How do meters mediate? Energy meters, boundary objects and household transitions in Australia and the United Kingdom

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Abstract

This paper investigates the changing role of an integral but often overlooked technology within our energy systems: the meter. Empirical cases from the United Kingdom and Australia demonstrate the repurposing of the energy meter. No longer just an instrument of metrology, the meter is increasingly seen by utilities and governments as a key enabling technology for a raft of objectives, from tariff reform to peak load reduction. We draw on the Science and Technology Studies concept of a boundary object to explore these changes. A boundary object is conceptualised as positioned between different social worlds – such as those of householders, government, and utilities – and as having sufficient interpretive flexibility to mediate between their distinct interests. Here we use the boundary object concept to explain the ways in which the meter is being reconfigured, and in particular to analyse the role of householders in the transition to digital meters.

Introduction

In the energy sector, as elsewhere, there has been progressive digitisation of infrastructures, including electricity and to a more limited extent gas and heat. In keeping with this overall trend, metering technologies are changing from mechanical to digital measurement systems. Approximately 200 million digital meters have been installed worldwide, including over 3.9 million in the United Kingdom (UK) and 3.5 million in Australia (Accenture, 2016: 21-22; UK BIES, 2016). Traditional mechanical meters provide limited functionality; they measure overall consumption over time, and need to be read on-site manually. Digital meters are in contrast able to provide many more functions, both to the utility and customer, including: frequent remote meter reading that provides much finer-grained consumption data, allowing improved network management and detailed customer feedback on energy use, facilitating easier and quicker switching of energy supplier; and managing export and import of electricity where customers have embedded generation. Digital meters are typically combined with additional services and technologies such as in-home displays (IHDs) or phone apps – wireless technologies linked to the meter but not a core element of it. The meter has thus changed from being a simple metrology device to something that performs or enables multiple dispersed functions, across different devices. In this way the digital energy meter is playing an increasingly important role in mediating the changing relationship between utilities and their customers.

In this paper we reflect on the nature and implications of the shift to digital meters, focusing on residential energy customers (hereafter referred to as 'householders') through three empirical cases in Australia and the UK, and using the Science and Technology Studies concept of a boundary object (Fujimura, 1992; Star, 2010; Star and Griesemer, 1989). The value and relevance of the boundary object concept is in positioning the meter centre stage in our analysis, thereby reflecting recent industry and government framings of the energy meter as a key agent of change. Whilst we recognise there are multiple other possible conceptual framings we could draw on, ranging from social acceptability (Mallett, 2007; Wüstenhagen et al., 2007) to governmentality (Dean, 1999; McGuirk et al., 2014) or boundary infrastructures (Star, 2010), the boundary object concept has been selected because of its central focus on objects and their social relations (Fujimura, 1992; Star and Griesemer, 1989). By instigating programs to replace meters in people's homes, utilities and governments have made the meters a focal point of action and discussion. This reframing of the meter, and the relationships it shapes and mediates, are issues which the boundary object concept helps us to understand. In other words, through a focus on the meter itself, changing social practices and relations are usefully brought to the fore. Moreover, a boundary object approach helps us explore the multiple understandings of the energy meter, across different communities and institutions. For a boundary object is defined as a tangible thing or concept that intersects multiple social worlds, wherein a 'social world' is defined as a group of people where "… at least one [common] primary activity… is strikingly evident … [e.g.] climbing mountains, researching, collecting" (Strauss, 1978: 122). In relation to this analysis we define social worlds according to their primary activity within the energy sector, including energy utilities (retailers, distributors), householders (consumers, as well as 'prosumers'), and governments and regulators. Social worlds typically have slightly different understandings of the same boundary object - termed 'local tailoring' – which are not usually seen or shared with others, as Star (2010: 607) explains "…local tailoring [is] a form of work that is invisible to the whole group...". The flexible interpretation of boundary objects is a defining characteristic, and is also described in terms of plasticity, with a boundary object being "… both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites." (Star and Griesemer, 1989: 393).

The main aims of the paper are twofold. First, drawing on recent empirical research in Australia and the UK to use the concept of the boundary object to assess the changing relationship between energy utilities and householders; changes which have been significantly mediated by the meter. With mechanical meters the social world of the householder was not engaged with their utility via the meter, and with digital meters this has altered. Digital meters are typically viewed by other energy social worlds (utilities, government) as a key 'enabling technology', allowing for greater engagement, interaction and influence on household energy practices. Second, the boundary object concept is used to explore conflicts in our case studies in Australia and the UK about the transition to more widespread use of digital metering. The idea of a boundary object was originally conceived to explain situations in science research where collective work (i.e. co-ordinated action across several disciplines or communities) was feasible even in the absence of consensus, because of the interpretative flexibility of boundary objects. With energy metering a number of difficulties have arisen as digital meters have been deployed, and yet in most cases the implementation of digital meters has proceeded: conflict has not impeded the 'collective work' of installing new meters. The concept of a boundary object thus provides a useful theoretical lens for exploring our cases, and below we explore the different understandings of the meter within discrete energy sector social worlds.

The paper is structured as follows: first, we outline our empirical research methods; second, we review the origins of the boundary object concept and how it has been applied subsequently; third, we present the main findings from our three case studies of the implementation of digital metering; fourth, in our discussion and conclusions, we reflect on the value of the boundary object concept in exploring changes to the utility-householder relationship, and the nature of conflict in our three empirical cases.

Methods

Our research has taken the form of qualitative social science case studies in the UK and Australia, in the period 2011 to 2016. Australia and the UK were selected for analysis because during this period there was active policy development and implementation of digital meters in both countries. In October 2008 the UK Government announced an intention to mandate smart electricity and gas meters for all households, with initial consultations on the program beginning in 2009 (DECC 2009). Further, since 2012 the UK has had new policies in place to support district heating, which has also necessitated new meters (DECC, 2012a). In Australia there has similarly been considerable activity with regard to the implementation of digital meters, especially in the State of Victoria where all households had digital electricity meters installed in the period 2009-13. Thus Australia and the UK have been at the forefront of digital metering policy development internationally - alongside Italy, California and Ireland, amongst others (see Accenture, 2016; ISGAN, 2014) - and, crucially, have actually implemented digital meters, thus providing us with rich empirical material.

The first UK case study comprises the introduction of digital heat meters for tenants at the 1960s Wyndford social housing estate in Glasgow, Scotland. The estate is owned by Cube Housing Association (HA) and comprises circa 1900 flats in multi-story and maisonette blocks. In 2012 the old electric heating system was replaced by new district heating, including the installation of digital heat meters in each house. Fieldwork in 2012-2013 comprised a 10% sample survey of households' experiences before and after the new heating. The sample of 154 tenants was based proportionately on type and size of housing, from 26-storey flats (the most common), through 4, 12 and 14 storey blocks, to maisonettes and sheltered accommodation. Size of housing ranged from studio to three bedroom flats, with a preponderance of studio and one bedroom accommodation. Sixty per cent of the tenant sample were single person households; 26% 2 person, 8% 3 person, and 6% 4-5 person households. We also interviewed 50 owner-occupiers (44% single person households; 28% 2 person; 16% 3 person and 12% 4-5 person households), living in maisonettes, who had bought their house under the UK's 'Right to Buy' legislation. Participants were interviewed at home, using a 48 item structured questionnaire and also inviting general comments. Further evidence was derived from interviews with three HA officials, three managers from the energy company and a local politician, and from HA records on energy advice to households. Summary findings were fed back to householders and discussed with Cube HA, the energy supplier, and Glasgow Council officials and elected members. Full details of the study are available at http://www.heatandthecity.org.uk/__data/assets/pdf_file/0005/166919/Heat_and_the_City_-_2014_-_Wyndford_survey_final_report.pdf .

The second UK case study involves a wider overview of the major UK government-led program (2016-20) to install smart meters in all homes and many small businesses.[1] Research comprised a policy document review and analysis in early 2014 of government documents relating to the smart meter program and the standards-setting process, supplemented in 2016-7 with further research. The 2014 government document review covered all webpages and documentation related to the Smart Metering Implementation Programme published on the Department of Energy and Climate Change website in the sections of the site called 'How we work with stakeholders'; 'All publications'; 'Further information'; and 'Consultations relating to technological standards (Functional Requirements and SMETS 2). Supplementary research was conducted in 2016-7 to gather updated information on the latest progress of the program (from the DECC and BEIS (Department for Business, Energy and

[1] See Pullinger et al (2014) for further details of the review process and documents covered.

Industrial Strategy, DECC's successor department) websites), and data on public attitudes, perceptions and salient points of householder concern with the program (from prominent campaign groups and services, and a recent research survey publication (CAS, 2016)).

The third case study is of a metering program in the State of Victoria, Australia, with fieldwork undertaken during 2015 and 2016 including: twenty-five expert interviews across Australian government (state and federal), utility and metering companies, industry bodies, nongovernmental and standards organisations, plus twelve interviews in the State of Victoria specifically about its metering program with key decision makers in government, utilities and social advocacy organisations; attendance at several specialist meetings and workshops; and an extensive policy literature review of relevant Australian state and federal government documents. Topics of enquiry in interviews included the motivations for transitioning to digital meters, what learning took place as the metering program evolved, including how problems were resolved, and interviewee perceptions of the value of digital meters to other energy stakeholders. Full details of the study are available at http://www.utas.edu.au/smart-grids-messy-society.

These three case studies were selected for analysis for a number of reasons, including: their different scale, ranging from national (UK-wide) to regional (State of Victoria, Australia), and local or community (Wyndford, UK); contrasts in how the digital meters have been framed by utilities and government; and to allow for the inclusion of heat digital meters (in the Wyndford case), not just electricity. It is important, however, to note the limitations of the case study approach we use in this paper, which is best described as research of complementary cases, rather than a comparative study. In particular, with research across three cases it is not possible here to provide a full, in-depth description of each case, due to space constraints. However, what we miss in depth we hope to gain in breadth. In other words, there is a value in bringing together the evidence and data from across the three complementary cases to highlight the commonalities in the role of the digital meter as flexible intermediary in the remaking of energy utility, government and householder identities, responsiblities and expectations.

Boundary objects: social worlds, interpretative flexibility, and local tailoring

The boundary object concept originates from Science and Technology Studies, and was brought into use to describe situations where complex science research was being done across a number of locations (the field, lab, museum) by different communities – expert and lay – who did not necessarily agree on what they were doing and why, but were able nevertheless to cooperate to perform good quality research. The term 'boundary object' was first introduced by Star and Griesemer (1989) to explain the ways in which a natural history research museum effectively functioned, where a number of boundary objects were identified including "…classification systems, specimens, field notes, museums and maps of particular territories" (1989: 408), which enabled the distinct social worlds of scientists, field ecologists, university administrators, farmers and animal trappers to all work together effectively to collect, classify and analyse specimens. The natural history collection and research work of the museum functioned, according to Star and Griesemer, because these boundary objects had flexibility in how they were understood by the different social worlds that intersected with the museum. For example, the animal trappers (typically farmers and other rural manual workers) were able to translate, negotiate and find a way of interpreting the museum guidelines about how to trap specimens that fitted with their own experience-based practices and know-how.

Subsequent applications of the concept have been wide ranging, and have for the most part been about more common and widespread boundary objects (i.e. known to several highly-populated social worlds), ranging from ecosystem services (Abson et al., 2014) to GIS technology (Harvey and Chrisman, 1998) and food labels (Eden, 2009), as well as smart meters (Poderi et al., 2014) and energy models (Taylor et al., 2014). Taylor et al (2014), for example, examine the way in which the long-established MARKAL energy model can be understood as a boundary object within the energy policy process in the UK, positioned and drawn upon by intersecting policy and academic communities. Poderi et al (2014) in their research on smart meter programs in Italy find that the smart meter is understood differently depending upon the characteristics of the community in which it is implemented, and describe this geographical variability as a form of local tailoring.

Whilst the boundary object concept has rather fallen out of favour in recent decades, with other theories typically being used to understand sociotechnical relations, ranging from assemblage (McCann, 2011), to governmentality (Luque-Ayala and Marvin, 2016), social practice theory (Shove et al., 2012) and social acceptance (Wüstenhagen et al., 2007)), we suggest the idea of a boundary object is particularly useful in understanding energy meters, because of its focus on the object of the meter, as well as its attentiveness to the discrete social worlds connected to it. Further, the concept of a boundary object is distinctive in its starting assumption of a lack of consensus. Social worlds interpret and understand a boundary object differently, and yet work is still able to be done, as Star (2010: 604) explains:

"My initial framing of the concept was motivated by a desire to analyze the nature of cooperative work in the absence of consensus. From my own field work among scientists and others cooperating across disciplinary borders… it seemed to me that the consensus model was untrue. Consensus was rarely reached, and fragile when it was, but cooperation continued, often unproblematically. How might this be explained? The dynamic involved in this explanation is core to the notion of boundary objects."

This insight is highly relevant in considering our case studies of energy meters in the UK and Australia, which demonstrate a lack of consensus about the shift to digital meters, and yet at the same time there has necessarily been some degree of cooperation between social worlds in order for digital metering to have been implemented. We explore below how seeing energy meters as boundary objects helps us better understand and explain the tensions arising in the transition from mechanical to digital meters. Further, such a perspective highlights how cooperation between social worlds with regard to the 'upstream' design and planning stages of digital energy meters has not involved energy consumers or householders to the same degree as other social worlds. Moreover, the case of electricity metering also raises questions about the boundary object conceptualisation of social worlds as relatively homogeneous, for in our analysis we find householders have responded in a range of ways to new digital meters.

As noted, a key value of the boundary object concept lies in its analytical positioning of the object centre stage, i.e. using the object – be it an energy meter or science theory – to better understand the social groups and communities that develop the object and intersect with it, and how the groups are able to work together effectively. As Star and Griesemer describe "… [boundary objects] emerged through the process of the [research] work. As groups from different worlds work together, they create various sorts of boundary objects" (1989: 408). Boundary objects do not have to be a tangible thing, they may be material, discursive, or conceptual (Eden, 2009), and the use of 'boundary' is intended to denote a shared space of common reference, rather than a rigid dividing line (Star, 2010). Indeed, boundary objects, positioned as they are at the intersection of multiple social worlds, are seen to be inherently fluid objects that are not yet settled: they are something that "… people act toward (and with)… materiality derives from action.." (Star, 2010: 602). Eden emphasises too "…the active meaning-making involved…" (2009: 179) in their creation and maintenance. Thus while boundary objects may be vital in the initial period of new research or innovation, over time they become stabilized and standardized - they are in effect a short-lived phenomenon - as the multiple 'flexible' (divergent) views of the boundary object converge into a more precisely defined or 'tailored' understanding, common to all social worlds, as Star (2010: 605) explains:

"...when the movement between the two forms [flexible and tailored] either scales up or becomes standardized, then boundary objects begin to move and change into infrastructure, [and] into standards.."

Traditional mechanical energy meters, in operation for decades, have been fully standardized amongst the core social worlds of utilities and government – there are few anomalies in how they are viewed by their different social worlds, and were therefore arguably no longer a boundary object. With the shift to digital meters a raft of new technical standards have been developed and implemented, and it could be said there is likewise little interpretative flexibility or divergence in views. However, a key change with the introduction of digital energy meters is in the role of the householder social world, for digital meters are a means to constitute novel forms of energy user identities among householders by enabling new activities in the home. The boundaries of the energy meter have thus expanded from traditional metrology functions to include a host of additional features mostly aimed at the householder, such as providing detailed feedback on energy consumption from digital devices and new types of energy tariff. There is value here in clarifying and distinguishing between the degree of interpretative flexibility about the technical functionality of a boundary object (judged to be low with regard to energy meters, even new digital ones), and the degree of interpretative flexibility about the socio-technical *purposes* enabled by it, once adopted 'in the wild' i.e. its ability to serve different ends and be repurposed by particular social worlds (judged to be high).

Such issues draw our attention to a final relevant aspect of the boundary object concept, that of the power relationships between the social worlds that intersect with a boundary object, including questions such as 'Who defines the boundary object's functions, and where and when it should be implemented and used, and by whom?'. The 'active meaning making' described by Eden (2009: 179) refers principally to local tailoring taking place within discrete social worlds, but it also raises the possibility of members of one social world influencing the meanings - the interpretation - of the object by other social worlds. In the case in hand of digital energy meters, utility and government social worlds seemingly have had the power to define the object, but householders have also demonstrated power in disrupting and obstructing the intended function and purpose of the new energy meters – complex and evolving issues which our empirical cases explore.

Implementing the digital meter: three case studies from Australia and the UK

i) *Australian electricity smart metering: conflict during implementation*

In Australia digital energy meters have been implemented most fully in one state – the State of Victoria – through a state-wide mandatory implementation program, called the Advanced Metering Infrastructure Program (hereafter the 'AMI Program'). In the period 2009 to 2013 2.8 million digital meters were installed, in 93% of homes and small businesses across Victoria (VAGO, 2015). Difficulties arose during the course of the AMI Program, and it was later decided by other Australian states and the federal government that a mandatory program would not be repeated elsewhere (Department of State Growth, 2015; NSW Minister for Resources and Energy, 2014; Queensland Department of Energy and Water Supply, 2013). Tensions centred mostly around costs, as the AMI Program was initially structured in such a way that any financial risks (such as unexpected cost increases during implementation) were borne by householders rather than the utilities or government. Moreover, additional costs were ascribed via a fixed standing charge to all households from the commencement of the program (January 2010), regardless of whether or not they already had a new digital meter installed (VAGO, 2015). Further, there were a number of broader governance concerns about the AMI Program, including: the degree of public sector oversight, the exclusion of retailers[2] from decision making, as well as access to digital meter data, and data privacy issues (see Deloitte, 2011: 9; VAGO, 2015: ix), as an interviewee commented:

"It was seen to be not very well implemented and it was expensive which mandated rollouts often are - the lack of competitive pressure, the lack of a consumer focus, I think. … it was driven by the electricity networks, so [was] very strongly technically focused" [Interview, Government policy officer, April 2015].

[2] A decision was taken early on by the Victorian state government for the AMI Program to be implemented by the electricity distribution companies (the companies who run the electricity networks, of which there are five in Victoria), with oversight by the then State Department of Infrastructure.

The Victorian Government position in giving approval for the AMI Program was that new digital meters would "… improve the competitiveness and efficiency of the electricity market", and more specifically were "…required to achieve… cost-reflective pricing" (ESC, 2004: 1). Utilities similarly tended to emphasise the role of digital meters in improving the economic functioning of the electricity market, to "…modernise Victoria's power infrastructure, to reduce costs for power infrastructure over time and prepare all Victorians for a future of greater energy efficiency and more renewable energy." (Ausnet, 2016). Thus digital meters were seen as providing solutions to a number of policy problems, but with a core focus on enabling energy market reform.

From the householder perspective there was a mixed response to the AMI Program. A detailed report by the Victorian Auditor-General (VAGO) found little value (financial or otherwise) ascribed by customers to the new meters, and yet households had significantly increased bills because of the meters; an average of $760 extra per household across the period 2010-15 (VAGO 2015). A vocal anti-digital meter protest group 'Stop Smart Meters Australia' formed - with over 7000 newsletter subscribers – as well as a dedicated political party in the 2010 state election called 'People Power Victoria', campaigning solely on the mandate of stopping the AMI Program "… centred on respect for human rights, the opposition to the mandated roll-out of wireless smart meters for electricity, gas and water, and on the commitment to re-establish a healthy environment for all." (People Power Victoria, 2016). However, the People Power Victoria party gained few votes (less than 2.6%) in the 2010 election and no seats (VEC, 2016), and Stop Smart Meters Australia were described by several interviewees as a highly vocal but relatively small community; "… a noisy minority" [Interview, Nov 2016].

The application of the boundary object concept to the AMI Program highlights the different understandings of the digital meter by the distinct social worlds intersecting with it - households, utilities, and government. The Victorian Government and utilities viewed digital meters as facilitating the functioning of the energy market and enabling innovation. But for the social world of householders these purposes did not resonate well, and instead issues of privacy, cost and health were more important (VAGO, 2015). As Eden (2009: 182) notes "…sometimes boundary objects are given different meanings by producers and consumers which fail to facilitate… 'collective work'"; and the AMI Program can be positioned as such an example. But the evidence is mixed: the collective work of installing the new meters was successfully completed, covering 93% of the customer base. Yet the difficulties encountered with the AMI Program were central in dissuading the federal government (and associated energy regulatory agencies) from implementing similar mandatory digital meter programs across the rest of Australia (see Lovell, 2017). Further, questions have been raised about the extent to which the digital meters are subsequently being used by householders in the way intended by utilities and government, with, for example, evidence of underuse because low-income households cannot afford to purchase in-home displays (IHDs), which were not provided as standard to householders (VCOSS, 2016). In this case, therefore, 'collective work' was largely achieved from the perspective of the utilities' and government's intended functionality and purpose for the meters, but less so for the householder social world. There are various reasons for this, but certainly an underlying factor was householders not being involved in the planning and design for the AMI Program, which was viewed by utilities and government as first and foremost a technical infrastructure project (DPI, 2007; Moore, 2015), as an interviewee closely involved in the AMI Program commented:

"And [in Victoria] ... they experienced the same lesson that I think absolutely everybody [who does].. a mandated meter rollout…. has the same observation [..] And it was ... 'at the start we thought that this was a technical reform but what we realised now it was actually a social reform. And in treating it as a technical reform we got the social side of it wrong.' That's a common refrain that keeps coming up." [Interview, Manager in a social advocacy organisation, July 2015]

ii) *Heat metering and billing in Wyndford, Glasgow: meters as a disciplining object*

Similar struggles coalesced around digital meters following the introduction of a new district heating system for Wyndford households, where interactions between the social worlds of the Cube HA, utility and tenants were complex and nuanced. The HA commissioned SSE, a large private sector energy utility, to build and operate the heating system, which included installing two digital meters in each flat: one meter recorded 'real time' heating and hot water consumed; the other calculated the price, using a tariff which combined a standing charge for the new network with a unit price for the heat supplied. For the HA, the meters were part of newly affordable and effective heating, improving the quality of people's lives, while increasing the rental value of housing stock. The utility construed the meters as objects of shared value: for the business, digital metering would secure efficiencies from automated records, streamlined billing, and cash flow data, and would help to manage anticipated debt or non-payment by low income households; households were in turn expected to benefit from the credit metering, which would display heating charges and spread the cost across the year in order to enable budgeting, in a similar way to direct debit billing. Articles 9(1) and (3) of the EU Energy Efficiency Directive 2012 require district heating suppliers to introduce heat metering and billing for all customers, as a means to support energy efficiency and to avoid waste. Digital meters were thus also partly a compliance measure, anticipating UK regulation[3], but also a means for the utility to record and charge every household for their heating and hot water consumption without needing to access individual properties. As a commercial enterprise, SSE set the tariff for heating at a commercial rate of return, with prices structured to be competitive with domestic gas central heating in similar properties. In 2012-2013 SSE estimated that average heating and hot water costs would be between £370 and £500 depending on the size of property (one, two or three bedrooms).

Most of the Wyndford estate households have very low incomes; the majority of the estate is included in the 2% of most deprived areas in the United Kingdom. Adult unemployment is almost 50% (and 75% of our sample of tenants), and one third of owner-occupiers had gross annual incomes of less than £10,000. This

[3] http://www.legislation.gov.uk/uksi/2014/3120/pdfs/uksi_20143120_en.pdf

compares with a UK 2012 median income of £25,960. For low income households accustomed to a single mechanical electricity pre-payment meter, their interactions with the new digital meters were diverse and not necessarily positive. Very low income households had habitually used the old pre-payment meters to control spending, in a form of economic-rationality driven by necessity: when their income ran out, the electricity went off, and charges stopped. The new digital payment meter removed this precarious, and negative, form of control for two reasons (see Webb et al., 2015). First, a daily standing charge continued to accumulate on the meter, even when heating was off. Second, the effect of spreading charges across the year meant a constant payment rate was programmed into the meter, resulting in accumulation of debts during any period when households did not add credit via their key card. Households in paid work who had not worried about paying their bills under the old system regarded the new heating system as something worth paying for, and did not track their day-to-day spending via the payment meter. However, those with limited paid work and/or reliant on welfare benefits, perceived the credit meter as adding complexity, because it did not visibly link heat used with price. Hence it did not offer the direct feedback necessary to budget. The second meter, which did record daily heat use, was originally installed out of sight inside a Heat Interface Unit, revealing an implicit utility assumption that this data was not a useful source of householder feedback. Some households asked for the meter to be moved to a place where it was easily visible. Its original location, however, added to the perception among those who objected to the cost of the new heating that the meters were material symbols of the social worlds of the utility and HA, who lacked authentic concern about their welfare and whose motives were not trusted.

The meters at Wyndford can hence be usefully conceptualised as boundary objects with fluid and contested meanings, susceptible to co-optation for different purposes. There were also important differences *within* the social world of Wyndford householders – a subtle but perhaps important nuance to the boundary object concept. Although satisfaction with the new heating was high (71% of tenants and 95% of owners were satisfied), a proportion of tenants perceived themselves as lacking the control over spending which the old meter had afforded them. This group felt that the process of upgrading their heating, with its new metering and tariff structures, was imposed, rather than negotiated, resulting in objection to heat charges. Considerable intermediary work was done by Cube HA, SSE and the city council to re-interpret the metering and billing relationships and to stabilise these. For instance, Cube HA appointed an Energy Adviser to work with tenants, at least 10% of whom were experiencing significant difficulties with debt and the new heating. The Adviser acted as an intermediary between households, Cube HA and energy suppliers, responding to confusion about the relationship between the data shown on the payment meter, bills and payments. A group of residents also gathered outside SSE's offices to protest about the price of the new heating, particularly its standing charge, and a local politician wrote to all households to collect evidence about heating costs. He then held meetings with both SSE and Cube HA about restructuring the tariff. In response, SSE introduced a low heat user tariff, with a zero standing charge, and households who meet the criteria, defined by eligibility for welfare benefits, were encouraged to switch. This work around the interactions of metered heating use, tariffs and cost has sought to neutralise conflict focused on the meter as a boundary object between the social worlds of energy supplier, housing association and households.

iii) *The UK Smart Metering Implementation Programme: greater attention to households*

The UK digital or 'smart' gas and electricity metering program is one of the most ambitious worldwide in terms of technological complexity and planned comprehensive coverage. 2016 saw the official (delayed) start of large scale installations, with an aim to install 53 million smart meters in 30 million homes and small business premises by 2020. By the end of 2016 (the most recent date for which data are available), 5 million smart meters had been installed in domestic properties, and 860,000 smart and advanced meters in non-domestic sites (BEIS 2017). Via the Smart Metering Implementation Programme, UK business and government have consistently portrayed the digital meter as a key enabling technology to address the 'energy trilemma' of maintaining affordability and security of supply whilst transitioning to a low carbon energy system (e.g. DECC 2016: 5).

In the UK the government and energy utilities (directly, and via network associations) led the development of the initial smart meter standards and program specifications (Pullinger et al., 2014). However, the program design included from an early stage a strong focus on the social world of householders (see for example DECC, 2012b: 9, in which the government 'recognises the importance of effective consumer engagement and the need to put consumer benefits and protections at the programme's heart.'). This is in a manner that differs from the State of Victoria and Wyndford cases and, crucially, there is evidence that this strategy is based on learning from other digital metering programs (see for example Smart Energy GB, 2013, a report detailing the learning that took place from Australia (the State of Victoria), the USA and Canada).

As part of this closer engagement with households, the UK Programme includes various substantive measures that appear aimed at increasing the actual and perceived benefits of the new digital meters for householders. For example, after extended debate between stakeholders, it was agreed that every home would receive a dedicated, physically moveable in-home display (IHD) specifically to present a home's smart meter data to the occupants. In line with the EU Directive that in part drives the program, this presents current energy usage and cost, and historic data going back two years (Pullinger et al., 2014). More recently, in response to technology change, the possibility of providing a functionally similar alternative such as a smartphone or tablet app has started to be explored, with trials ongoing (see DECC, 2016). Digital meter installation has also been made voluntary for private home owners, a move designed to help avoid public perceptions of (mistrusted) energy suppliers 'forcing' new technology onto them. A measure of householder control over which data is shared with their utility has also been incorporated, in response to privacy concerns (for instance, householders can choose for smart meter readings to be automatically transmitted to their supplier half-hourly, daily or monthly (Energy UK, 2013)). Data can also be shared by householders with third party devices and other organisations to obtain additional services such as easier tariff comparisons and switching between suppliers, more sophisticated energy feedback and management, or any other potential service which third parties find there is a market for (DECC, 2013a: 33-34). Further, a Code of Practice was developed with the intention to increase householder 'confidence with the installation process' and 'ensure that consumers receive an appropriate standard of service and are treated fairly and transparently' including measures such as no up-front costs or sales during installation, advice during the installation visit on how to use the system to improve energy efficiency, and an evaluation of ways to meet the needs of vulnerable customers (DECC, 2013b: 27), as well as the establishment of a dedicated independent organisation ('Smart Energy GB') to oversee the process, promote awareness and manage perceptions. In a number of ways, therefore, substantial care has been taken to ensure digital meters provide functionality aimed specifically at enhancing householders' capabilities to use the energy data collected in ways they find desirable (at least, as perceived by the government and utility social worlds), and to respond to and manage the meanings householders associate with the meters.

A recent survey indicates that this approach focused on the householder social world has had a positive effect. Public awareness of the UK program appears to be high: a survey in Scotland suggests some 60-83% of households have heard of smart meters, with nearly two thirds of those interested in having one (CAS, 2016: 48-53). Overall, support for the program is also high, with only 11-15% of people against it, the remaining being either supportive (31-49%) or neutral (35-53%) (*ibid*., 2016). Doubts do remain – the highest public concerns relate to invasion of privacy and program costs being passed on via bills (*ibid*., 2016). As in the other cases above, there are groups, albeit small, vocally objecting to the program on these grounds and others, e.g. its large overall cost, unclear source of official calculated financial benefits, technical problems with early installations, and potential negative impacts on the fuel poor or on health. For example, Stop Smart Meters UK, whose Facebook page had over 4,000 likes and 4,000 follows in May 2017[4], and the petition ‘We do not consent to the roll out of smart meters in the UK’ on campaign website 38 degrees[5], had nearly 17,000 digital signatures as of May 2017, the majority arising in the preceding 8 months.

It is still unclear whether the utilities’ and government’s goals for the program for installing digital meters will be met, but the positive or at least ambivalent attitude of the UK public - as indicated by the recent CAS survey - suggests they could be achieved. Even without significant householder engagement with the meters or their functionality, acceptance of their installation by householders would in effect constitute a high degree of success for the social worlds of government and utilities, enabling the ‘collective work’ of managing energy system supply and demand more effectively with much higher resolutions of energy use data.

Discussion and Conclusions

We have demonstrated in our analysis above how the digital meter has been framed as an enabling technology by key ‘upstream’ energy sector social worlds, critical to the transition to a secure, low carbon energy system at an affordable cost, and allowing for greater engagement and interaction with the social world of householders. Whilst we recognise some of the limitations of the broad case study approach we have taken in this paper, our three case studies clearly show that the digital meter is understood differently by the social worlds of government, utilities and householders, and some of the implications of this interpretative flexibility, both positive and negative, have been demonstrated. In discussion and conclusion we return to reflect on the two key aims of the paper, namely using the boundary object concept to assess the changing relationship between utilities and householders, and in exploring conflicts about the transition to digital metering.

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[4] https://www.facebook.com/Stop-Smart-Meters-UK-370392813005017/

[5] https://you.38degrees.org.uk/petitions/we-do-not-consent-to-smart-meters

Analysing the changing relationship between utilities and householders: insights from viewing the meter as a boundary object

Meters have always been boundary spanning objects - they control, standardise and frame the identities of, and relationships between, key energy sector social worlds of government, utilities and householders, and are a component actor implicated in configuring their qualities and powers. However, as our cases demonstrate, energy meters are currently in the midst of a contested and uneasy transition period, wherein old framings and ways of doing are shifting into new ones: mechanical energy meters are a longstanding, relatively stabilised technology in comparison to the digital meter, whose capabilities are still evolving. The mechanical energy meter is remembered and has obduracy in a host of subtle ways through standards and practices; and at the same time the functions, and particularly the purposes, of new digital meters are not yet precisely and commonly defined by all social worlds intersecting with them. With mechanical meters the social world of the householder was not closely engaged with the utility via the meter, but, as we observe from our three case studies, with digital meters this has changed. By instigating programs to replace meters in people's homes, utilities and governments have made the meters a focal point of action and discussion. This reframing of the meter, and the relationships it shapes and mediates, are issues which the boundary object concept helps us to understand. Through a focus on the meter itself, changing social practices and relations are usefully brought to the fore.

A key insight from the boundary object concept is "…understanding local tailoring as a form of work that is invisible to the whole group..." (Star, 2010: 607). In other words, the 'local tailoring' of the energy meter within different social worlds is not usually seen by other social worlds. This conceptualisation is particularly relevant for better understanding householders, where 'local tailoring' in relation to digital meters is underway, and where emerging empirical evidence highlights two issues in particular. First, householder 'local tailoring' appears in many cases to be misaligned with the preconceived ideas of other social worlds about how householders would respond to digital meters. For instance, in the cases of Wyndford and the Victorian AMI Program, the digital meter's attributed qualities (i.e. the benefits attributed to it by governments and utilities, primarily financial) have been contested by householders who distrust the claims of its proponents and dispute the distribution of costs. In the UK smart metering case, in contrast, the meter's functions have been deliberately framed in such a way as to allow more local tailoring by householders, e.g. by enabling the data collected to be shared with third party service providers to provide, potentially, any additional function for which there is sufficient market demand. Second, and relatedly, we observe that within the social world of householders, certain individuals and groups are responding in quite different ways to digital meters, indicating that the conceptual assumption of social worlds as cohesive - having shared views and a common mode of operating - is an oversimplification. For example, a vocal minority of householders in each of the cases have criticised the new digital meters and demanded changes. In these cases householders have demonstrated a range of responses to digital meters, suggesting households could usefully be more finely categorised into a number of social worlds.

Exploring conflicts in the transition to digital metering

The concept of a boundary object was originally conceived to explain situations in science research where collective work was feasible even in the absence of consensus, because of the interpretative flexibility of boundary objects (Star and Griesemer, 1989). With energy metering a number of difficulties have arisen as the digital meter has been deployed. Our three case studies demonstrate how new digital energy meters have been, and are in the process of being, implemented, but this has not for the most part been a process characterised by consensus. The boundary object concept thus helps us to recognise first and foremost how a lack of consensus does not necessarily prevent technology change occurring: the 93% installation rate for digital meters in Victoria illustrates this well. Boundary object scholars would interpret this situation as an outcome of the interpretative flexibility of boundary objects, meaning that locally tailored views within discrete social worlds are able to co-exist, and do not compromise the overall objective of the project or program. We concur with this view, but also suggest there are limits to the boundary object concept in cases where actors have different levels of power and resources. Clearly households do have considerable collective influence (notably in Victoria their responses to metering contributed significantly to stopping mandated implementation in other Australian States), but they did not have equal say alongside government and utilities at the time of program design. In this way the boundary object concept draws our attention to the degree of involvement of the social world of householders in the framing, development and implementation of new digital meters. It is clear that the involvement of householders has not been high, and this has been a key source of conflict and difficulty, although with our third case study of the UK-wide smart metering program there are notable differences in the degree to which the boundary object of the digital meter "… emerged through *the process of the work*." (Star and Griesemer, 1989: 408, emphasis added). In other words, in the UK-wide program the "process of work" has been a more collective one from the outset, paying regard to and striving to include the social world of householders and their views and needs. This appears to be setting the stage for a more positive implementation process for digital meters in the UK.

The digital meter boundary object is more physically dispersed than mechanical meters: there are technological 'add-ons' (wireless, digital, such as IHDs) that are separate from, but connected to, the meter in a way that was not possible with the previous generation of meters. This is relevant in thinking about conflict because it means that the technology of the digital meter itself is inherently more flexible and open to modification in different ways, by different social worlds. In other words, the shared space of the new boundary object is not yet fixed, and it is suggested that this provides an important means to reduce conflict, because there is considerable scope for further 'local tailoring' by households so that new digital meters more closely match their needs and objectives. The extent to which digital meter 'add-on' technology innovation is being fostered and led by the social world of householders is at present uncertain, but there are indications that it is indeed taking place (see for example OpenEnergyMonitor, 2016; Robinson, 2016).

In conclusion, the core value of the boundary object concept applied to the introduction of digital energy meters is that it offers a means to reveal the newly contested qualities of energy meters, which have for most of the 20th century been invisible to householders. In so doing, attention is drawn to material struggles over the shape of the future energy system: will it be, for example, a future defined and controlled largely by existing large utilities, or by a mixed economy of householders, local suppliers and prosumers, or by a disrupted and uncertain energy supply with struggles between different social worlds as each seeks some means to constitute an energy economy to meet their needs? Since the digital meter disrupts established identities and ways of doing in the energy sector it potentially re-opens the spaces for resistance to incumbent energy actors, and it may work simultaneously both as a means to anchor structural grievances over social injustices and exclusion and to enable greater energy democracy.

Bibliography

Abson D, Von Wehrden H, Baumgärtner S, Fischer J, Hanspach J, Härdtle W, Heinrichs H, Klein A, Lang D, Martens P, 2014, "Ecosystem services as a boundary object for sustainability" *Ecological Economics* **103** 29-37

Accenture, 2016, "Realizing the Full Potential of Smart Metering",

Ausnet, 2016, "Metering and meter reading", http://www.ausnetservices.com.au/Electricity/Managing+Usage/Metering+&+Meter+Reading.html

CAS, 2016, "Smart Move: taking stock of the smart meter rollout program in Scotland", (Citizens Advice Scotland (CAS))

Dean M, 1999 *Governmentality: power and rule in modern society* (Sage Publications Ltd, London)

DECC, 2012a, "The Future of Heating: a strategic framework for low carbon heat in the UK", (Department of Energy and Climate Change (DECC), London, UK)

DECC, 2012b, "Smart Metering Implementation Programme Consumer engagement strategy: Consultation document", (Department of Energy and Climate Change, London)

DECC, 2013a, "Smart Metering Implementation Programme: Government Response to the Consultation on the Second Version of the Smart Metering

Equipment Technical Specifications Part 2.", (Department of Energy and Climate Change (DECC), London)

DECC, 2013b, "Smart Metering Implementation Programme: Second annual report on the roll-out of smart meters", (Department for Energy and Climate Change, London)

DECC, 2016, "In-Home Display licence conditions: Consultation response", (Department of Energy and Climate Change (DECC), London)

Deloitte, 2011, "Advanced metering infrastructure cost benefit analysis", (Department of Treasury and Finance, Canberra, Australia)

Department of State Growth, 2015, "Tasmanian Energy Strategy: Restoring Tasmania's energy advantage",

DPI, 2007, "Victorian Government Rule Change Proposal - Advanced Metering Infrastructure Rollout", (Department of Primary Industries (DPI), Melbourne, Victoria)

Eden S, 2009, "Food labels as boundary objects: How consumers make sense of organic and functional foods" *Public Understanding of Science*

ESC, 2004, "Mandatory rollout of interval meters for electricity customers", (Essential Services Commission, Melbourne, Vic)

Fujimura J H, 1992, "Crafting science: Standardized packages, boundary objects, and" translation."" *Science as practice and culture* **168** 168-169

Harvey F, Chrisman N, 1998, "Boundary objects and the social construction of GIS technology" *Environment and Planning A* **30** 1683-1694

ISGAN, 2014, "AMI Case Book Version 2.0: Spotlight on Advanced Metering Infrastructure", (International Smart Grid Action Network (ISGAN), South Korea)

Lovell H, 2017, "Are policy failures mobile? An investigation of the Advanced Metering Infrastructure Program in the State of Victoria, Australia" *Environment and Planning A* **49** 314 - 331

Luque-Ayala A, Marvin S, 2016, "The maintenance of urban circulation: an operational logic of infrastructural control" *Environment and Planning D: Society and Space* **34** 191-208

Mallett A, 2007, "Social acceptance of renewable energy innovations: The role of technology cooperation in urban Mexico" *Energy Policy* **35** 2790-2798

McCann E, 2011, "Veritable inventions: cities, policies and assemblage" *Area* **43** 143-147

McGuirk P, Bulkeley H, Dowling R, 2014, "Practices, programs and projects of urban carbon governance: Perspectives from the Australian city" *Geoforum* **52** 137-147

Moore K, 2015, "Overview of the Victorian Smart Meter Program - a mandated smart meter roll-out", (New Zealand Smart Grid Forum, New Zealand)

NSW Minister for Resources and Energy, 2014, "NSW gets smart about meters",

OpenEnergyMonitor, 2016, "OpenEnergyMonitor - Homepage", https://openenergymonitor.org/emon/

People Power Victoria, 2016, "People Power Victoria - Homepage", http://www.peoplepowervictoria.org.au/home

Poderi G, Bonifacio M, CAPACCIOLI A, D'ANDREA V, MARCHESE M, 2014, "Smart Meters as boundary objects in the energy paradigm change: the CIVIS experience", in *A Matter of Design: 5th STS Italia Conference* Eds Claudio Coletta, Sara Colombo, Paolo Magaudda, Alvise Mattozzi, L L Parolin, L Rampino (Italy)

Pullinger M, Lovell H, Webb J, 2014, "Influencing household energy practices: a critical review of UK smart metering standards and commercial feedback devices" *Technology Analysis & Strategic Management* **26** 1144-1162

Queensland Department of Energy and Water Supply, 2013, "The 30-year electricity strategy. Discussion paper - Powering Queensland's future", (Queensland Government - Department of Energy and Water Supply, Brisbane)

Robinson P J, 2016, "Green Tools: Is Civic Tech Advancing Environmental Action and Governance?", in *Association of American Geographers 2016 Annual Meeting* (San Francisco, USA)

Shove E, Pantzar M, Watson M, 2012 *The Dynamics of Social Practice: Everyday life and how it changes* (Sage, London)

Smart Energy GB, 2013, "Smart Meter Central Delivery Body: Engagement Plan for Smart Meter Roll-out", (London)

Star S L, 2010, "This is not a boundary object: Reflections on the origin of a concept" *Science, Technology & Human Values* **35** 601-617

Star S L, Griesemer J R, 1989, "Institutional ecology,translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39" *Social Studies of Science* **19** 387-420

Strauss A, 1978, " A social world perspective" *Studies in symbolic interaction* **1** 119-128

Taylor P G, Upham P, McDowall W, Christopherson D, 2014, "Energy model, boundary object and societal lens: 35 years of the MARKAL model in the UK" *Energy Research & Social Science* **4** 32-41

UK BIES, 2016, "Smart Meters - Quarterly Report to end June 2016", (UK Department for Business, Energy and Industrial Strategy (UK BIES))

VAGO, 2015, "Realising the benefits of smart meters", (Victorian Auditor-General's Office (VAGO), Melbourne, Australia)

VCOSS, 2016, "Making energy visible: using smart meters and in-home display units to improve energy efficiency for people facing disadvantage", (Victorian Council of Social Service (VCOSS), Melbourne, Australia)

VEC, 2016, "Victorian Electoral Commission (VEC) - State Election 2010 results", https://www.vec.vic.gov.au/Results/state2010resultsummary.html

Webb J, Hawkey D, McCrone D, Tingey M, 2015, "House, home and transforming energy in a cold climate" *Families, Relationships and Societies* **5** 411-429

Wüstenhagen R, Wolsink M, Bürer M J, 2007, "Social acceptance of renewable energy innovation: An introduction to the concept" *Energy Policy* **35** 2683-2691