-attack-dyn-mirai-botnet
[18] McKenna, E., McManus, M., Cooper, S. and Thomson, M., 2013. Economic and environmental impact of lead-acid batteries in grid-connected domestic PV systems. Applied energy, 104, pp.239-249.
[19] Darby, SJ (2012) Metering: EU policy and implications for fuel poor households. *Energy Policy* 49, 98-106
[20] Darby, S.J., Liddell, C., Hills, D. and Drabble, D. (2015) Smart Metering Early Learning Project: synthesis report. For the Department of Energy and Climate Change, London