EnergyREV

Privacy and data sharing in smart local energy systems: Technical report

Carol Vigurs, Chris Maidment,
Michael J. Fell and David Shipworth

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Authors

- Carol Vigurs
- Chris Maidment
- Michael J. Fell
- David Shipworth

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Abstract

Objectives

The purpose of this review is to investigate the nature of privacy concerns in the context of Smart Local Energy Systems (SLES) to enable us to provide evidence-informed guidance on how SLES providers can minimise both concern and cause for concern around privacy.

We aimed to answer the following questions: What are the contextual factors, interventions (and their attributes), mechanisms, and other mediating/ moderating factors impacting on privacy concerns as a barrier to involvement and extent of data sharing in smart local energy systems?

Search methods

We searched 11 data bases of academic literature, including SCOPUS, WoS, 16 websites of relevant organisations, Google Scholar and Google and the UCL online library for energy sector literature and additional searched for systematic reviews in related energy or data sharing sectors

Selection criteria

We included empirical studies that included measures of privacy concerns in relation to sharing energy use data in the first instance, then supplemental evidence from systematic reviews in related sectors that were about privacy concerns or barriers to data sharing.

Data collection and analysis

We used the Socioecological ecologic model for human development as the organising framework to understand privacy concerns in different contexts, the different data collection technologies that people interact within the individual and personal, interpersonal, work and community and the wider socioeconomic and cultural domains.

Main results

We found 34 studies that had a measured outcome related to privacy concerns and energy data sharing and 22 systematic reviews on related sectors.

The main privacy concern we found evidence for was that sharing detailed energy use data had the potential to reveal information about home life, and to intrude upon autonomy, choice and control. Many people feel strongly about retaining control over information about themselves, their home life, and ways of living. Setting privacy controls are a part of modern life, and people are accustomed to make decisions around sharing data on accepting cookies on websites, and setting privacy controls in social media, ticking boxes to not receive marketing material and so on. On the other hand, people rarely read the terms and conditions of website privacy policies, mainly because they are difficult to access, understand and apply to one's own case. Truly informed consent to share data will not depend on only the provision of information and trust in the sender of the information but developing useable privacy notices, tailored to the needs and preferences of customers.

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Evidence from other sectors suggests that people are willing to accept new technologies and sharing data if the benefits of doing so are clear, anticipated, mutually beneficial. Trust, through increasing knowledge and understanding was a mechanism for overcoming privacy concerns, but this was mediated by the organisation providing the information. The extent of trust in governments and organisations is context and culturally dependent but there exists a general suspicion that for-profits would not work for customers' best interests, but non-profit organisations were trusted more that they would ensure appropriate safeguards to privacy were in place.

The quality of evidence was mixed in terms of execution of study and relevance to this review Studies were often limited to people's views on hypothetical scenarios, that is, how they would feel, instead of their direct experience or surveys of their current views and experiences. Interventions to overcome privacy concerns that act as barriers to data sharing have not yet been tested formally in the literature. The included studies may overstate people's willingness to adopt socially desirable behaviours, such as concerns for the environment or measured changes in behaviour in the short terms. Self-election into studies will also likely include participants who are more tech savvy than perhaps the general population.

Evidence from impact studies was limited; as a result, we supplemented this evidence with systematic review evidence to see what lessons could be learned and applied from different contexts and mechanisms of data sharing where there are privacy concerns in related energy sectors or established and trusted data sharing sectors. From this we constructed 8 overarching principles of a model intervention, based on the barriers and mechanisms to data sharing in different contexts, and translated these principles into 8 action-oriented recommendations for SLES providers:

1. Build on existing trust to deliver mutually beneficial outcomes
2. Ensure people feel in control of their data and environment
3. Help people to understand new products and services
4. Design SLES around user priorities and make these benefits clear
5. Monitor, and use a variety of approaches to, actively widen engagement
6. Consider everyone effected by data sharing when seeking consent to share data
7. Provide clarity on how data will be used (and how misuse will be prevented)
8. Consider leveraging 'horizontal sharing' where appropriate

Conclusions

People's expressed privacy concerns that potentially act as barriers to data sharing were varied and differed by privacy concerns in different domains. One barrier to participation with good supporting evidence was that people will resist the intrusion on their autonomy, choice and control in the individual domain. This could be actively resisted by refusing to install data collection technologies, for instance, or passively by non-participation in changing or adapting energy use behaviours. Both of which are necessary for SLES to achieve their goals of managing energy demand and building resilience in the smart grid.

Inclusion and informed consent will require active outreach from SLES providers in a variety of ways to meet people's abilities and preferences as well as ongoing education and support to ensure that privacy concerns are adequately addressed, the benefits of sharing data are realistic, and participation is by informed and active choice.

The gathering and use of energy use data in the home is relatively new. Therefore, design processes should incorporate the means to evaluate effectiveness, include a diversity of perspectives and respond quickly to unintended consequences.

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1 Background

Privacy is a key issue for those planning and implementing smart local energy systems (SLES). Privacy issues have been highlighted as a possible barrier to the willingness of both energy users (e.g. consumers, residents, industry) and SLES implementers (e.g. local practitioners, companies, policymakers) to participate and share data in SLES. This could limit the potential of SLES schemes to deliver good societal outcomes.

The purpose of this review is to investigate the nature of privacy concerns in the context of SLES to enable us to provide evidence-informed guidance on how SLES implementers can minimise both concern and cause for concern around privacy.

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2 Methods

2.1 Questions and approach

This process of reviewing literature is similar the process of primary research but at a higher or 'meta' level. Primary research goes and collects data from research participants. Systematic reviews use these primary studies as their sample. A systematic synthesis uses the results of the primary research studies to answer the research review question(s).

A systematic realist review is one that attempts to include and describe complexity of interventions, in terms of not only what works, but how and for whom, under what circumstances by examining the interactions between the interventions, contexts and mechanisms (Pawson et al 2005). A rapid realist review (RRR) then, is one that is faster to deliver than the traditional realist systematic review, in order to respond to policy issues that are emerging and time sensitive (Saul et al 2013). The limits a rapid review may be applied to achieve this may be the numbers of sources searched or the types or quality of evidence, or rapid quality assessments, but is explicit in what way trade-offs, if any, are made between an exhaustive and comprehensive review to a timely and useful systematic review.

Taken these aspects together, we apply an "agile" systematic review method, one that responds to and identifies review priorities of review users, is iterative and reflective, includes consideration of complicated and complex aspects of interventions, and develops, tests and refines theory on how an intervention does or could work.

A rapid realist review may have several questions that emerge from a map of the research literature and consultation with both Prospering from the Energy Revolution (PFER) demonstrator projects and EnergyRev consortium members, as they incorporate the review findings into their learning, development and practice and develop new theories and rapid review questions.

2.2 EnergyRev consortium consultations

Following work on a review of reviews of smart local energy systems and a systematic map of empirical studies on smart local energy systems (SLES), two topic areas emerged from the findings (see appendix for list of relevant documents) and from consultations with PFER demonstrators: 1. Privacy and 2. Organisational arrangements. These were posed to the EnergyREV work package leads to discuss how these topic areas interacted with their work priorities and issues that have arisen. These research needs and priorities were discussed and summarised, and the topic of privacy and data security was found to be most commonly mentioned as a priority area. A rapid realist review question was developed from this.

The components of review question and the types of study that are included, form the basis of the pre-specified eligibility criteria for the review (Higgins 2011). Not all of the criteria may have equal weight, and some may be less relevant when framing rapid systematic review questions or exploring and developing new theories or links in the theory of change. The design of the review question is intended to capture complexity (emergent properties) and complicated aspects (multiple components) from a systems perspective to develop and understand the theory (or theories) of change.

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Starting assumption:

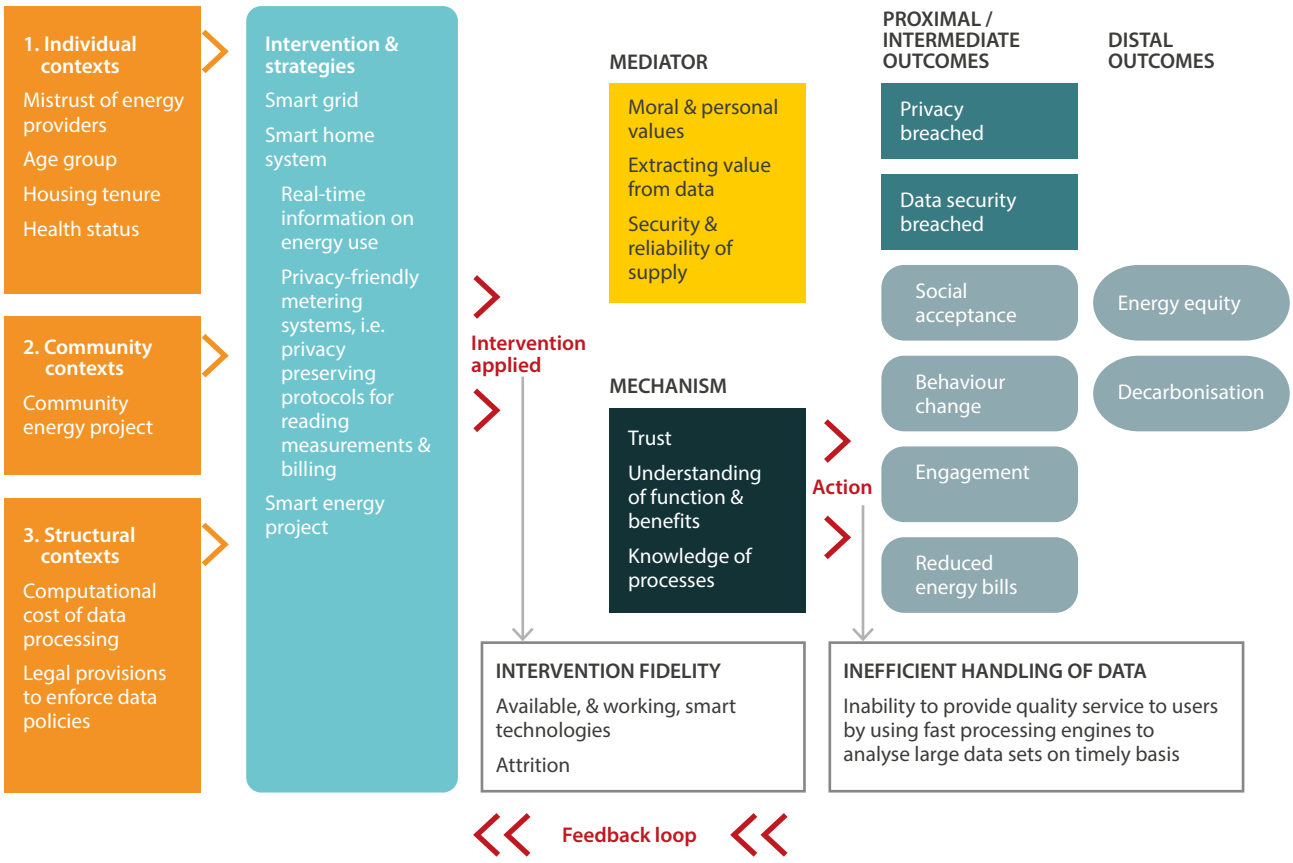
- That concerns relating to data privacy are a potential barrier to (a) user and (b) implementer involvement and data sharing in SLES. These barriers may need to be overcome if SLES with good outcomes are to be realised.

Higher order question: What are the contextual factors, interventions (and their attributes), mechanisms, and other mediating/moderating factors impacting on privacy concerns as a barrier to involvement and extent of data sharing in smart local energy systems?

Lower order questions include:

1. What are the demonstrated or likely privacy concerns of potential and existing SLES (a) users and (b) implementers?
2. What are the key threats to privacy in SLES, and how far have these been shown to be reflected in levels of privacy concern?
3. Do threats/concern around privacy differ as a result of the 'localness' of SLES?
4. To what extent have privacy concerns been demonstrated to be a barrier to involvement and data sharing in SLES and other directly relevant circumstances, and for whom?
5. What interventions have been employed to mitigate concern (and cause for concern) in relation privacy in contexts relevant to SLES?
6. How effective have these interventions been in delivering
   a. involvement
   b. data collection, use and sharing, and
   c. good outcomes for (a) users, (b) implementers, (c) society, and (d) others?

Figure 1: Privacy in SLES: First development of a theory of change.



7. What are the mechanisms by which the interventions are thought to work?
8. How has the attainment of outcomes been mediated or moderated by (a) the context in which interventions have been delivered (including to whom) and (b) the attributes of the interventions?

Initial programme theory

We took as the starting point a problem-oriented approach to the review:

Problem: That access and use of data is a key issue in planning and implementing smart local energy systems (SLES). Privacy issues have been highlighted as a potential barrier to access and use of data for both users (customers, residences, industry) and SLES implementers (e.g. local authorities, energy providers, policy makers). These barriers could limit the potential for SLES to realise good outcomes.

Figure 1, above, shows the first phase of a development of a theory of change based on the contexts, mechanisms and outcomes that were found in the review of reviews of smart local energy systems (Vigurs et al, forthcoming).

2.3 Rapid Realist Review search strategy

We developed the following list of search terms connected to the initial programme theory above to identify relevant documents. We applied pearl-growing techniques to search terms in systematic reviews in other sectors that were about privacy. We ran pilot searches and use different search terms in combination (adding, altering or removing terms where necessary) around the different concepts of privacy, privacy behaviours and regulation to arrive at a list of documents which is both sufficiently broad and manageable given the constraints of a rapid review.

- **Concepts of Privacy**

- Privacy
- Private
- Personal
- Sensitive
- Secure
- Security
- Anonymous
- Anonymity
- Confidential
- Intimate
- Safety
- Data privacy

Near3 Data OR information

- **Data sharing and privacy behaviours**

- Behaviour
- Attitude*
- Calculus
- Concern*
- "Tradeoff"
- Trade-off
- Intention
- Preserv*
- Issue*
- Anxiet*
- Incentiv*
- "Risk perception"
- Caution
- Paradox
- Trust
- Barrier
- Perception*
- Perceived
- "Data sharing"
- "Willingness to disclose"

- **Data protection**

- Policy
- Policies
- "By design"
- Pbd
- Requirement*
- Regulation
- "General data protection regulation"

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- GDPR
- "Disclosure avoidance"
- "Statistical disclosure limitation"
- "Disclosure control"
- Preserving
- "Open access"
- "Data access"
- Monitoring
- De-identification
- "Data protection"

We selected studies relevant to the rapid review from the EnergyREV research portal, and conducted additional searches for studies published in peer reviewed journals in indexed bibliographic databases, and studies published elsewhere, such as on organisational websites. In addition to searches of bibliographic databases and grey literature, we identified papers that are linked to any effectiveness studies identified, as part of an integrated mixed methods study or as a "sibling study" (e.g. qualitative, economic or process evaluations associated with specific effectiveness studies). Supplemental evidence for systematic reviews in related topics and sector areas was conducted in Google and Google scholar and UCL Library portal.

2.3.1 Databases

The following provide examples of the databases which were searched using free text and subject headings terms (others may be identified depending on the specific subject of the review):

- Scopus
- Web of science
- Ei Compendex
- Engineering Village – GEOBASE
- IBSS
- Sociological Abstracts
- ABI/Inform
- Periodical Abstracts PlusText
- Applied Science & Technology Abstracts
- Journal of Economic Literature
- Current Abstracts

2.3.2 Websites

- IEEE Power & Energy Society
- Department for Business, Energy & Industrial Strategy
- Ofgem
- Citizens Advice
- Sustainability First
- Distribution Network Operators
- National Grid
- Cambridge Energy Policy Research Group working papers
- UK Energy Research Centre
- European Commission Research and Innovation (Energy)
- US Department of Energy (including SciTech Connect)
- Renewable Energy Association
- The Association for Decentralized Energy
- Privacy International
- The Information Commissioners Office
- Liberty

2.3.3 Search engines

- Google
- Google scholar

2.4 Screening studies: applying inclusion and exclusion criteria

Inclusion and exclusion criteria were first applied to titles and abstracts. Full papers were obtained for those studies where abstracts suggest that the studies might meet the inclusion criteria. Where the title and abstract provided insufficient information to be certain, the full paper was obtained and the inclusion and exclusion criteria re-applied. Those that did not meet these criteria were excluded.

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2.4.1 Inclusion criteria

- Study is published in English. The review does not currently have resource to provide translations of studies not published in English. Studies not published in English were not excluded at the search stage but is included in the count of published studies and is available should resource become available at a later date.
- Study must include consideration of privacy concern and, in particular, the role this plays in choices around to what extent customers participate. The study will not be included if it presents only a technical solution with no interaction with consumer privacy concerns.
- The study must include outcomes or views and experiences.
- Study must present clear methods for their research.
- Studies with a focus on energy will be prioritised for inclusion, with studies in other areas included on the basis of theoretical and practical relevance.

All studies that meet the criteria were entered into the EPPI-Centre systematic EPPI-Reviewer systematic review information management (Thomas 2010) software.

2.5 Characterising included studies

The studies classified as eligible following the initial screening were coded using keywords specific to this study. All the keyworded studies will be added to the larger EPPI-Centre database for general access via the website.

The included studies were described according to the following key characteristics:

1. Date of publication
2. Study methods
3. Geographical location
4. EnergyREV theory of change challenge area
5. Study aims
6. Intervention aims
7. Participant characteristics
8. Characteristics of the person(s)/ organisation(s) delivering the intervention
9. Intervention type
10. Intervention components/ content
11. Outcome measures
12. Intervention contexts
13. Implementation factors
14. Type of publication
15. Funder of research

2.6 Identifying and describing studies: quality assurance process

The review team blind screened a sample of studies independently against the inclusion criteria compared results and discussed any areas of disagreement until consistency in screening was reached.

2.6.1 Data extraction

The characteristics of the studies, data on the results from the study were extracted using a standardised template across studies.

Quantitative: effects sizes, confidence intervals, sample size, P values, standardised mean differences etc. were extracted where available.

Qualitative themes: illustrative quotes, analytical themes. Author discussions on implementation and factors that impact on outcomes.

Mechanisms and contexts: Key to understanding how complex interventions work is the interactions between the contexts, mechanisms and outcomes. Further detail was extracted from studies on the authors' discussion on factors that effected outcomes, and contextual factors such as interventions settings, content of the intervention, characteristics of the participants.

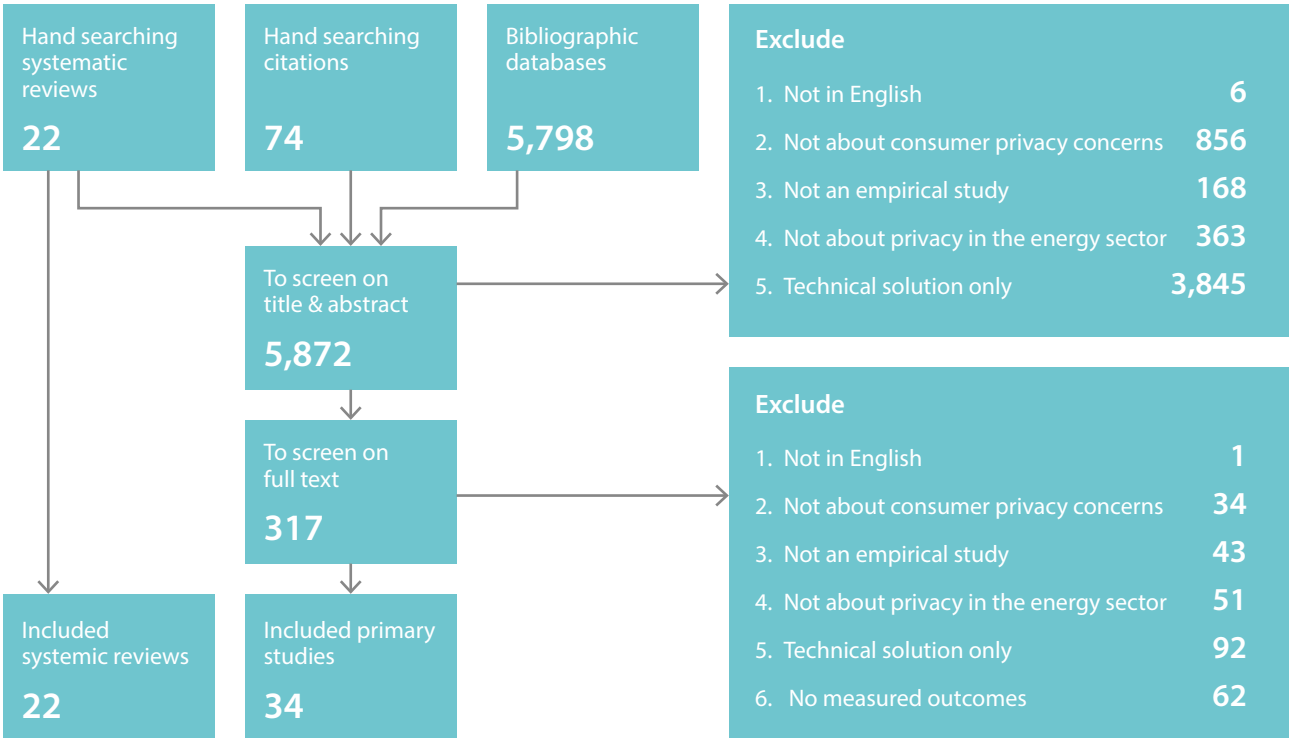

Figure 2: Flow diagram of the identification, screening and inclusion process.

2.6.2 Quality assessment (QA) of studies

Individual studies were quality assessed with a checklist appropriate to each of the study designs, to assess the threats to validity common to these types of studies. The checklist will assess the study's:

- internal validity; how reliable the study is in its execution
- construct validity: the extent to which the concrete measures in the study match up to the intervention theory of change (Judd et al 1991)
- conclusion validity (rigor): the reliability and trustworthiness in reaching its findings and conclusions (Cook and Campbell 1979)
- relevance/generalisability; to what extent the findings are replicable and generalisable to the SLES context, as well as the relevance of the study to this rapid review

2.6.3 Quality assurance of QA coding decisions

A sample of studies was double blind coded by two reviewers comparing and discussing any disagreements until consensus was reached. Decisions were referred to a third reviewer where a consensus could not be reached.

Findings

2.7 Description of the included studies

Smart local energy systems (SLES) is a relatively new research area (Maidment et al forthcoming, Vigurs et al forthcoming) and research on privacy concerns around energy sharing data in this context even more so, consequently, more than two thirds of the studies included in this review were published in or after 2015 and none published before 2011. The vast majority of studies were conducted either North America (over a quarter in the USA alone) or western Europe (with around a fifth in the UK). They covered a wide range of academic disciplines, most commonly computer science, energy, social science, technology, business and engineering. With the exception of a few industrial or commercial reports, all of the studies were published in academic journals or as conference papers.

While nearly half of the studies examined either smart meters or smart grids, the rest investigated a range of technologies and approaches. For those studies carried out in a particular setting or population, most were based in an urban, residential environment with adult participants, primarily of working age, participants usually had some knowledge and experience of Smart technology use.

Around three quarters of the studies used observational methods, predominantly surveys, case studies or interviews. These were mostly used to investigate what might affect people's perceptions and acceptance of an intervention or technology although some used these methods to assess technology development or implementation. The quality of these studies was mixed: although many were highly relevant, fewer were highly robust (half of the surveys and case studies and none of the interview studies). There was only one experimental study that tested the effect of a real-world intervention.

Most studies on people's perceptions and attitudes, psychological measures were used more than any other type of numerical measure; most frequently measures of privacy concern or acceptability. Measures of technological performance and social norms were also used by some studies while a few measured behavioural or economic outcomes. Only one study measured environmental outcomes. Themes that emerged from qualitative studies most commonly related to the people involved in SLES and the impacts of SLES: the actors involved, who sees the data and who benefits.

The study and interventions characteristics are in the following table. The quality assurance measures for both internal and external validity are indicated with ++ for high, + medium and – low. Measures of quality were assessed against the steps taken by the researchers to minimise bias common for the type of research design.

Type of study	Number of participants	Type of intervention	Components of intervention	Aim of intervention	Users of data
S1 • Bailey (2015) ++/++ • Canada					
Observational • Survey	1470 CPEVS survey n = 530 in discrete choice experiments	• Smart charging of PEVs	• Alternative energy source • Budget information	To allow load management, reduce system costs, subsidise PEV market, increase use of renewables	• Energy provider
S2 • Begier (2014) –/++ • Poland					
Observational • Interviews • Survey	4 focus groups, 302 interview participants Total: 963 persons	• Smart meters	• Communication • Email information • Home computer • In home displays • Information • Internet access • Personal visit by representative • Variable rates	Main technical purposes of smart metering, like energy saving, reducing total energy consumption, especially reducing peak demand of energy	• Criminals • Energy provider
S3 • BEIS (2018) +/++ • Great Britain					
Review • Audit	NA	• Regulation • Regulatory framework	• Communication • Smart meter • Smart metering Data Access and Privacy Framework.	The Framework establishes sector-specific provisions relating to the processing of energy consumption data, which are designed to complement, but not replace, wider data protection legislation (e.g. GDPR)	• Consumers • Energy network operator • Energy provider • Third party organisations
S4 • Choe (2012) +/+ • USA					
Observational • Activity diary • Interviews	11 couple households	• In home sensors	• Diary • Home computer • Sensor lights • Technology education session	Sensors can help make decisions about energy efficiency.	
S5 • Citizens Advice Bureau (2019) ++/++ • Great Britain					
Observational • Survey • Process evaluation	3,008 online interviews 213 face to face interviews.	• Smart appliances • Smart meters	• Smart meter	Smart meters and smart devices aim in part to facilitate a more flexible electricity system	• Corporations • Energy provider

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Type of study	Number of participants	Type of intervention	Components of intervention	Aim of intervention	Users of data
S6 • Da Silva (2012) –/++ • Multiple locations					
Observational • Survey	Not clear end prosumers of electricity in the residential sector	• Demand Side Response • Small scale renewable energy provision • Prosumers • Smart grid	• Real time information	Smart grids provide services for prosumers (e.g. comparing usage to similar local households), based on information provided by the prosumers (e.g. real time consumption data).	• Energy provider "retailer"
S7 • Delmas (2014) +/++ • USA					
Experimental • Quasi	66 rooms, 102 participants	• Feedback • Public vs. private feedback	• Email information • Home energy monitoring device • In home displays • Information posters • Real time information	(To) test the efficacy of detailed private and public information on electricity conservation.	• Not stated
S8 • Fell (2015) +/++ • Great Britain					
Observational • Survey	2,159 / 2,302 people full omnibus study	• Demand Side Response	• Electric heating	Demand side response (DSR) Simply defined as 'change in electricity consumption patterns in response to a signal' (Element Energy 2012, 9), DSR offers the ability to sculpt demand for electricity to fit the available supply.	• Not stated
S9 • Giordano (2011) +/+ • Europe					
Observational • Survey	Not clear	• Smart grid	• Authentication • Authorisation • Certification • Encryption • Ensures integrity and confidentiality	(to).. foster greater consumption awareness taking advantage of Smart Metering systems and improved customer information, in order to allow consumers to modify their behaviour according to price and load signals and related information.	• Criminals • Market analysts • Insurance companies

Type of study	Number of participants	Type of intervention	Components of intervention	Aim of intervention	Users of data
S10 • Guerreiro (2015) –/+ • Portugal					
Observational • Survey • Discourse analysis of blogs	515 residents in the city of Évora	• Smart meters	• Not stated	Smart meters permit smart grids, including by giving people feedback on their energy use so they can alter consumption patterns	• Energy provider
S11 • Hansen (2017) +/+ • Denmark					
Observational • Case study	20 households	• Smart grid	• Electric vehicles n=17 • Geothermal Heat pump Hybrid air/ water HP with gas, air/water HP • home energy monitoring device • Internet access • Photovoltaics PVs • Real time information • Sensors • Smart meter • Sun Wells	the main idea of Insero Live Lab was to test the remote control of electricity-consuming devices (EVs and HPs) combined with electricity-producing devices, PVs.	• Consumers • Energy provider
S12 • Hess (2014) +/++ • Canada • USA					
Observational • Case study	75 organisations or information sites that gave reasons for opposing smart meters	• Smart meters	• Not stated	Smart meters can help achieve "more resilient and sustainable electricity consumption"	• Not stated
S13 • Hmielowski (2019) ++/++ • USA					
Observational • Survey	1035	• Smart meters	• Information • Description and picture of smart meter (and mechanical meter).	To support/inform the installation of smart meters to increase energy efficiency, reduce costs and greenhouse gases.	• Energy provider

Type of study	Number of participants	Type of intervention	Components of intervention	Aim of intervention	Users of data
S14 • Hoenkamp (2012) +/+ • The Netherlands					
Observational • Case study	National	• Smart meters	• Compulsory roll out • In home displays • Real time information • Smart meter	Smart … play a crucial role in reaching the energy efficiency goals of the 20-20-20 targets of the EU Climate and Energy Package	• Not stated
S15 • Horne (2015) +/– • USA					
Observational • Survey	Study 1 (S1) 353 Study 2 (S2) 355	• Smart meters	• Real time information • Smart meter	Smart Meters contribute to the technical capacity of utility companies to manage demand (through demand response programs), incorporate renewable sources of electricity into the system, and increase the overall efficiency and reliability of the system	• Energy provider • Third party organisations
S16 • Huang (2016) ++/+ • Not stated					
Model • Mixed strategy Nash Equilibrium game	NA	• Incentives	• Alternative energy source • PV • Battery • Smart meter	The goal of our price-based incentive approach is to allow both parties, namely consumers and the electricity provider, to negotiate consumption and data sharing such that all parties can potentially profit from interactions.	• Energy provider
S17 • Jakobi (2017) +/+ • Germany					
Observational • Focus group • Interviews	63	• Smart thermostats	• An App • Dashboard • Diary – home log book • Feedback • Information • Internet access • Remote controls • Sensors • Smart meter • Smart plugs • Smartphone • Web Portal • Z wave	Products mainly address issues of security, energy savings and comfort. Monitoring and saving energy by avoiding standby consumption, automated switching off of devices and appliance-based measurement of energy consumption as well as visualisation of consumption.	• Not stated

Type of study	Number of participants	Type of intervention	Components of intervention	Aim of intervention	Users of data
S18 • Jakobi (2019) +/++ • Germany					
Observational • Ethnographic case study	Survey: 34/200 App: 205	• Smart meters	• An App for Android • Customer choice of level of disclosure • Information • Internet access • Smart meter	(smart) meters are designed to collect information on power consumption and send it to third parties.	• Advertisers • Consumers • Third party organisations
S19 • Kapade (2017) +/+ • Not stated					
Model • Game theory	1000 modelled households	• Incentives	• Area networks • Smart meter	To incentivise consumers via a credit-based system to share power consumption data that is beneficial to industries.	• Data Collectors • Third party organisations • Unethical individuals
S21 • Moere (2011) –/+ • Australia					
Experimental • Quasi experimental study	Intervention 6 Control 5	• Smart meters	• Feedback • Internet access • Outside home display • Sensors • Wireless network	Providing comparative feedback may have a positive effect on behaviour change by triggering feelings of competition, social comparison or social pressure [26].	• Consumers
S22 • Naus (2015) ++/++ • The Netherlands					
Observational • Focus group • Survey	Focus Group: 12 Survey: 171	• Smart grid	• Consumption • Domestic production • Energy meter • Real time information • Variable rates	Government bodies at different levels have formulated targets to promote a transition to a low-carbon economy. households are increasingly positioned as active participants with a responsibility to act as 'change agents'	• Energy provider
S23 • Ofgem Year 9 (2018) +/++ • Great Britain					
Observational • Deliberative workshops	62 in four groups	• Half-hourly settlement	• Smart meter	Half-hourly settlement uses more fine-grained electricity consumption data from smart meters. It could allow more innovative energy products to be commercialised.]	• Energy provider • Government agencies

Type of study	Number of participants	Type of intervention	Components of intervention	Aim of intervention	Users of data
S24 • Pournaras (2016) +/+ • Germany – Smart phone evaluation • Ireland – Smart Grid evaluation					
Model • A supply-demand system	Data on 6000 participants	• Incentives • Smart grid	• Authorisation • Budget information • Customer choice of level of disclosure • granularity of data collection • rewards • Software tools	A Smart Grid project that studies the impact on electricity consumption of residential and enterprise consumers in Ireland.	
S25 • Sexton (2018) –/– • England					
Observational • Case study	5 in Energy case study interviews	• Energy governance	• Consumption data	Sharing, linking and re-use (secondary use) of government administrative data	• Government agencies • Researchers
S26 • Snow (2014) ++/++ • Australia					
Observational • Interviews	S1: 23 households S2: 35 households	• Smart meters	• Feedback • In home displays	The emerging standard of visible and sharable electricity consumption information empowers families with multiple avenues to measure, share, discuss and learn how to better manage and reduce their usage.	
S27 • Horne (2019) +/++ • USA					
Observational • Experimental vignette survey	S1: 100 per condition n=300 S2: 300 per condition, n=1200	• Smart meters	• An App	In its transition to a sustainable, reliable, efficient 'smart grid,' the system is integrating increasing amounts of ICT.	• Users of data • App providers
S28 Toft (2015) ++/– • Denmark					
Observational • Interviews	24 households	• Smart grid	• Geothermal Heat pump	One of the key elements of the Smart Grid is that electricity consumers make some of their consumption available as flexible capacity to balance the grid. Consumers' flexible capacity is only available to the grid if the consumers adopt Smart Grid technology (SGT) that establishes the link between the electric system and the consumer.	• Not stated

Type of study	Number of participants	Type of intervention	Components of intervention	Aim of intervention	Users of data
S29 • Valor (2019) –/– • Multiple locations					
Review • "Exhaustive review"	K =100+	• Interactive feedback (via displays, apps, web portals etc.)	• An App • In home displays • Web Portal	To design domestic energy/ eco feedback displays that are "more effective in creating the desired household behavioural change to maximise energy conservation."	• Not stated
S30 • Van Aubel (2019) ++/++ • The Netherlands					
Observational • Case study	National	• Smart meters	• Central administration • home energy monitoring device • In home displays	To discuss the how and why certain choices have been made in the Netherlands, in relation to roll out of smart meters	• Not stated
S31 • Vermont Trasco LLC (2014) ++/+ • USA					
Observational • Case study	Reliant 600,000 ENO 150,000 SVE 21,000 CMP 600,000	• Smart grid	• Advertising • Community outreach • Critical peak rebate • Customer training • Day ahead • Email information • Incentives • In home displays • Partnerships with local organisations • Programmable Communicating Thermostat • Phone calls • Public meetings • Smart meter • SMS Messaging • Social Media • Software tools • trained customer • Variable rates • Web Portal	Smart Grid Investment Grant projects (aim to) modernise the electric grid, strengthen cybersecurity, improve interoperability, and collect data on smart grid and customer operations.	• Not stated

Type of study	Number of participants	Type of intervention	Components of intervention	Aim of intervention	Users of data
S32 • Walter (2018) +/++ • Multiple locations • Germany					
Review • Systematic • Observational • Survey	101	• Transport • Connected, private cars	• Event data recorder (EDR) • Informative intelligent speed adaption (ISA)	Enabled by numerous connected sensors, new cars offer new functionalities, provide higher security levels and promise to enhance the comfort of travelling.	• Ambulance • App providers • Breakdown service • Car manufacturer • Family • Garage • Police • Hotels • Insurance companies • Traffic control center • Third party organisations
S33 • Winter (2015) +/+ USA					
Observational • Interviews	9	• Smart meters	• Feedback • In home displays • Personalised information • Real time information • Smart meter • Variable rates • Wireless network	Smart meters allow a utility to send commands to the meter, such as turning off the power due to nonpayment of tariffs or reducing the amount of energy available to a home based on the time of day or type of energy use.	• Corporations • Energy provider • Government agencies • Unethical individuals
S34 • Yao (2019) ++/++ • USA					
Observational • Action research	25	• Smart homes	• An App • Co-design • Hardware devices • Policy / regulation • Sensors • System modes	To create smart home designs that address users' privacy concerns.	• Car manufacturers • Third party organisations

2.8 Narrative and realist synthesis

None of the included studies measured numerical changes in outcomes that would be suitable for a meta synthesis. Instead, a narrative synthesis was performed. We identified the patterns and themes in the texts of the included study's findings. Compatible with the realist review approach, we considered the programme theories for studies that aimed to overcome privacy concerns and the common themes of barriers to data sharing. Where evidence was limited, we searched for additional systematic review evidence from related sectors that share comparable problems and issues with privacy concerns to further develop and refine the theories on interventions that would be effective in overcoming privacy concerns, how, for whom and in what contexts.

High order question: What are the contextual factors, interventions (and their attributes), mechanisms, and other mediating/moderating factors impacting on privacy concerns as a barrier to involvement and extent of data sharing in smart local energy systems?

Within this question is a series of lower order- sub-questions which are detailed below:

1. What are the demonstrated or likely privacy concerns of potential and existing SLES (a) users and (b) implementers?
2. What are the key threats to privacy in SLES, and how far have these been shown to be reflected in levels of privacy concern?
3. Do threats/concern around privacy differ as a result of the 'localness' of SLES?
4. To what extent have privacy concerns been demonstrated to be a barrier to involvement and data sharing in SLES and other directly relevant circumstances, and for whom?
5. What interventions have been employed to mitigate concern (and cause for concern) in relation privacy in contexts relevant to SLES?
6. How effective have these interventions been in delivering
   - involvement
   - data collection, use and sharing, and
   - good outcomes for (a) users, (b) implementers, (c) society, and (d) others?
7. What are the mechanisms by which the interventions are thought to work?
8. How has the attainment of outcomes been mediated or moderated by (a) the context in which interventions have been delivered (including to whom) and (b) the attributes of the interventions?

Barriers and facilitators to data sharing through privacy concerns, contexts and factors

(sub-questions 1, 2, 3, 4, 5, 6)

For these questions we consider the specific types of privacy concerns extracted from studies to see how these are demonstrated to be barriers to data sharing and participation.

We used the socio-ecological model (SEM) (Bronfenbrenner 1977) as an organising framework for understanding privacy and privacy concerns in different contexts. What information sharing is appropriate in one contextual domain, may not be appropriate in another. Breaches of privacy could be understood as the inappropriate or unauthorised transfer of information or knowledge from one domain to another. The framework offers a guide to understanding the different contexts of the determinants of privacy concerns and the barriers and facilitators to data sharing where interventions to address privacy concerns could target their efforts. Successful interventions to address privacy concerns would likely be multi-dimensional and address concerns in each domain.

The socio-ecological framework starts with the individual, their personally held beliefs, preferences, sense of self and core values.

The micro system round the individual consists of the closest interpersonal relationships of family and home, around this the meso system two of more systems in which the individual actively participates such as the workplace or community in which they live and the outer domain is the macro system consisting of relationships of wider influence, such as the social and cultural contexts in which the micro to meso are situated.

The included studies suggested that, where there were privacy concerns, these were around the intensification of home-based data collection proposed by smart local energy systems, particularly smart meters, and that patterns of behaviours that could be inferred by this had the potential to disrupt the socially acceptable norms of control over information about oneself in the different domains.

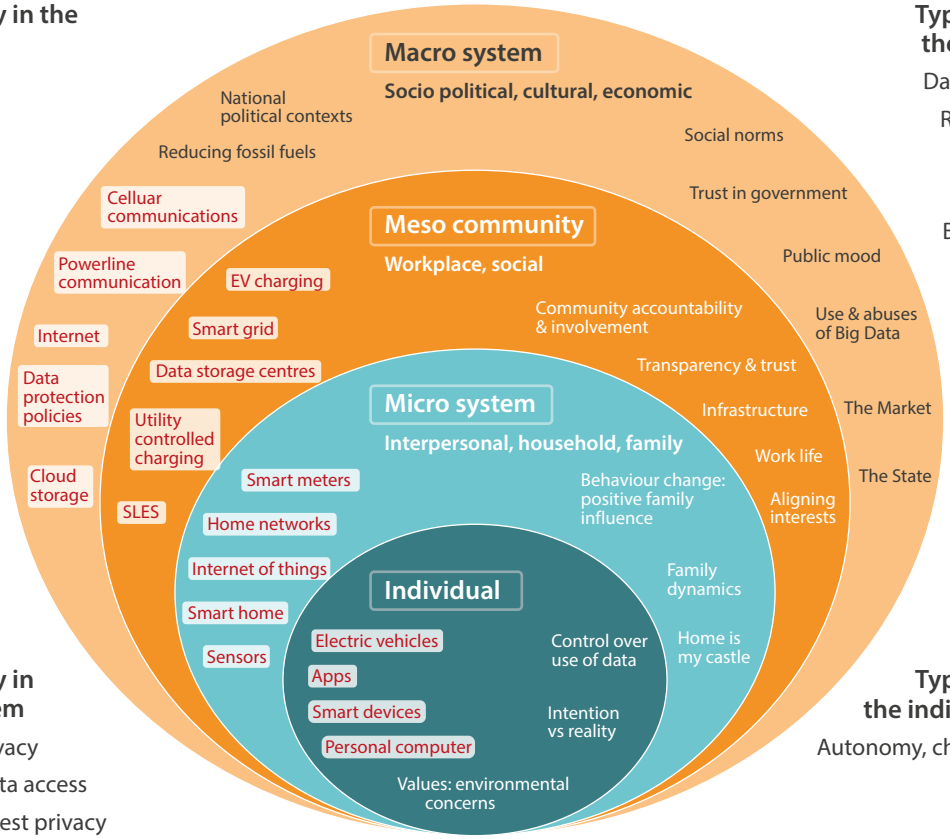
The following chart shows the demonstrated or likely privacy concerns in the form of barriers and facilitators to energy data sharing in these contextual domains. Interventions that overcome or address these privacy concerns then, are those that are hypothesised to facilitate data sharing.

The text in red refers to the technologies in the studies that the domain interacts with. At the most personalised technologies in this individual domain are vehicles, smart devices such as smart phones home computers and apps, which are in the main password protected, owned by, and/ or for use by one person at a time.

Figure 3: Themes emerging from the review.

Type of privacy in the macro system
Surveillance
Discrimination

Type of privacy in the micro system
Data overcollection
Relational privacy
Location privacy
Traceability
Backward privacy



Type of privacy in the meso system
Reputational privacy
Unauthorised data access
(Consumer) interest privacy
Data misuse

Type of privacy in the individual domain
Autonomy, choice and control
Data ownership
Anonymity
Identity privacy

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2.8.1 Types of Privacy concerns in the individual context domain.

The most commonly expressed type of privacy concern (and mechanisms) was around the individual's sense of autonomy choice and control (16 studies).

Control was a term used in diverse ways. It could be described by study participants as control over who has access to information and also having control over what happens to the information after it was collected and/or used and it could also mean being controlled by outside agencies. Privacy concerns around autonomy choice and control attempt to balance the desire to access and benefit from data sharing services with the desire to control the extent of the data shared and limit the uses of that data once shared. These kinds of privacy management behaviours include changing privacy settings where these are available, deleting cookies, choosing hard to guess passwords and other actions to set boundaries around the depth and breadth of data sharing.

Fewer participants expressed privacy concerns around data ownership, which was around having control over the data collection and its use, as well as having the option to delete data (S35). Participants were less trusting of profit-making third-party organisations to work in the particicpants' interests, but did not seem to be overly concerned with the value of the data they shared. few thought it had or could generate value to themselves.

Participants were familiar with the idea of address and account data being anonymous. In one study (S6) nearly all (90%) participants considered anonymity a condition of data sharing and assumed that data would be anonymised as a privacy preserving measure.

Identity privacy referred to more than the technical information of addresses and bank details in anonymity privacy, but are around protecting or reserving the information that could be used to infer who a person is: their interests, preferences, and ways of living (S18).

Some felt this could create a commercial identity profile could be used for segmented advertising and marketing, which individuals would not have visibility of and over time could limit people's choices (S33). (See also consumer interest privacy in the Meso privacy domain and discrimination in the macro domain)

2.8.2 Barriers and facilitators to data sharing in the individual domain.

Perceived loss of control over who can access the data can be a barrier to participation

Even where privacy concerns are low, having a perceived lack of control over data sharing creates concerns. Participants indicated a "principled desire" to be in control of their data sharing such that they would be able to decide, for instance, which parties could access the data under which circumstances. Setting the boundaries around who has access to data and who has ownership of the data, shares both risk and responsibility between the customers and providers through the mechanisms of choice and consent. (Nissenbaum 2010)

> "For now, I don't see any way of misusing my data that could turn out to be my downfall. [...] It would be nice, however, to see what data is transferred or stored. If I can control this, it's on me to decide what may be transferred or used."
> (S16 single-person household)

Perceived loss of control over the use of data can be a barrier to participation

For many participants, costs savings were an incentive to share data, and one way of realising costs savings was through flexible energy demand use tariffs. Included studies that considered privacy and balancing energy demand to access lower charges found that relinquishing control and decision-making over the use of their appliances, or vehicles to balance energy demand was intrusive and disempowering for some people. (S5, S9, S11, S16, S18, S19).

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There were some positive views over giving over some control, if this meant that there was an energy expert overseeing the function of the system and could warn of any issues suggested by higher than usual energy consumption.

Participants expressed a desire to keep control over times of day or that some practices that should not be given over to remote control (S2). For some participants, the thought of losing control over appliances or level of heating in the home was given as a reason for non-participation.

A community-based energy project also showed sensitivity to the fact that not everyone can change their individual energy demands on demand from the community energy systems and the reasons may be unknown to the group. None of the participants suggested that the group had a right to know what those circumstances were.

> "…because you don't know the situation of the people in the house. So just to… choose to switch off someone's electricity… I know that we could make do and we'd be fine… But there are other houses maybe they couldn't or maybe there's something about them that we don't know…" (Frances, S20)

Choice mechanism: options to opt out are often a condition of opting in

In 9 studies participants raised issues over having the choice over setting the boundaries of data sharing, and this was a conditional barrier to data sharing (S5, S9, S16, S18, S19, S22, S23, S25, S28). Even when privacy concerns were low, participants wanted to know what information was being shared with third parties in order to make informed choices in what data to share and with whom and in doing so share responsibility for the data sharing with the vendor (S16, S19). When given the choice, most customers do make some changes to disclosure settings. (S18) Projects noted the need to involve customers at the earliest opportunity to allow them to choose the level of involvement (S9).

Where no choice exists in the form of opt outs, the numbers of people who wanted smart meters dropped by a third in one study (S5, S23). Some people do not wish to relinquish control at any price. Sometimes this is due to the lack of trust in energy providers to work in their best interests (S22) while others do not wish to see their choices limited in their ways of living, such as by lowering heating temperatures, turning off appliances (S25, S28).

> "The one that's fairest to everyone is opt-out, that's the fairest." (S23)

Information and the amplification of risk

When people are given detailed information about potential privacy risks for all situations, this can seem overwhelming, create a sense of lack of personal control and in some studies; participants then withdraw consent. Providing information does not necessarily overcome privacy concerns and can have a negative effect where concerns were low to start with (S16, S19). It was also reported in one study that many of those with a smart meter could not recall the level of consent they gave and a third of the respondents could not recall what level of data they gave consent to share (S5). This is supported by research in other studies that finds that people do not tend to read the terms of a conditions and or do not understand them fully when they do. When faced with the terms of conditions, another study found that people would withdraw their consent at the point in time that the terms and conditions were presented to them(S18).

Increasing knowledge (mechanism) by providing information is mediated by the trust in the sender.

Additional review evidence on technology use and acceptance, find that "privacy perceptions influenced trust, which in turn influenced the perceptions of risk" (Thiesse 2007). As perceived risk ultimately impacts on an individual's intention to use, this was a negative predictor of new technology use and acceptance. (Pavlou 2001). The individual's trust in the sender of information about risk influences their decisions about the balance of risk and rewards and intention to use the technology.

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Research on risk and decision making suggest that people base their decisions on risks and potential hazards on a range of different "signals", not only technical information. In theories of social amplification of risk (Kaspersen et al 1988), the risk can be amplified (or attenuated) at two stages: the first is at the moment of transfer of information about risk, the second is at the stage where the individual processes the risk signals, through what they know through the media, cultural norms and values, direct and indirect experiences of the risk and hazard being communicated, and finally trust in the persons or organisation communicating the risk. Technical or legal information is combined with these other factors when individuals make their assessment of risk.

Knowledge is a mechanism for data sharing, and can be a barrier as well as facilitator.

People's prior experiences and direct knowledge of data sharing affects their decisions and understanding of potential risks. Increasing the practical knowledge of how technologies work can alleviate privacy concerns.

Few people had reported that they had personally experienced a data breach but those that had, had less support for smart meters and data sharing (S13). Knowledge around data sharing and privacy was generally low. People had little knowledge of what opportunities and benefits there were in data sharing as well as little knowledge of the energy efficiency of appliances and actual prices of services (S3, S7). On the other hand, people who considered that they had a good understanding of how things worked were more positive towards data sharing (S6, S5) People who were more positive towards technology use general, were less opposed to smart meters (S13).

When asked about what the most important elements of informational campaign to introduce smart metering systems, participants said it was knowing more about how they worked (S2). People who have the smart meters (and know more about how they work in practice) are more willing to share data. (S5)

Privacy controls are a part of life

Several studies show that people are already familiar with settings and controls over their data sharing. Nearly all participants in studies that were offered options to adjust controls over data sharing did so. Some participants accept that controlling privacy and access controls may be necessary as well as being inconvenient even annoying, (S33). Most people shared information informally with friends and neighbors to compare energy use, costs and efficiencies of appliances and so on. People felt that sharing of data to third parties was a fact of life, even if they were not necessarily enthusiastic about it (S23) or felt that it was largely out of their control. However, it is worth noting that participants in seven studies were selected for their prior knowledge of smart meters, or similar data collection technologies, in order to have an opinion about them. (S2, S17, S18, S22, S26, S34). As a result, people who are already comfortable with using technology (and privacy controls for them) are likely to be over-represented in research about data sharing technologies.

In one large UK based study, People who do not have smart meters believe them to collect intrusive data but people who have smart meters are less likely to believe this (S5). As this is comparing people who have meters with people who do not but not comparing attitudes before and after, we do not know whether (a) privacy concerns were a barrier to participation for the people who did not have the smart meters, or (b) that privacy concerns are allayed for customers once they get them, as they are get to know how they work or that privacy is no longer a concern at all given how useful and integrated into usual routines it becomes, like other data sharing technologies in common use.

Trading privacy risk for rewards: Cost savings

Saving money is often cited as an incentive for the enrolment in initiatives that require sharing private data but the evidence on how they achieve cost savings is mixed.

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People tend to be willing to share data for cost savings from paying only for the energy they have used instead of estimates and forecasts, and changing consumption patterns to cheaper tariffs at different times, but there is less sustained behaviour change in reducing consumption and some reluctance to allowing energy providers to decide energy saving consumption patterns for them.

However, there is a danger that low energy use customers will be unable to realise any cost savings if they cannot reduce their consumption further and/or are unable to change their energy use habits e.g. Single, older people (for whom cost savings were more of a priority) people on a low income who are operating their energy usage at a minimum already, people with caring responsibilities, people at home with health conditions that have higher heating needs.

In order to anticipate energy costs savings, customers should be able to anticipate what sorts of savings they are likely to make before consenting to share data in exchange. A 2018 Systematic review of Consumers' perceptions of energy use and energy savings in the area of energy savings strategies suggest that people are not very knowledgeable in this area, and tend to underestimate energy usage in high energy using devices and overestimate energy use in low usage appliances (Lesic et al 2018).

Mechanisms of personal values can facilitate data sharing

The review found 4 studies that said that people who were concerned for the environment were more likely to engage in data sharing and were less concerned about privacy. These individuals were sometimes described as intrinsically motivated, that is, participating towards the benefit of the environment was its own reward but some participants also respond to seeing proof of environmental gains, and being seen to "do the right thing". However, the sustainability of exchanging privacy for environmental gains is not clear. Two studies measured behaviour change.

One found that students who belonged to an environmental group performed better than non-member participants, in reducing their consumption of energy when energy use data was made public. It was not clear whether the positive behaviour change was sustained over the longer term. The other study showed that people with pro-environment values were less concerned about privacy and had a higher enrolment rate in utility-controlled charging for their vehicles. The other two studies tended to ask people about their future intentions, or reactions to hypothetical situations.

Looked at another way, the social desirability of having concern for the environment should be considered a potential source of bias in surveys that ask people about their values and associated future intentions. While beliefs and values are predictors of future behaviour, there exists a value-action gap between what people say they is important to them and acting on it when given an opportunity to do so. Studies that have identified this value-action gap related to environmental and climate concerns include: waste recycling at home (Barr 2006), school (Chan 1996), college (Bogo 1999), city (Chan 1998) and in the community (Blake 1999); eating meat (De Waal 2017); hydrogen energy (Flynn 2009); transport (Anable 2006); electric vehicles (Lai 2015) and more. There appears to be a weak relationship between pro-environmental values and sustained behaviour change.

2.8.3 Privacy concerns in the micro, interpersonal context

Types of privacy in the home domain were concerned with included: location privacy – i.e. that data may reveal the physical location of the home to inappropriate individuals; traceability – i.e. that data breaches and subsequent inference may reveal information about the household ; and relational privacy – i.e. that data contains information about oneself that manages the norms, roles and expectations of one's relationships with others. Relational privacy mediates the choice and control over who one enters into relationships with.

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Second only to the individual sense of self, autonomy and control, studies revealed that the home was considered a reserved space, and can be guarded on principle without any direct or specific threat to privacy identified. Home was described as a "castle" a refuge, protected, and private space for peaceful enjoyment, and non-interference (S4 S18, S22, S29, S30, S32, S33.) Vehicles enjoyed a similar level of privacy that was valued by customers.

> "The fact that the electric company can tell when I've turned on the dishwasher or a light bulb or the TV- that's pretty fascinating to me. I don't know how they do that, but do I want them to know that? well it's not a bad thing. It's still a private thing…" (S4)

2.8.4 Barriers and facilitators to data sharing in the micro Interpersonal system, family and home contexts.

Positive family influences as a facilitator to exchanging privacy for benefits of reducing energy consumption

There is some evidence of enthusiasm to share/view data on household energy use for the purpose of comparison with other family members. There was (at least initially) interest in knowing how much energy different devices used, and in educating family members in energy use. These studies usually asked participants about hypothetical scenarios and intentions to use so It is not clear to what extent the change in household energy use is sustained in the longer term after this initial enthusiasm. (See also privacy exchange for cost benefits through behaviour change in the individual domain.) Some studies showed that the initial enthusiasm waned after the implications of detailed energy use data sharing became apparent. (S4, S18, S21, S22)

Customer engagement: communication of benefits by household

Several studies indicate that people were reassured of their privacy concerns with personalised and detailed communication about the purpose, use and benefits (S2, S3, S6, S9, S17 and S18) personal visits were preferred in one study (S2) with over half of the participants saying that they would like detailed information on how the system worked, and would enable fast detection of faults and repairs, while older people preferred communication by letter followed by a visit (S2). Communication of benefits needs to be tailored to the household. People were disappointed and surprised in one study that the smart meters did not seem to be compatible with other smart devices in the home, and felt left to their own devices to work out how to make the system work, with concepts that were unfamiliar to them (such as using if-then-else algorithmic logic) (S17).

Family dynamics: maintaining relational privacy within the home

There is some recognition of the potential for privacy issues to arise when data on activities etc. are shared within households as well as to third parties. In households with multiple users, there may be as many different privacy concerns and energy saving or cost saving priorities (S26) and a model of the consent with the sole "bill payer" may not reflect the diversity of risk and benefits of sharing energy usage data within the household. One participant in a study of a smart home co-design (S34) expressed concern over other members of the same household being able to access to her credit card details, and suggested voice recognition as an authentication that could allow for multiple users.

Detailed energy use data could reveal patterns of behaviour that family members would wish to control or limit visibility of under typical circumstances, such as adult content TV viewing or who is (or isn't) doing the chores around the house (S4).

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Detailed and real-time energy use data could enable some family members to monitor and control the behaviours of other members of the household in ways they were not able to do before and may not be welcome by other members of the household. (S26)

> "So… he monitors it all on his thing (computer) and it drives her insane! So, she thinks its dreadful, she feels violated all the time, cos his workmates will be walking past his desk. One even called her one day saying 'Wow Kay, your power is going through the roof!'" (S26)

Such technologies that can reveal patterns of behaviour, location or control over devices and will need to consider how such technologies can be used as "vectors of control".

As there was little direct evidence from the energy sector on the impact of energy data collection on coercive control in the home, although this was indicated in the disquiet of members of the household, aware that there could be a shift in power through information within the home.

Research on the use of smart technology for coercive control in the home is limited, most likely due to the fast-changing pace of new smart technologies for the home being developed, but the UK charity Refuge had already identified that 72% of their service users had experienced some form of technology-mediated coercion and control. In response and in consultation with domestic abuse charities, IBM has recently published a report (2019) on Coercive Control Resistant Design Principles' (Nuttall et al (2019) which, in the context of providing smart local energy are:

- **Diversity**. SLES providers should recognise their diverse user base and have a diverse development team.
- **Privacy and choice**. SLES providers should empower all of their users (not just the named "bill payer") to easily make active and informed decisions about their privacy settings.
- **Security and data**. SLES providers should build secure technology, and only collect necessary data, which will limit the risk that the data can be intercepted and/or be used maliciously.
- **Combatting Gaslighting**. Data collection and control over data should disrupt attempts at manipulating someone into doubting their memories and judgement with pertinent, timely notifications and auditing. I.e. there should be limits to deletion of records of activity.
- **Technical ability**. SLES providers should ensure that the use of the technology is intuitive and can be understood by all who could be affected by it, regardless of their technical confidence.

Home occupancy

Participants in four studies (S18, S19, S20, S21) expressed concerns that there a was potential vulnerability to criminals who can use detailed energy use data, i.e. patterns of no or very low usage data, that could show when the resident is not in the house. But this was an aspect that was only superficially explored in the studies.

> "…They could even 'see' when you are going to bed [by seeing when you] switch off the lights." (S18)

2.8.5 Type of privacy concern in the Meso system

Reputational privacy is difficult to define. The person whose reputation is in question may be largely unaware of it, except when it is perceived to be damaged. This includes the control of information about oneself that effects one's good standing in others' opinions. Reputation represents a shorthand heuristic for the confidence that can be placed in us to "do the right thing" or to be trusted and for this reason reputation has value and is to be protected.

The internet, the web, and records held in digital form provide an element of risk to privacy and reputation not seen before. Digital records offer greater levels of access to a greater number of people and makes the diffusion and lifespan of information difficult to control (Kirly 2015).

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Nine studies considered reputational privacy or related privacy concerns in the meso system of community and workspace (S3, S4, S7, S20, S22, S23, S26, S27, S30).

2.8.6 Barriers and facilitators to data sharing in the Meso system of community, social group, workplace contexts

Peer pressure as mechanism can be positive or negative

People tend to be willing to share energy data with family, friends and neighbors to make comparisons of technology (demonstrating little privacy concern in this kind of data sharing) (S7, S22, S25, S27) Comparing new technologies can be a conversation starter, a way of learning about how technologies work and their functionality and other people's experiences of them, perhaps show them off, but there was less interest in their energy use (S25). Learning that a technology is widely used suggests that its use is a socially acceptable, and so the risks are assumed to be less (S27). Sharing knowledge can foster a supportive environment where individuals learn and get recognition from their peers (S7), and feel part of a collective good (S20).

Only one of these studies was based on a community energy project and considered peer pressure in the context of a community project, with the other studies mainly limited to participants' views of their future intentions and hypothetical scenarios. The study of community energy in practice also cited some negative effects of peer pressure which could impact on one's reputational privacy in the community. Willingness to share energy use data with neighbors declines as individuals consider how this data might be used.

> "Sometimes it feels a bit futile if you don't think anyone else is doing it. So, I think if you know that other people are doing it, it makes you feel you're having a bigger impact." (S20)

> "You can also see it as an invasion of your privacy. Someone is going to meddle in. You might experience some sort of social pressure on the way you do your housekeeping." (S22)

Trusted third parties for data use

Participants in several studies were more trusting of organisations that did not have a vested interest in energy to handle their data. These included government agencies, consumer organisations, and environmental organisations (S23). Study S5 included police as a trusted organisation that could have access to energy use data to identify some kinds of crime and that data could be shared with health care providers for vulnerable customers would be acceptable.

These organisations were seen to uphold standards, to be neutral, and provide safeguards, S3 found that a regulatory framework provided reassurance (and overcame privacy concerns) to customers that appropriate safeguards over their data were in place.

Other studies suggested that the energy provider could be the trusted organisation, but that the more organisations that were involved posed more of a risk to data in terms of misuse and data breaches.

Local Energy provider as trusted expert

Rather than being seen as intrusive, input from local energy providers as experts may be welcomed where this helps with complex or unfamiliar technologies or provides a clear benefit, such as monitoring for safety or spot unusual consumption patterns that could indicate a problem, and could even harm the user experience if this expert oversight was absent when it was expected (S11, S18, S22).

> "We have those sensors in the rooms; then I see it as natural that they look if it runs alright. Or are they just letting everything run without even keeping an eye on what is going on? There must be a reason for why we have sensors in various rooms." (p7:S11)

Local Energy provider trusted as community energy arbiter

While community control and accountability can be appealing, it requires time and effort (S22, S30). Some energy users expect this to be part of the service provided by energy companies (part of the premium), particularly enforcement which can lead to ethical issues or could create unpleasant environments when done by peers. Energy companies can provide the middle ground, neither too close or too distant. this means that relational and reputational privacy between the members of community's energy groups can be maintained by being released from responsibilities of monitoring and disciplining its members (S22).

In S22, participants pointed to the energy company as arbiter in "conflict situations" that can arise in the absence of formal rules and with "a lack of authority over someone else's roof". Energy companies could serve to provide the "new balance" that allows for more de-centralised and democratic control over energy production (S22).

> "...If you have the ambition to become energy-neutral, then you need to have an element of exchange. And if you exchange, you need an institution to organise that." (S22)

Barriers and facilitators for providers

Aligning interests. Positive outcomes for SLES providers are mediated by public support

Without the right incentives or regulation, there was a general shared feeling that companies may prioritise their interests at the expense of their customers' interests, which may have a self-defeating impact on uptake (S5, S11, S14, S16, S18, S28, S30). Customers believed that the main benefit was likely to be to the energy companies and not to themselves (S18, S28), or at least not enough benefit to make any disruption or change of energy use habits worthwhile (S5). Study aims of providers suggested that without widespread support from the public, the commercial benefits of SLES may not be realised (S16, S30).

Work life

Only one study suggested privacy concerns around work life could be a barrier to data sharing, in one area it suggested the use of energy use data could be used to over-monitor workers' behaviours, employers could use energy data to monitor employee behaviours, time spent making coffee, for instance, and in another it suggested the differences in the appropriateness of sharing data for professional purposes compared to personal use. (S18). In vehicles, the Event Data Recorder (EDR) was acceptable in professional vehicles, but most refused to equip their private car as they perceived this to be an invasion of privacy.

As mentioned in the relational privacy in the home, this detail of data collection has a potential to be a vector of control, in providing opportunities for more surveillance than would be expected than in private life. On the other hand, Increased patterns of home working is likely to blur the distinction between home and work-life, and home and work energy demands. Before Covid-19 figures from the Office of National Statistics (ONS 2018) show that 13.7% of the UK workforce worked from home part of an already rising trend. (The latest figures from ONS, 2020 under Covid-19 now shows this is now 46.6%). Homeworking may become the default for those that can at least for the foreseeable future.

A systematic review (Hook 2020) found that home energy use may reduce the climate effects of commuter travel. But these benefits may be offset by increased energy use in the home in terms of heating or ICT use and in the longer term perhaps longer commuting times on non-teleworking days.

In more direct impact on privacy, people are likely to share their home with others who are not part of the same organisation and confidentially and security of data may be at risk in the home. There may be security issues around the transmission and storage of data and the use of personal devices for work use. This was a concern raised by organisations, but not for individuals.

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Pro-active communication and outreach

Most of the information on types of preferred communication came from one large study of four case studies with several thousand participants (Vermont Trasco S31). The case studies described lessons learned in the implementation of community wide smart local energy systems, however, privacy was discussed only briefly. The study found that customers want simple, timely and tailored communications (e.g. weekly emails about bills). Customers valued reliable and predictable bills, weekly emails were appreciated to avoid monthly "bill shock".

It was clear that there was no one-size-fits all solution when it comes to channels of communication, with some customers preferring self-guided means of accessing information, while others preferred active communication from the energy providers. Web portals were more mixed in their success and their overall effectiveness was still "an open question" customer requests were for website interfaces to be easier to understand and use than currently.

2.8.7 Types of privacy concerns in the Macro socio-political, economic and cultural context.

The types of privacy concerns that related to the macro, socio political economic and cultural contexts were surveillance and discrimination by social, political or market stratification. Concerns around surveillance talked about government spying and "Big Brother" a general unnerved sense of being watched, or investigated without any specific reason. (S2, S6, S12, S14, S18, S20, S22, S24)

Data used to discriminate against individuals included price and product discrimination, where individuals were presented with different offers and tariffs based on their membership of groups of similar types. This erodes individual's choices and rights by being subsumed into broader political, commercial and social groups. There were concerns around not being able to know that they were being treated in non-preferential ways, and so would be unable to challenge or rectify this.

2.8.8 Barriers and facilitators to data sharing in the Macro socio-political, economic, cultural context.

Social norms

Social norms are defined as the " rules and standards that are understood by members of a group, and that guide or constrain social behaviours without the force of law" (Cialdini and Trost, 1998, p. 152)

In a review of reviews on social norms (Legros and Cisaghli 2020) authors found general agreement in the reviews on what social norms were: in that they incorporated some element of "social"; that they usually help with decision making in some way, most of the reviews said that they incorporated an understanding of cooperation and social, order, and that social norms effect people's wellbeing. On the other hand, social norms can encourage negative behaviours, such as smoking or drinking alcohol, discrimination, even violence against socially perceived outgroups. Expectations of social norms are not seen to influence participation more than individual beliefs about technology, concerns for the environment and incentives. Widespread adoption may help establish a social norm and expectations that something that is widely used, or approved of by their friends, can be assumed to be trustworthy.

The impact of increased individual understanding of smart meters however was contradictory in this context as it both reduced the demand for social norms by emphasising individual decision making, whilst simultaneously increasing the expectation for social norms against smart meters when more was known about the types of data they could collect.

Social norms around privacy and data sharing technologies are an influence on people's decisions that there is societal consensus that privacy is an important aspect of life that should be preserved. Social norms can take time to catch up to the new challenges of emerging technologies and their uses.

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Companies that use data in novel ways may find resistance from customers who find its use "creepy", in that its use may be legal but not generally considered acceptable (Le Zion and Polonetsky 2014).

In related systematic reviews, social norms were found to have a significant effect on a range of pro-environmental behaviours and people who expressed environmental concerns appeared to be less concerned about data sharing. In defining social norms, the review adds to the definition given above the idea that social norms are something that is conditionally followed, and motivated by external (vs. internal) enforcement.

What people approve of doing (injunctive norms) and what people actually do (descriptive norms) can be considered another expression of the values-action gap.

For people who looked to social norms to decide whether new technologies are generally accepted, there is a risk of over or underestimating the general consensus view.

In the review of reviews of social norms, Legros and Cisaghli 2020 Correcting misperceptions was, by far, the most commonly cited mechanism across the reviews.

Social norms can be influenced, or corrected for misconceptions in normative beliefs by sending/ receiving more accurate information as Individuals can over-estimate the approval or disapproval of others in the same social group to reflect their own beliefs. Injunctive norms are commonly more effective in changing behaviour as they signal clearly the approval or disapproval of the group in taking a given action. And Injunctive norms are more effectively used in interventions when framed positively. (Cialdini 2003). By focusing only on the negative behaviour, one wants to change signified that it is a social norm, so, for good or ill, acceptable.

The correcting misconceptions was often used by health interventions that encourages change in behaviour by demonstrating that fewer (or more) people than thought engage in the behaviours.

Knowledge, understanding and acceptance is mediated by the public mood

Three studies considered the impact of the public mood on privacy and data sharing (S3, S5, S20). All consider the recent impacts of negative experiences of data sharing on general acceptance and participation in smart meters (S20), smart grid (S3) and energy markets, particularly in switching (S5). Negative media stories could communicate more widely any problems and issues around privacy and data sharing, effecting societal acceptance. For people coming from a low-knowledge base of energy systems, these media stories could be the main source of information for people on the risks of data sharing with energy companies. The intensity of the telling and retelling of news stories of data breaches and online privacy violations may amplify this perceived risk (Kasperson et al. 1988; Renn et al. 1992) to a wider group of people, and now other more platforms such as Twitter and Facebook (Chew and Eysenbach 2010). Recent examples of include how smart meters are represented in UK media, on both left and right, media stories around smart meters with headlines of "is your smart meter spying on you?" Guardian 2017, "The smart meter snoopers: already in homes as part of a little known 20m plan to track energy habits" Daily Mail 2019.

The market

Allowing market forces alone to govern the types of in home displays available to customers to help them change their energy use behaviours may have been the reason uptake has been slow and the projected energy savings were not realised [38].

In the same study, it was suggested that competitive tendering needs to balance being specific and being realistic about the level of security that is required: being too specific could limit the market actors that can meet such high standards and so raise prices, and yet leaving the requirements too vague would lead to a "race to the bottom" in terms of pricing and standards.

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Manipulation of the goods and services displayed to the customers via targeted advertising, was generally unpopular. (S18, S22, S32). The balance of market forces and regulation, are also context specific, UK rules on using data for marketing goods and services falls under GDPR, which states (amongst other things) that "Marketers must offer a clear opt-out, inform the individual of the processing activity and have a compelling case for why someone may be interested in their goods or services.".

Trust in governments

Trust in government represents confidence of citizens in the actions of a "government to do what is right and perceived fair" (Easton, 1965).

There were mixed impacts of trust in governments: In some cases, a lack of trust in government may encourage the independence offered by SLES individually or in community projects. More frequently however the distrust of technology that passes data to government (e.g smart meters) may discourage participation in SLES.

Many of the studies reported that there was a general fear of surveillance, but this concern was often non-specific, a general unnerved feeling of being watched or of a creeping of authority and surveillance into the home, sometimes described as "Big Brother". (S2, S10, S12, S30).

Big data

The sharing of data for one purpose did not raise concerns, however combining with other data sets to form "Big data" did. Such large-scale data uses could socially, politically and economically "sort" individuals, leading to discriminatory practices that, being a commercial practice, would be subject to less scrutiny and regulation than that of data collected and used by the State. This may limit the choices available or make correction of mistakes near impossible as this segmentation would be hidden to the individual.

> "I have nothing to hide. It is just that connections will be made between different databases. That will result in a profile… For many that profile will be just fine, but for a small minority this profile will mark them as terrorists!" (S22)

A systematic review of the potential applications of Big data in smart energy management reported potential benefits, (Zou 2016) also listed security and privacy as one of the most serious challenges. The review suggests customer ownership of data as a right, and customer data used only with explicit permission, it also suggested external governmental regulation and industry self-regulation as possible solutions.

Trust in corporations

With regards to data sharing, profit-making organisations tend to be trusted less. It was safer by default to distrust them until one knew more about them or it was based on experience, than other data users (S23). Organisations with a vested interested were the least trusted (insurance companies for vehicles and advertisers for across the board) (S23).

At a national level, opting out is a condition of opting in

Public opposition is heightened where there is no opt-out provision. Providing 'opt outs' that require consent to share data will likely reduce public opposition to smart meters but perhaps at the expense of slower uptake.

Where the implementation of smart meters was compulsory, this was met with organised, public resistance, that was enough to delay national implementation (Netherlands S14, S30, S12 Canada, USA, S29 European countries).

In Germany (S18), where smart meters are mandatory for large energy use customers, new builds and existing structures undergoing renovation, privacy and data security concerns were a major reason for the late introduction of an opt-out clause for customers (although not for large energy use customers or prosumers).

National case studies of implementation of smart meters in the USA consistently found that giving customers the choice of opting out was a condition of opting in. But opt-out rates were also lower where there were financial penalties or costs of opting out.

Data policies

The regulatory environment and parliamentary deliberations applied to data sharing may affect perceptions of risk by the public and therefore the expectations of privacy protection that govern policy decisions (S14, S18, S25, S30). Data policies in a single country may fall foul of regional, e.g. European laws. in study S30 the Initial proposals of laws for smart meter rollouts did not consider consumer privacy beyond the Dutch data protection act and conflicted with article 8 of the European Convention on Human Rights.

Demographic factors that impact on data sharing

Sharing the benefits: "Hard to reach" or "far to reach" groups

All demographic groups expressed concerns over data privacy and there were no specific demographic characteristics that made people more likely or less to share data than others. Across all social groups two factors indicated reluctance to share data: prior knowledge and experiences of data violations.

Most of the participants in the studies were well-informed, "tech-savvy" and already engaged in technology and data sharing, often this was a condition of participation or participants self-selected into the study based on their prior knowledge and interest in the topic. Groups that were underrepresented in studies were those groups that are often described as "hard to reach". Groups that are hard to reach are at risk of social exclusion or isolation and in the context of technology or SLES may be left behind from the benefits of shared decision-making and a decentralised, more democratic energy system.

The definition of hard-to-reach is not uncontested, it will vary from place to place and understandings may differ based on the level of their "hard to reach-ness" (One reconceptualisation of hard to reach is "far to reach", which places the emphasis on the service provider to make the effort to overcome barriers. (Coe et al. 2008)

People with a low income

People in lower socio-economic groups in the included studies said that they were less likely to be aware of the data sharing choices available with smart meters. Research from related areas suggest that people with a low income are less likely to have the technology resources that would gain confidence in the privacy implications of data sharing on the other hand, people on low income are more likely to rely on data sharing technologies that are insecure (such as cheap, older smart phones). In one survey of US low income privacy attitudes, lower income groups were more, not less concerned for potential privacy violations that their wealthier counterparts as they were aware of the privacy risks but felt they had little choice in the technologies available to them. (Pew Research 2015)

Fuel poverty Organisations such as National Energy Action (NEA) campaign for Action for Warm homes recommends sharing of energy use data to support fairer, accurate and transparent billing, and to give greater control over energy consumption. (NEA 2020)

Older people and technology use

Barriers and facilitators for older people identified in these studies included a greater interest in saving money than for environmental concerns (S2) (people who are more environmentally concerned are less concerned about privacy when saving energy). This is also found in other research that says that environmental concerns and active participation (joining environmental groups, outdoor recreation activities) declines with age. (Johnson 2004)

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Older participants expressed more expectations of (social) norms against smart meters, (S15) but as with other groups, individual assessments of risk were more important than perceived social norms when making their decisions about smart home devices. (Klobas 2019)

Evidence from related sectors show that families are often involved in decisions in using home-based technologies, such as assistive technologies (Abrilahij and Boll 2019, and providing additional support on tailoring the technology to meet individual needs encourages its use. (Kloblas 2019)

Older people's incentives to share data may differ to younger people priorities: families may welcome the opportunity to remote monitor their loved one to alert them to safety or health issues by tracking usual activities (S4, S18), but older people themselves had mixed feelings about data sharing from not wanting to be a burden, to feelings that an over reliance on technology could replace human contact. Older people were generally positive about the benefits of smart homes for assisting with independent living and health monitoring. (Pal et al 2017)

The principal-agent problem. Who pays and who benefits are at odds for tenants in the private sector

There was no direct evidence of privacy concerns being barriers and facilitators to tenants in the private rented sector in the energy related studies. In related sectors, a systematic review of the tenant and landlord perspectives of energy efficiency interventions points out that in areas of high demand tenants may not feel in a position to bargain or negotiate with their landlords over sharing data for energy efficiencies, particularly if there are installation costs involved., In terms of privacy concerns, suggesting that tenants engage with sharing energy use data and install smart energy technologies may infringe upon their relational privacy between the landlord and tenant in unwelcome ways.

Tenants may not feel that any disruption brought about by installation is worthwhile if they are not staying in the property for a long time, or they may fear retaliation in their tenancy not being renewed if they develop a reputation for being troublesome. There is a mismatch between the investment of the landlord and the beneficiary of the tenant in energy efficiency measures. The so-called principal-agent problem.

> "If the potential adopter [of energy efficiency measures] is not the party that pays the energy bill, then good information in the hands of the potential adopter may not be sufficient for optimal diffusion." (Jaffe and Stavins 1994).

The review suggests that private rented tenants, without a central unified tenants association, are in a poor position to negotiate with landlords, and not necessarily uninterested in data sharing.

The review suggests that economic and regulatory incentives as well as working with both the landlord and tenant are likely solutions to this problem. More barriers to landlords include the time as well as financial investment needed when there is a high turnover for tenants as technologies would fall into disuse over time as tenants change fairly frequently. (McCarthy et al 2016). According to the Office for national statistics, younger households are more likely to rent privately, with those in the 25 to 34 years age group representing the largest group. The private rented sector accounted for 20% of households in the UK. (Family Resources Survey 2017)

Tenants in social housing

UK Government figures for the proportion of households renting from social landlords were 17% of UK households (3.9 million) in years 2016 – 2018. The average age of social housing tenants tends to be older than for the private rented sector. The Average tenancy length in social housing is 11 years compared to 3.9 years in the private sector. (Ministry of Housing, Communities and Local Government 2018)

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While landlords in the private sector may be reluctant to install data sharing technologies for their tenants, social housing landlords appear more enthusiastic (Burns and Hood 2017). There are benefits of economies of scale and stability of tenure compared to the private rental sector.

In related systematic reviews, McCabe et al 2018 found that social housing tenants were more motivated by cost savings than environmental concerns (this may be a function of the older average age of social housing tenants). Tenants were willing to respond to energy use feedback, but this was sustained only with ongoing engagement and education efforts. (Bahaj and James 2007 in McCabe 2018)

Lack of genuine engagement and involvement of social housing residents in the development and implementation of renewable energies led to declining trust and a lack of belief in the benefit of engagement, which in turn led to little or no change in energy use behaviours. (Moore et al., 2015, Pickvance, 2009, Wheal et al., 2004 in McCabe et al 2018). Residents may not have had much of a choice, an intrusion on their relational privacy, about whether to share data or not, but they were able to resist in-kind with non-participation in adapting their energy use behaviour. Social housing residents who were characterised by being elderly, fuel poor, high heat users may be less likely to engage in or benefit from sharing data without additional support.

The review suggests that implementers should be careful not to "oversell" the positive outcomes expected. (Pickvance, 2009, Owen et al., 2013 in McCabe 2018). Providers who work with and involve social housing tenants, cost-in and provide ongoing support, education, training and maintenance of the technologies were more likely to be successful in achieving tenant's acceptance and engagement. (Owen 2013 in McCabe 2018).

Theories of change in studies

(Sub questions 7, 8)

There were few studies that directly addressed people's privacy concerns with interventions designed to overcome them, instead studies described privacy concerns around data sharing technologies as potential barriers and facilitators to technology use and associated data sharing. Mechanisms were the behind-the-scenes, cognitive, emotional or behavioural "triggers" that act as elements in decision making balancing privacy concerns with benefits of data sharing.

Privacy concerns were related to the perceived individual and social consequences that an unauthorised sharing or use of personal data would have in different contextual domains. As data sharing technologies are not without risk, interventions to overcome concerns about the impacts of privacy breaches would be successful if they can minimise the impact of any potential breach of privacy by design as well as understand the how different types of privacy concerns are incorporated into people's decision making about sharing data.

Thirteen studies explicitly referred to a theory of how interventions to address privacy concerns could work, Nine studies cited social theories and theories about individual behaviour.

The theories in the studies could be grouped into types of mechanisms across continuum of entirely social influences on behaviour to entirely individual.

Social behaviour mechanisms were bound up in social norms to provide a framework on the general consensus on what is approved or disapproved of, whereas theories of individual decision making were bound in rational choice decisions of calculating risks against the rewards.

Privacy ethics lie between the normative understanding of social norms (what one should do) and individual decision-making (based on rational and free choice).

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These ethical frameworks provide the guiding principles on differential impacts, by which different stakeholders can deliberate over what the risk and benefits of novel technologies could be in the absence of established social norms, legal and frameworks and without direct experience or full and perfect information. They are conditional in that they depend on the current contexts and technology being reviewed at the time and may change over time.

Five of these were studies smart meters (S10, S12, S15, S18, S33), three about the smart grid (S11, S22, S28), two studies were about incentives (S16, S19), one study on energy governance (S25), 1 study was about public vs private energy use feedback (S7), and one study was about views on demand side response (S8).

	Social theories of behaviour		Individual theories of behaviour
Technology	**Normative**	**Conditional/ relative**	**Rational Choice**
Smart meters	Theory of "phantom risk" (S12)	Technoethics (S33) • The Framework of Contextual Integrity	Theory of Reasoned Action (S10) • Perceived behaviour
	Social norms (S15)	Theory of procedural justice (S10)	Technology Acceptance Model (S10) • Perceived ease of use and perceived usefulness
		Theory of social practice (S18) • Usable privacy	
		Risk perception (S10)	
Smart grid	Theory of "phantom risk" (S12)	Scripting- in-scription / de-scription (S11)	Innovation Diffusion theory • Innovation adoption theory (S28)
		Social practice (S22)	
Incentives			Game theory (S19)
			Non-cooperative game theory (S16)
Energy governance		Social contract theory (S25)	
Feedback (Public vs. private)	Social norms • Theory of normative conduct (S7)	Theory of warm glow altruism (S7)	
		Theory of true altruism (S7)	
Demand side response			Theory of planned behaviour (S8) • Locus of control

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Theories of social behaviour

Known, unknown and unknowable risks (S12)

Programme theories around trust included the theory of "phantom risk". This theory aims to understand why there may be a lack of trust in expert opinions by lay persons on risks associated with an unproven (sometimes disproven) causes. Examples of this include wireless radiation associated with mobile phone masts, In the context of smart meters, public opposition cited fears around potential causes of health risks as well as fire hazards, loss of jobs, threats to security (theft) which expert opinion dismissed as non-existent to minimal.

The theory of phantom risk indicates that other factors than privacy concerns alone may underpin people's concerns and non-acceptance of technology such as lack of power and agency, sensationalist stories in the media and lack of knowledge around the technologies (Elvers et al. 2009, Cousin and Siegrist 2010, Claassen et al.2012 in Hess 2014).

Social Norms (S15) – private data

Social norms are defined as the " rules and standards that are understood by members of a group, and that guide or constrain social behaviours without the force of law" (Cialdini and Trost, 1998, p. 152) Social norms reflect a perception of a generally held positive or negative societal consensus view. In theories of social norms, norms emerge in response to new behaviours that may incur a cost and as such the behaviour needs social regulation by approval or disapproval. In the case of smart meters, expectations of normative rules increase where threats to privacy present as the potential costs of the new technologies. the more harmful an individual thinks the new behaviour is, the greater assumption that there is or will be social norms to control it. However, people often under or overestimate the consensus view and interventions that aim to influence social norms tend to be around correcting misconceptions. People's actual behavioural responses to social norms is also conditional, people can still decide for themselves and Individual goals can take precedence, regardless of the social norms, as these are not rules that are not enforced.

This study used the understanding of social norms and norms emergence to understand the ways in which new privacy threats affects the expectations and demands for social norms in response to smart meters.

Social norms – Theory of normative conduct, Theory of warm glow altruism (S7)

Social norms around energy conservation establishes a moral benefit of conserving energy (Levitt and List,2007). And conversely societal approval of establishing one's green credentials by adopting energy conservation behaviours signals a moral benefit.

This study sought to test this norm through a nudge intervention, by making energy use data public to comparable households (in the university halls of residence) energy conservation for all to see would signal one's "green virtues" as well as some gentle competition to encourage behaviour change. Unlike providing only private data, making data public could activate the extrinsically motivated with the potential for social approval with associated benefits of an enhanced pro-social reputation. Common knowledge of energy conservation behaviours establishes a normative conduct – i.e. this is what one should do, whilst keeping this data private does not.

The theory of warm glow altruism acts as the reward for prosocial environmental behaviours, that is: it feels good to do good.

Theories of privacy ethics: between social norms and individual decision making

Technoethics (S33) and the framework of contextual integrity (Nissenbaum 2010)

As the word suggests, techno-ethics explores the connections between two worlds of information and communication technologies and ethics, a moral framework by which we can anticipate what people might consider good, acceptable or fair.

Smart meters pose new challenges to the norms of a separation of private and public spheres and potential

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conflicts between moral and political values, For example, as on the one hand by ensuring fair access to the benefits of convenience and efficiency that detailed data collection and data sharing can offer, and on the other, a potential for intrusion on personal and private sphere, or discrimination in the political or economic sphere where governments or corporations treat people differently. The authors examine the norms that individuals refer to and rely on when it comes to expectations on what is ethical practice in data sharing and its use and the normative conflicts that underpin the anxieties and concerns around smart meters.

Theories of social practice (S22, S18)

Theories of social practice (S22, S18) takes the everyday routines of people as the unit of analysis "to draw attention to the social and material context of human conduct" (Naus 2015). The theory balances the two opposing paradigms of voluntarism: that it is individuals and their attitudes and beliefs that determine how they act and the systemic or structural paradigms of external pressures of new technologies and policies will influence behaviours. By focusing on social practices, the theory considers the coproduction and feedback loops missing from purely individualist and structuralist approaches in explanations of how Individuals think, choose and act, such as in managing their privacy and sharing data but also are drawing from "rules of the game", culture and shared knowledge (Spaargaren 2010).

Social practice: Usable privacy in smart meters (S18)

In study S18 a practice-based approach is applied to understanding how people make sense of smart meters and privacy in the protected area of the home. The study considers how transparency in the communication of risk is used to make privacy decisions and is incorporated into everyday practices. In smart meter energy data collection, consumers try to understand the abstract nature of energy use data, and apply this to the real-world implications of intended and unintended disclosure.

Social practice: Consumers as change agents in smart grids (S22)

This study considers the decision-making processes of householders' decision to participate and share data in smart grid development, and how these decisions and practices are shaped by power and social relations in which the smart grid is embedded. The study looks at the factors that enable these households to become "change agents" and the privacy and autonomy barriers that could prevent them from adopting new practices. A social practice approach recognises that the households' role has changed over time from passive agents or captive consumers, to active change agents through the expanded opportunities of cooperation through sharing of information– both through horizontal engagement with other households, in citizen and community led smart grid projects and vertically, opening up the household to outside by outsourcing tasks and disclosure of information. In this theory of social practice, smart local energy systems offer opportunities to transform the everyday "energy management practices" of households through revealing and quantifying ways of living through monitoring and generation of data on energy consumption, thus making the home an explicit site of environmental action (Naus 2014).

Theory of procedural justice: fairness in decision making (S10)

In terms of fairness, procedural justice was a theory put forward by S10 Guerreiro 2015 to understand the acceptance and use of smart meters. Procedural justice is when the processes of decision making are transparent, fair and appropriate (Clayton and Opotow 2003), and would involve stakeholders in the decision-making process. The understanding is that if the process is transparent and seen by all to be fair; that they respect and recognise people's agency, dignity and voice, then people are more likely to accept the outcome, even if they don't agree with it. On the other hand, feelings of injustice and unfairness can create suspicion, resistance, and loss of trust and which is difficult to regain and will pose a barrier to acceptance and participation.

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Social contract (S25) Data protection is a public good

The social contract theory has a long history of explaining why people consent to being governed, apparently accepting restrictions on personal liberty for the benefits of social protection. A widely used definition would be that citizens "comply with the fundamental social rules, laws, institutions, and/or principles of that society', 'by rational agreement' even though individual reasons for complying differ (Stanford Encyclopedia of Philosophy, 2017). From the 20th century on this idea of contract by rational consent considers the conditions under which citizens would consent (Rawls 1972) assuming they had all the relevant information on a particular issue and acted reasonably and fairly.

Given the complexities of consent, and what individuals can reasonably know and expect about what they are consenting to in terms of their privacy rights and data sharing Taylor (2015) argues that from a data implementers' perspective, data protection should too be framed not just in terms of individual rights and responsibilities but as a collective public good. Sharing of data and consent should be that to which individuals would reasonably and fairly choose to consent to and for purposes that they could reasonably expect. Services that use data in unexpected ways, while perhaps legal, may not yet be acceptable.

Scripting (S11) Meanings of shared control

Scripting – in-scripting and de-scripting describe the different ways individuals can take control of and adapt prescribed behaviours that were "scripted" for them. Authors refer to two conflicting visions of the future energy consumer (Balta-Ozkan et al): either the main change is purely technical and customers passively respond to this new arrangement or they are to be active agents of change themselves, by engaging with the processes of energy provision and consumption.

The study describes the ways of understanding control from an implementer and customer perspective, such as "control over," technological control, or "being controlled" and the meaning of control in the reserved space of the home. The design of the smart grid trial in the study allowed for remote control of appliances as a way of balancing demand and appeared to promote a preference for passive customers in its design (in-scripted), but in practice finds that customers find ways to negotiate with, adapt, and control devices to work for them into their everyday practice which at times were at odds with the original intention and design (de-scripted).

Theories of individual behaviour

Smart meter acceptance

Technology Acceptance Model and theory of Reasoned Action (S10)

Technology Acceptance Model (TAM) proposed by Davis (1989) has the perceived ease of use and perceived usefulness as the mechanisms that influence attitudes towards smart meters and towards intention to use. (Krantz 2010, Stragier 2010, Venkatesh 2000 in Hess 2014).

In the same study, author refers to the Theory of Reasoned Action (TRA) explains how getting from intention to use to action was mediated by the individual's sense of self efficacy and control, similar to the concept of ease of use in the technology acceptance model. Both TAM and TRA assume that the individual balances the perceived risk of smart meters with their usefulness and ease of use, making the rational choice for smart meters.

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Demand side response

Theory of planned behaviour (S8) and locus of control

The theory of planned behaviour (Ajzen, 1991), links attitudes, subjective norms and behaviour with two aspects of people's assessment of their ability to act effectively (self-efficacy) and the extent to which control is available to them (controllability).

A psychological explanation behind the capacity of a person to assess their ability to act effectively is the theory of locus of control (Rotter 1954) that is the extent to which an individual believes that that they have power and influence over the outcomes of events in their lives, An external locus of control is a belief that one is not in control of events, a fatalistic view, while conversely the internal locus of control holds beliefs in one's own power in influencing events and outcomes.

In terms of smart meters, the authors consider to what extent an individual's internal or external locus of control is associated their intentions to engage in demand response energy use behaviours.

Innovation Diffusion theory (S28)

Innovation adoption and innovation diffusion theories are theories of individual behaviour explaining and predicting how and why some people are more willing to adopt new innovations before others within a social system (Rogers' 2003), and diffusion is through which channels and at over what time period these ideas of adoption spread. Early adoption of innovation may be mediated by individual personality attributes, such as openness to change, risk aversion and innovativeness while innovation attributes can affect whether an innovation is adopted or not. Innovation diffusion theory applied to the adoption of solar panels (Gärling and Thøgersen 2001) identified 5 attributes:

1. Relative advantage
2. Compatibility
3. Complexity
4. Trialability
5. Observability.

Research in this area also suggest that consumers' involvement in the product as having a strong effect on the intention to adopt while demographic factors have less of an impact on predicting who would be an early adopter consumer. (Arts et al. 2011)

Incentives

Game theories S19, S16

2 modelling studies (S16, S19) test what level of incentive offer tips the balance for a customer to trade privacy for benefits. In S16 this was in the form of discounts offers, in S19 virtual credits, coupons. In game theory, the two players are. the energy provider that needs the fine, granular data from the customer to design reliable responsive grid systems, but this comes at a risk for player 2, the customer, in terms of sacrifices of privacy and potential risk of data being intercepted and customers safety compromised. Players in this scenario "compete" to achieve their interests.

2.9 Guiding principles for interventions to address privacy concerns

From these barriers and enablers of data sharing and privacy concerns in different contexts, and the mechanisms underpinning how people make decisions privacy and sharing data we derived the following 8 guiding principles for the smart local energy service providers. This would include all stakeholders, energy service providers, community groups, private and cooperative who are involved in the design and delivery of smart local energy services.

1. Recognise the mutual benefits of data sharing for smart local energy systems and work with customers as partners
2. Involve people in the design of data sharing technologies from the start
3. Give people a say on the third parties that they are happy to share data with
4. Empower people to set the boundaries around the flow of information about themselves

5. Ensure that the purpose and value of the data collected is transparent and fair
6. Ensure that everyone that is affected by sharing of data is involved in giving their informed consent
7. Recognise that technologies for revealing and monitoring behaviours in the home can be used in unexpected and unwanted ways
8. Ensure there are channels of feedback and ongoing communication to continuously improve service delivery

Guiding principle 1

Recognise the mutual benefits of data sharing for smart local energy systems and work with customers as partners.

This principle was derived mainly from barriers and enablers in the Meso system of community and also one barrier that related to the wider socio-economic and cultural contexts. This was in recognition and acceptance (mechanism) that the benefits of sharing data through knowledge and understanding was not one sided on the side of the consumer with promised of lower bills, but an integral part of the smart local energy system sustainable success. The stated aims for SLES in the studies included reducing system costs, increasing the use of renewables, reducing total energy consumption, especially reducing peak demand. Energy customers' active participation in data sharing is an essential part of meeting these aims (outcomes). By working with customers as partners should overcome the privacy concerns that data is being extracted and exploited for profit with little to gain on the customers' side (mechanism).

Some populations are at risk of exclusion from decision making about data sharing, for instance when any initial cost investment is not theirs, or access to other income and benefits have been made conditional on their data sharing. SLES implementers should make resources available for ongoing support, education and involvement to realise ongoing participation for mutual benefit.

Recommendations for SLES providers

- **SLES service providers should build on existing trust to deliver mutually beneficial outcomes**
- **SLES service providers should monitor, and use a variety of approaches to, actively widen engagement**

Guiding principle 2

Involve people in the design of data sharing technologies from the start

Most of the privacy concerns expressed in the studies were around the sense of loss of choice autonomy and control, this sense of loss of autonomy and control was met with active resistance, even on a national scale, and passive non-participation in other cases (outcomes) this was overcome when implementers tailored their approaches to address individual concerns and values and were clear about what benefits could be expected, while at the same time, not overselling the benefits (mechanisms). Some people were keen to save money, while others were attracted to environmental benefits of conserving energy and enabling increasing renewable energy (mechanism). While people who were familiar with technology were more likely to be research participants (as this was a factor in self-selection or a condition of participation) some of the participants still found the website portals difficult to understand and use. Others found integrating new technologies with other connected devices in the home challenging and were surprised when their integration was not straightforward as they had expected. Involving people at the earliest opportunity in the design of the data sharing technologies will be more likely to be trusted (mechanism) and used (outcomes).

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Recommendations for SLES implementers

- **SLES service providers should ensure people feel in control of their data and environment**
- **SLES service providers should design SLES around user priorities and make these benefits clear**

Guiding principle 3

Give people a say on the third parties that they are happy to share data with

People are already familiar to some extent with the right to have some control over privacy settings, and new technologies are assumed to include these everyday controls (contexts). However, usable privacy policies, that is: those that people can actually read, understand and make informed decisions about are currently the exception not the rule. SLES designers and implementers have an opportunity to build-in the concept of useable privacy from the start. People differ in their opinions of acceptable third parties to share data with, although for profit organisation are lower on the list for most people (mechanism). However, some people find the idea of targeted advertising appealing while for others this is the least acceptable third party they would be happy to share data with. People should be given the option of choosing for themselves (mechanism).

Recommendations for SLES implementers

- **SLES service providers should ensure people feel in control of their data and environment**
- **SLES service providers should design SLES around user priorities and make these benefits clear**

Guiding principle 4

Empower people to set the boundaries around the flow of information about themselves

Privacy represented the controlled flow of information about oneself in the different contexts of individual beliefs and values (mechanism) the family and home and wider contexts of work life and community, and the socio economic and cultural domains (contexts) what is considered acceptable or appropriate sharing or revealing of information about oneself or family one domain may not be in another. The loss of control over this flow of information was felt to be to be disempowering (mechanism). The setting of boundaries can vary for different domains, for different purposes and change over time. To make privacy settings usable, they should be easy to access, understand and to change (mechanism).

Recommendations for SLES implementers

- **SLES service providers should ensure people feel in control of their data and environment**
- **SLES service providers should consider leveraging 'horizontal sharing' where appropriate**

Guiding principle 5

Ensure that the purpose and value of the data collected is transparent and fair

A lack of clarity over the extent and purpose of data collection led to declining trust and ambivalence (mechanism) over whether people would really see any benefit themselves. Some were disappointed that the flexibility in energy use to qualify for lower tariffs, meant losing some functionality in their day-to-day routines which they did not anticipate (mechanisms). Concerns of the use of energy data were on the whole low (context) and people were more interested in how the technologies worked and for what purpose.

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Overwhelming people with hard-to-understand privacy conditions generated suspicion and a withdrawal of consent as a default safety position (outcomes).

Recommendations for SLES implementers

- **SLES service providers should help people to understand new products and services**
- **SLES service providers should design SLES around user priorities and make these benefits clear**
- **SLES service providers should provide clarity on the intended use of data**

Guiding principle 6

Ensure that everyone that is affected by sharing of data is involved in giving their informed consent.

There are wider impacts of data sharing of both risk and benefit than traditional notions of the single bill payer and informed consent should reflects this as participation of all members of the household are needed for the benefits of data sharing to be realised (outcomes) Family members may differ in their priorities and perceived benefits of data sharing (mechanism) , for instance, families of older people saw some advantages in being able to remote monitor their loved one, but this was received less enthusiastically by the older people themselves who did not want to see this kind of monitoring replace human contact.

There was an assumption in some studies that understanding new energy data sharing technologies was probably too difficult for older people, while studies in other sectors suggested that in fact they were quite keen to learn about smart technologies potential to retain independence and maintain health.

Low income and vulnerable people in receipt of social protection may already feel more monitored in their everyday life compared to the general population and energy related benefits often call for energy use data collection as a condition of energy related benefits.

Social housing landlords may be enthusiastic over the economies of scale of the benefits of energy efficiency but neglect to involve their tenants in this decision making, but what was clear from the studies of energy data collection and also related sectors was that without involvement and support for active participation of the person sharing the data, these energy efficiencies would not be realised as the desired behaviour change will not be sustained.

Recommendations for SLES implementers

- **SLES providers' consent to share data should consider everyone effected by data sharing**
- **SLES service providers should monitor, and use a variety of approaches to, actively widen engagement**

Guiding principle 7

Recognise that technologies for revealing and monitoring behaviours in the home can be used in unexpected and unwanted ways.

New technologies and new uses for technologies can have unintended consequences. The use of detailed energy use data can shift the balance of power within the household to the one who can access and control this data. Reactions to previously unknown information about energy use ranged from being found to be fun and interesting to a bit annoying to controlling and abusive. SLES should incorporate design principles that energy use data cannot be exploited by those that seek to use this to control and abuse others.

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Recommendations for SLES implementers

- **SLES providers' consent to share data should consider everyone effected by data sharing**

Guiding principle 8

Ensure there are channels of feedback and ongoing communication to continuously improve service delivery.

The principle is related to the principle above, that new technologies and uses of technologies can face unintended consequences. Taking an ethical approach to responsible innovation (RI) should include ways of quickly learning and responding to these unintended consequences (outcomes). Open channels of communication will encourage collective reflections and evaluation of different stakeholders (mechanism) on the successes and challenges of new ways of using data and their potential and actual impacts. Technology innovation should be an ongoing process rather than only linear one of design followed by implementation, but should include mechanisms of evaluation, stakeholder involvement, redesign and refinements. Ethical issues may not be apparent at the design stage but emerge over time and from different perspectives.

Recommendations for SLES implementers

- **SLES service providers should monitor, and use a variety of approaches to, actively widen engagement**
- **SLES providers' consent to share data should consider everyone effected by data sharing**

3 Conclusions

People's expressed privacy concerns that potentially act as barriers to data sharing were wide ranging and depended on the different privacy concerns in different domains. One barrier to participation with good supporting evidence was that people will resist the intrusion on their autonomy, choice and control in the individual domain. This could be actively – by refusing to install data collection technologies for instance, or passively by non-participation in changing or adapting energy use behaviours. Evidence from other sectors suggests that people are willing to accept new technologies and sharing data if the benefits of doing so are clear, anticipated, mutually beneficial and includes choice and control. Not for profits are more trusted than for profit organisations to work in customer interests.

Inclusion and informed consent will require active outreach from SLES providers in a variety of ways to meet people's abilities and preferences. as well as ongoing education and support to ensure that privacy concerns are adequately addressed, and the benefits of sharing data are realistic, and participation is by informed and active choice.

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Table:	Privacy concerns barriers and facilitators

S1 Bailey (2015) ++/++	Anticipating PEV buyers' acceptance of utility controlled charging

Study characteristics

Geographical location

- Canada

Components in intervention

- Alternative energy source
- Budget information

Cost information really

Type of participant

- Residential

Sex of participants

- Male
- Female

Level of education

- Bachelors degree
- Graduate/ masters level
- High school/ College
- Middle school

Housing tenure

- Home ownership
- Renting

Age

- Adults

Other characteristics

- Own vehicle

Outcomes

Psychological Measures

Acceptability

We name the four classes based on differences in preferences, as indicated by different co–efficient estimates. Specifically, these classes are: **Anti–UCC**, **Charge–focused**, **Cost–motivated** and **Renewable–focused**.

The Charge–focused class is the largest and is estimated to represent 33% of respondents. Following this, class sizes decrease from the Cost–motivated (27%) to the Anti–UCC (21%) and Renewable–focused classes (19%) respectively. Respondents in the Renewable–focused class represent individuals that value UCC and renewable electricity most highly. These respondents are less cost sensitive than the other pro–UCC classes and are the only class to have significantly more likely to be highly educated and have a higher level of biospheric values than the other classes and significantly less likely to perceive UCC as an invasion of privacy relative to all other classes.

Overall in the PHEV–64 km design case, simulated enrolment varied from 49–71% by program scenario. Across UCC program scenarios, the Anti–UCC class had a relatively low probability of enrolment (2–9%). The Renewable–focused class had a consistently high enrolment rate (79–94%), even with a UCC program that includes 0% renewable electricity – showing that this class is largely in favour of UCC in general. The Charge–focused class was fairly sensitive to UCC program designs, ranging from a low of 26% for scenario 4, to a high of 80% for scenario 1. The Cost–motivated class also varied in program enrolment across scenarios, ranging from a low of 71% in the baseline scenario to a high of 100% in scenario 1.

Overall UCC program enrolment appears to be highly influenced by cost savings – seemingly even more than the percentage of renewables. We also observe that the guaranteed minimum charge (GMC) attribute had a strong effect on simulated UCC enrolment overall, and in the Charge–focused class in particular.

Privacy concern

We asked if respondents perceive UCC as an invasion of privacy to which 24% agreed or strongly agreed. The survey also asked if respondents believed that UCC would "take control away from me in a way that I would not like" to which 39% of respondents agreed or strongly agreed [Wasn't possible to capture role of privacy in discrete choice exps]

Value

Generally, respondents perceived that UCC can benefit the environment and goc should support it 68%

Findings

- Negative

The Anti–UCC class demonstrates strong and consistent opposition to program enrolment.

Factors

Individual / inter–Personal level factors

- Knowledge
  Minorities of Early Mainstream respondents were concerned about privacy (24%) and "loss of control" (39%) in relation to a UCC program. These concerns over privacy and control are likely to be a consequence of consumer understanding, consumer trust toward UCC programs, and trust toward the electric utility.

	• Trust Minorities of Early Mainstream respondents were concerned about privacy (24%) and "loss of control" (39%) in relation to a UCC program. These concerns over privacy and control are likely to be a consequence of consumer understanding, consumer trust toward UCC programs, and trust toward the electric utility. The Anti–UCC class demonstrates strong and consistent opposition to program enrolment. In this exploratory study, we cannot be sure of the primary concerns of this class, though respondents in this class do indicate stronger concerns regarding privacy than the Renewable–focused and Cost–motivated classes. These respondents may also have lower levels of trust in their electric utility – though we did not directly assess this. **3.3. How relevant is this study to the review? (Surveys)** • High **Overall, how reliable are the findings of the study (surveys)** • High
S2 Begier (2014) –/++	**Effective cooperation with energy consumers: An example of an ethical approach to introduce an innovative solution**
Study characteristics	**Outcomes**
Geographical location • Poland **Components in intervention** • Communication preferred communication: personal visit of an authorised representative of energy supplier (10% and 3%), information transferred by the owner of a multi–family house (8% and 1%), available telephone info–line (5% and 1%). • Email information preferred communication: e–mail (11% and 39%), personal • Home computer • In home displays • Information preferred communications: information attached to the bill for energy (27% and 18%), informational campaign on TV (27% and 4%), information available for inhabitants on a staircase (12% and 4%)	**Type of privacy concern** • Agency, choice and autonomy – a sense of helplessness • Data misuse **Personal data trading** • Surveillance energy consumers may feel watched or even investigated Qualitative themes (ie not numerical measures of current status, and hypothetical or real change) **What are the advantages?** Elderly people emphasise their need to receive lower bills instead of lower emission of CO2. **What are the disadvantages?** They prefer meter readings done by a person– In their opinion it is some comfort in life to have such visits of persons who are well known and welcome for them. Their threats concern mostly economic aspects, like potential theft of energy by some dishonest people, and the cost of smart metering system as a whole. Respondent stated an opinion that smart meters bring benefit first of all to producers of these meters. But respondents were also afraid of potential surveillance Data transferred remotely may be insecure/stolen (11% and 9%). • Equipment. **Who sees the data?** They have no fears that somebody may illegally observe their supplied figures and habits (they think they have nothing to hide). **Findings** • Small positive effect Citizens' attention (62%) concerns mostly economic aspects of a new system. People want to pay (82% of the representative sample) just for the energy that they have already consumed instead for the forecast and get equal bills to pay during all year.

S2 Begier (2014) –/++	…continued
• Internet access only 37% of all respondents living in rural area use internet, 55% of inhabitants of cities use Internet at their homes. 15% participants in the age 65+ use Internet at home 79% respondents in the age brackets <25, 34> use it at home • Personal visit by representative preferred communication: personal visit of an authorised representative of energy supplier (10% and 3%) • Variable rates **Geographical characteristics** • Rural –Siedlce • Advanced economy – Poznan **Type of home** • Multi–family home – Siedlce **Work status / income** • Below average – Siedlce **Age** • 31–45 • Over 40s in Siedlce • 46–60 **Other characteristics** • Prior knowledge/ experience As many as 61% social and 25% Internet respondents do not know functions of smart meters of electrical energy (Research of…, 2012, p. 18) because they have had no opportunity to meet such equipment	• Small positive effect Inhabitants (65%) declare their will to transfer their energy consumption outside hours of the peak demand. Energy consumers are able to formulate and express strong and weak points of smart meters. Some threats concerning intrusion of privacy have been also expressed by respondents. The paper letter sent through the traditional post has been selected by respondents as the most required form • No effect/ neutral They indicate electric kettle and electric heating as the most energy–consuming home. The washing machine and electric oven, although energy–consuming, are the most important devices and people are not going to change their habits to resign from using them (see Report of …, 2012, p. 16). Some energy consumers may feel watched or even under surveillance but most of them think only about the content of their own wallet. • Negative … these respondents associate installation of smart meters with the lack of freedom and choice only a minority of respondents tries to express somehow their threat that "the Big Brother is around the corner". **Factors** **Social factors** **Communication** Most important elements of informational campaign required to introduce the smart metering system: Explanation how a smart meter works (41% and 59%). Information when and why new meters will be installed (35% and 42%)., Exchange of meters will be on energy seller's cost (35% and 72%). New meters cause that people pay for the really consumed energy (34% and 37%) instead of receiving bills based on a forecast. Information about who covers cost of functioning of a new meter itself and energy consumed by it (24% and 26%). Protection of data concerned with electrical energy consumption at home; those data are transferred from smart meters (21% and 25%). Explanation what happens with a meter in the case of a break of energy power or another defect in the power net (20% and 11%). Ensuring that a new system will improve a detection of failures in the power supply and fast repair of damaged net elements (16% and 9%). **Individual/ inter–personal level factors** • Demographics technological innovations are introduced which may be too difficult to learn them by elderly people. • Environmental Concerns People's positive attitude towards challenges concerning protection of natural environment cannot be overestimated. There is a need to persuade citizens to proposed technical solution like smart metering system, for example • User behaviour People's declarations, wills, and stated figures do not always translate into real practices. Respondents know how they should act but they do not for some reasons, mostly of an economic nature. **Values and preferences** Respondents appreciate personal visits of authorised persons at homes and direct conversations. **3.2. How relevant is the phenomena explored relevant to this review? (Qual)** • Medium

S2 Begier (2014) –/++	…continued
• Understanding of energy system (Whole sample (963) Internet respondents (302) respondents declare that smart meters provide: • Exact and reliable measurement (9% and 7%, respectively), • The current volume of consumed energy in a given period (8% and19%), reading a meter without any involvement of a human reader (6% and 10%), • Help in energy saving (2% and 7%). In all respondents' opinion the most important strong point of a smart meter is a fact that inhabitants pay just for the consumed energy (40% and 38%, respectively).	**Overall, how reliable are the results? (Qual)** • Low
S3 BEIS (2018) +/++	**Smart Metering Implementation Programme: Review of the Data Access and Privacy Framework**
Study characteristics	**Outcomes**
Geographical location • Great Britain **Components in intervention** • Communication A national communications infrastructure – the Data and Communications Company (DCC) – has been established, which enables authorised users to access data from smart meters, subject to the provisions of the Smart Energy Code (SEC). • Smart meter **Setting** • Home / microbusiness area	**Type of privacy concern** • Agency, choice and autonomy "The central principle of the Framework is that consumers have control over who can access their energy consumption data, how often and for what purposes, except where this is required for regulated purposes." **Psychological Measures** • Privacy concern **Findings** • Small positive effect "Privacy concerns in relation to smart metering have remained low and research has found that the existence of the Framework offers reassurance to some consumers that appropriate safeguards are in place." [Various sources cited demonstrating continued low levels of privacy concern.] • No effect/ neutral The authors find that information provision is important for giving consumers control but not for overcoming privacy concerns as these are low already.

S3 BEIS (2018) +/++	…continued
	Factors
	Methodological factors • Research commissioner Research conducted for Citizen's Advice found higher levels of privacy concern than research for Government and energy companies. **Individual/ inter–personal level factors** • Attitudes Ipsos MORI research identified 4 broad customer types (& therefore behaviours) based on attitudes towards sharing: Happy to share, Depends who's asking, Quid pro quo & Big Brother. NB: Consumer awareness of (and interest in) how energy systems and actors operate is often low: "attitudes in this area may be influenced by wider events and views on privacy more generally." • Demographics "Whilst overall concerns are low, variations in attitudes do exist between consumers – for example, on the basis of age." • Information Citing recent Citizens' Advice research: "Significantly, most respondents (60%) who had expressed [privacy] concern felt reassured when the provisions of the Framework were explained". Authors: Little evidence of consumers actively seeking to share data with third parties for benefits, possibly because of low awareness of the (few) opportunities available. • Motivations Citing research Ofgem research: "Where consumers could potentially benefit directly from sharing their data, a third (34%) were willing to share in all scenarios, a further 37 were willing to share in at least one scenario." **Organisational factors** • Consumer engagement "Information received by BEIS from the large energy suppliers indicates significant variation in the proportion of an energy supplier's customers who are opting in to share their half–hourly consumption data. It is likely that this variation arises from a combination of factors, including: whether energy suppliers are actively requesting this data, differing approaches to consumer engagement and the extent to which consumers are being offered attractive services in return." • Market operation Citing recent Ofgem research: "Consumers' willingness to share increased slightly when scenarios related to improved market operation – such as more efficient settlement processes – were tested, with over half (55%) willing to share in all scenarios, whilst 71% were willing to share in at least one scenario and 13% were unwilling to share." **Methodological factors** • Research commissioner Research conducted for Citizen's Advice found higher levels of privacy concern than research for Government and energy companies. **3.2. How relevant is this review to the EnergyRev review's questions? (SR)** • High **Overall assessment of reliability of the findings (SR)** • Medium

S4 Choe (2012) +/+	Investigating Receptiveness to Sensing and Inference in the Home Using Sensor Proxies
Study characteristics	**Outcomes**

Geographical location

- USA
- CM: Same.

Components in intervention

- Diary
- Home computer
- Sensor lights
  the sensor lights are used in place of the real sensors (video, audio, electricity use) as people often do not know what the real sensors actually do without some contextual relevance.
- Technology education session

Children

- Yes n=16
- No n=6

Sex of participants

- Male n=10
- Female n=12

Time in current residence

- 6–10 years
- Average 7.7 years

Level of education

- Bachelors degree n=14
- Graduate/ masters level n=4
- High school/ College n=4

Housing tenure

- Home ownership n=14
- Renting n=8

Age

- CM: 28–54 (all ages given in Table 1)

Type of privacy concern

- Agency, choice and autonomy
  one was concerned that the electricity company would restrict their electricity use
- Data misuse
  Participant said that it was not the business of companies to know detailed type of information:
  "It would be nice to capture some of his behaviour on video and then show it to, like, his therapist or something. 'Cause it's hard to explain—when you're in the moment, and then go to the therapist and try to explain exactly what went on, you know conversations could get heated up if somebody was supposed to be doing chores, and we've got them videoed, you know, watching a TV program or something. I'd rather just not worry about that, and make sure the chores get done later, as opposed to have something that people would go back and start referring to. You know, I think at this point, you know, you're much happier not having that access."
- Data over–collection
  Some participants felt that the electricity company would not have time to review this daily data anyway
- Relational privacy
  …supposed to be doing chores, and we've got them videoed, you know, watching a TV program or something. I'd rather just not worry about that, and make sure the chores get done later, as opposed to have something that people would go back and start referring to. You know, I think at this point, you know, you're much happier not having that . "I guess, realistically, it might still bother me be– cause, for instance, even though my wife and I are a couple, there are still probably things that either one of us might do at any given time that is private that we wouldn't share with the other person. And so—like if I put in an X–rated thing, I wouldn't really want somebody to be able to tell – you've been watching these videos a lot.
- Reputational privacy
  sensors data could be used to monitor and judge the behaviour of others in the household. A breach privacy within the home.
  Page 7: "I guess, realistically, it might still bother me be– cause, for instance, even though my wife and I are a couple, there are still probably things that either one of us might do at any given time that is private that we wouldn't share with the other person. And so—like if I put in an X–rated thing, I wouldn't really want somebody to be able to tell – you've been watching these videos a lot, you know."
- Trade off
  Collecting more data increases the usefulness and functionality of the application but increases the harm to privacy if a breach occurs.

Psychological Measures

- Privacy concern

Findings

- Positive
  initially reticent, participant saw the benefits of using the sensors for health and care. "Anything can be used for good or evil,. I guess" again there was initial strong resistance to the sensors being in the bedroom , but then some benefits could be seen of monitoring sleep patterns.

S4 Choe (2012) +/+	…continued
	• Positive Participants who were initially opposed were more favourable when they thought they might receive a discount on their utility bill or reward in kind "cable would be nice. I would carefully weigh the proposal" some participants were excited about the idea of real time feedback (on electricity use) so they could experiment with energy efficiency of competing behaviours – such as handwashing dishes vs. dishwasher, or to decide when to replace an appliance.. To convince other household members to change their behaviours… to bargain with – persuade a landlord to replace inefficient appliances • Negative Some participants initially excited about the technology came back with reservations. "This has been on my mind all week. The fact that the electric company can tell when I've turned on the dishwasher or a light bulb or the TV– that's pretty fascinating to me. I don't know how they do that, but do I want them to know that? Well it's not a bad thing. It's still a private thing… I don't know if its good or bad – I am undecided" H10a participants were asked about data sharing outside of the home, many were uncomfortable and unnerved, . One was concerned that the electricity company might restrict their electricity use
	Factors
	Social factors • Socio demographic characteristics Participants were mainly middle income **Individual/ inter–personal level factors** • Values and preferences **3.2. How relevant is the phenomena explored relevant to this review? (Qual)** • Medium energy use data is only a small part of the study, respondents are thinking about hypothetical scenarios **Overall, how reliable are the results? (Qual)** • Medium
S5 Citizens Advice (2019) ++/++	**Clear and in control: Energy consumers' views on data sharing and smart devices**
Study characteristics	**Outcomes**
Geographical location • Great Britain **Components in intervention** • Smart meter **Setting** • Homes **Type of participant** • Residential **"Race", ethnic group identity** • Not recorded/reported	**Type of privacy concern** • Data misuse Sharing with third parties 7% • Identity privacy Info is personal 11% • Unauthorised data use 8% **Qualitative themes (ie not numerical measures of current status, and hypothetical or real change)** • Behaviour and intentions People vary in how comfortable they feel with sharing data, and the level of benefit they expect to get in return Younger people are moderately more likely to be comfortable sharing their data with companies than older people Most people will share data with companies, subject to what they will get in return. Just under a fifth do not want to share data in any circumstances.

S5 Citizens Advice (2019)	…continued
Sex of participants • Male • Female **Age** • Adults	• Its the future Most people agree that smart devices are the future Around half think that smart devices improve the service they get • Who sees the data? But over half of people are concerned about their data being shared by companies whose smart products they use Over half of people did not trust that their personal data was safe. Only a third of people said they trusted that their personal data was safe. **Findings** • Positive The trade–offs show people are most likely to share data to take advantage of lower cost energy though time of use tariffs. • Mixed effects People need to be able to control their data People vary in how frequently they want to share their data, and what they want to share it for. Being able to choose settings that reflect their preferences can improve trust and encourage people to engage. The next most attractive was tailored energy efficiency advice. However, this option becomes much less attractive if it requires particularly detailed data. Targeted marketing was the least attractive option. • No effect/ neutral Reasons for concern about smart meter data The highest proportion, a third, are unable to explain what they are concerned about. The main concerns that were specified included the collection of personal information and the risks about what could happen to their data. • Negative 9 in 10 people think opt–outs are important. Without consent to data sharing, the number of people who want a smart meter drops by almost third. The right protections can reassure people that their data will not be misused. Data choices must remain central to the smart meter rollout. Almost a third of people who currently want a smart meter would not want one if they did not have these choices. People tend not to want targeted advertising based on their smart meter data The research showed that consumers are most likely to share their smart meter data to take advantage of lower cost energy through time of use tariffs. Advertising and marketing is likely to put them off sharing data. People who DON'T have a smart meter this they collect intrusive data. Many people without a smart meter do not want one For people without a smart meter, similar numbers say they wouldn't want one (44%) to those that say they would (40%). However they are much more likely to say they definitely would not want one.
	Factors
	Technical Factors • Smart meters People who have a smart meter tend to be more comfortable sharing data with third parties (77 vs 53%) People WHO DO NOT have a smart meter believe them to collect intrusive data • Veracity of data The more detailed data is the less comfortable people are sharing it Over 6 in 10 people are comfortable sharing data on an monthly basis. This declines to 5 in 10 for daily data and just over 4 in 10 for more frequent data sharing. The same number of people are comfortable with sharing data on a half–hourly or near real–time. However, the number who are very uncomfortable increases with near–real time sharing.

S5 Citizens Advice (2019)	…continued
	• Acceptance Reasons for not wanting a smart meter Common reasons for not wanting a smart meter related to not seeing the need for the change. Negative media stories, like publicity around problems with switching, also play a role. • Compensations and benefits % in favour of following uses: Energy suppliers using smart meter data to identify and monitor vulnerable consumers 60% Police using your smart meter data to identify some forms of crime 62% **Individual/ inter–personal level factors** • Consumers' perception People who have a smart meter tend to be more comfortable sharing data with third parties (77 vs 53%) Consumer values versus competitiveness Without permissions, interest in getting a smart meter drops Almost a third of those who currently want a smart meter would not want one if they did not have these choices. • Control and autonomy Across the board, people think opt–outs are important 9 in 10 people thought opt–outs were an important condition for data sharing. • Demographics Higher socio–economic groups more like to think SMs collect intrusive data (31% of AM, 18% of DE). Younger people slightly more likely to be comfortable (61 % 18–24, 50% 75+) People from lower socio–economic groups were less likely to be aware of choices around data when getting a smart meter(25% AB vs 44% DE not aware) • Knowledge People who have a smart meter tend to be more comfortable sharing data with third parties It is unclear if this was a result of their experiences with their smart meter, or if people with higher levels of trust are more likely to want a smart meter in the first place. Consumers without a smart meter would be more likely to opt for monthly data sharing than more frequent sharing. When they accept a smart meter, most people are not fully aware of the choices and permissions available Many of those with a smart meter don't recall the level of consent they gave. A third of people didn't recall what level of data they gave consent to share – the most common single response. This reflects existing research that indicates consumers tend not to read terms and conditions about data use. When they do, they often do not understand them. However, this does not mean that these protections are not important to people. • Trust We asked people about different measures that could help give them better transparency and control over how their data was used All the measures we asked about would help reassure most consumers. This suggests a range of protections can all contribute to consumer trust. However, a minority of consumers will not be reassured even with these protections. Supplier needing to get my explicit permission to use the data for marketing reassured a great deal 43% reassure a fair amount 32% Preventing companies sharing my data with others reassured a great deal 39% reassure a fair amount 33%. Being able to change settings for different suppliers or organisations accessing my data reassured a great deal 33% reassure a fair amount 40%. Supplier having to remind me regularly what level of data I am sharing with me reassured a great deal 32% reassure a fair amount 42%. Making it easy to opt out of sharing data more than once a month reassured a great deal. 31% reassure a fair amount 43%.

S5 Citizens Advice (2019)	…continued
	• Supplier being clear about how they intend to use my data, what data they use and what for reassured a great deal 22% reassure a fair amount 48% **Organisational factors** • (Organisational) Trust Reasons for not wanting a smart meter: Common reasons for not wanting a smart meter related to not seeing the need for the change. Negative media stories, like publicity around problems with switching, also play a role. **3.3. How relevant is this study to the review? (Surveys)** • High **Overall, how reliable are the findings of the study (surveys)** • High
S6 Da Silva (2012) –/++	**A Survey Towards Understanding Residential Prosumers in Smart Grid Neighbourhoods**
Study characteristics	**Outcomes**
Geographical location • Multiple locations …mostly European from Spain, Germany, France, and Italy, while a smaller percentage came from other parts of the world such as Egypt and Australia. **Components in intervention** • Real time information real–time and historical access to energy consumption and production, better access to weather information, generation mix, and pricing **Type of participant** • Residential **Sex of participants** • Male – majority • Female – minority •	**Type of privacy concern** • Agency, choice and autonomy • Acceptance of automated devices or 3rd party managed devices. • Surveillance **Behaviour measures** • Data sharing • Willingness to change: providing information to their energy retailer. **Findings** • Positive Around 60% of respondents were willing to share usage information in return for additional benefits (value–added services), whereas only a little over 10% were willing to share this on social media. Around 90% were willing to share usage information with their energy provider anonymously. **Factors** **Technical Factors** • Data collection ~90% of respondents willing to communicate Usage expectations to their retailer but only ~50% willing to do the same with Activity data (behaviour patterns, e.g. when on vacation). NB: over 90% said that sharing should be done under privacy preserving measures such as anonymisation. **Individual/ inter–personal level factors** • Control and autonomy From Fig 10 (by sight): Around 94% of respondents were "willing to allow automatic management of devices as far as this does not affect any loss of comfort" but only around 49% were willing to allow third party control. However, 81% would be willing to allow a third party to manage trading their excess energy production.

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S6 Da Silva (2012) –/++	…continued
Age • 16–30 • 18–44 • 31–45 • 18–44 **Other characteristics** • Understanding of energy system "On average, they considered themselves as having a good understanding of the electrical energy system and of the energy consumption of their devices" [although authors note that people tend to understand whether certain device's consumption is too high or too low better than they understand intermediate levels]	**Overall, how reliable are the findings of the study (surveys)** • Low **3.3. How relevant is this study to the review? (Surveys)** • High
S7 Delmas (2014) +/++	**Saving power to conserve your reputation? The effectiveness of private versus public information**
Study characteristics	**Outcomes**
Geographical location • USA **Theory** • Theory of normative conduct • Theory of warm glow altruism **Components in intervention** • Email information	**Type of privacy concern** • Reputational privacy • Data sharing on energy was deliberately revealed and manipulated reputational privacy in nudging people to energy towards conservation. **Psychological Measures** • Altruism **Social measures** • Organisational membership • Member of an environmental organisation **Performance measures** • Energy Use • Environmental measures • Environmental factor **Findings** • Positive When private feedback was combined with public information (posters showing above or below average use) there was a saving of around 20% mainly from high energy users • No effect/ neutral No effect for private information can induce conservation. No significant differences for Plug load and lighting

S7 Delmas (2014) +/++	…continued
• Home energy monitoring device new technology was developed that allowed for the rapid retro fit of the rooms selected for the experiment. The new technology involved augmenting off–the–shelf plug point energy meters(which measure plug load) with sensing technologies to measure light usage and heating/ cooling; and radios to wirelessly communicate with an internet–enabled gateway. • In home displays Experimental condition rooms had their own energy use dashboard • Information posters Public information was displayed on posters, giving the room and energy usage compared to above/ below average energy use • Real time information **Setting** • University halls of residence **Type of participant** • Residential **Sex of participants** • Male • 52% • Female • 48% **Level of education** • Bachelors degree • Year of Study 1.48 sd 0.941 **Work status / income** • Students	**Factors** **Methodological factors** • Treatment The intention to treat did not translate into actual treatment received. **Individual/ inter–personal level factors** • Consumption • Experiment participants used on average 15 times more electricity for heating and cooling than over head lighting during Ehe baseline period consumers have little awareness of the energy efficiency of appliances and of the price of the services produced by electrical appliances • Environmental Concerns Baseline period regressions found that environmentalists used significantly less electricity than non– environmentalists • Values and preferences "Once the poster got up,it became serious…""I liked the poster,it made us want to get green dots.""We want to make it green because red looks bad.""I thought the posters were pretty crucial to the whole process. It gets everyone else involved.""We did not want to attract attention because we were red.""I turned off all the lights and wear a lot of sweaters so I could get a green dot.""When I got a green dot, I received high 5."

S7 Delmas (2014) +/++	…continued
Housing tenure • Room • Single Room 0.71 **Age** • 16–30 • Average age 18.5, SD 1.167	
S8 Fell (2015) +/++	**Knowing me, knowing you: The role of trust, locus of control and privacy concern in acceptance of domestic electricity demand–side response**
Study characteristics	**Outcomes**
Geographical location • Great Britain **Theory** • Theory of planned behaviour **Components in intervention** • Electric heating participants were asked to imagine that their heating operates exactly as it currently does but is powered by electricity **Other characteristics** • Responsibility for paying bills individuals who are jointly or wholly responsible for payment of their household energy bills	**Type of privacy concern** • Information privacy • Interest privacy In the case of DSR, privacy issues are at stake not only in the energy data which may be shared but around control signals and consumers' responses to them. For example, consumers' financial rationality could be deduced from their response to TOU price changes (Li et al., 2014). • Non–Intrusion **Psychological Measures** • Locus of control **Privacy concern** • Regarding privacy concern, 69 % and 70 % of people had respectively opted not to provide personal information and asked for personal information to be removed from a database, while 55 % said they had signed up to the Telephone Preference Service. **Findings** • No effect/ neutral Largest (association) for the dynamic TOU tariff with no automation with privacy concerns, where there is the most direct 'intrusion' by an external agency .. as someone on such a tariff is clearly making themselves quite vulnerable to the supplier's choice as to when to charge peak, medium or low rate prices, with no guarantee that they (the consumer) will be able to respond appropriately. Is probable that the very benign nature of the DLC tariff presented (with unlimited overrides and only a small possible effect on temperature) allayed concerns. Direct load control did not have the strongest association with privacy concern, suggesting that the mere fact that an external agent is acting directly in the home is not considered to be a greater threat to privacy that having an automated (or even manual) response to price signals. • Negative Privacy concern is negatively associated with acceptance.
	Factors
	Economic factors • Tariffs Being on a TOU tariff currently is associated with higher acceptance of the static TOU and dynamic TOU with automation tariffs.

S8 Fell (2015) +/++	…continued
	Individual/ inter–personal level factors • Demographics There are significant associations between age and acceptance only for the unautomated static and dynamic TOU tariffs. In both cases the tariffs are less popular with people aged 65–74, while for the static TOU tariff is also more popular amongst people under 45. Static tariffs with automation associated with : Live alone, concern about future power cuts. Dynamic TOU: Age 65–-74, Private tenant, income 14–28k, income not disclosed, Dynamic TOU with automation associated with: social tenant • Environmental Concerns Dynamic TOU and Dynamic TOU with automation associated concern about future climate change • Tenure of home Tenure is significant for both dynamic TOU tariffs, where being a private tenant is positively associated with acceptance of dynamic TOU without automation, while being a social tenant is negatively associated with the automated dynamic TOU tariff. **3.3. How relevant is this study to the review? (Surveys)** • Medium exploratory work on the role of privacy in making willingness of purchase decisions, alongside other factors. Detail on types of privacy outlined in background were not tested **Overall, how reliable are the findings of the study (surveys)** • High
S9 Giordano (2011) +/+	**Smart grid projects in Europe : lessons learned and current developments**
Study characteristics	**Outcomes**
Geographical location • Europe **Components in intervention** • Authentication Authenticate and authorise users, groups and devices on all interfaces (such as GUI and other IT systems) • Authorisation • Certification Recommend the use of certificates to enable application level security • Encryption Strongly encrypt the data in transit. • Guarantee the integrity and confidentiality of data exchanged and stored Ensures integrity and confidentiality • Not stated	**Type of privacy concern** • Agency, choice and autonomy Reviewer: from customers would not allow the utility to control thermostats in their homes at any price [53]. **Performance measures** • Transaction costs **Findings** • Negative customers would not allow the utility to control thermostats in their homes at any price [53]. The responses received from project coordinators have been generally quite poor in data protection and security
	Factors
	Technical Factors • Complexity Concerns over privacy issues and transparent access to the market (e.g. use of complicated hardware/ software, need to do energy calculations) might severely hinder the participation of consumers and therefore the profitability of MSPs and of Smart Grid investments.

S9 Giordano (2011) +/+	…continued
	• Infrastructure The role of ICT An open and secure ICT infrastructure is at the core of the successful implementation of the Smart Grid. Addressing interoperability, data privacy and security is a priority requirement for making the ICT infrastructure truly open and secure and reducing transaction costs among Smart Grid users **Individual/ inter–personal level factors** • Engagement of participants Most projects highlight the need to involve consumers at the early stages of project development, to give consumers the freedom to choose their level of involvement • Trust It is imperative to ensure that consumers have trust in of the whole Smart Grid process and receive clear tangible benefits. • Understanding It is imperative to ensure that consumers have understanding of the whole Smart Grid process and receive clear tangible benefits. **Organisational factors** • Transparency lack of transparency on privacy issues might severely hinder the participation of consumers and consequently the profitability of the Demand Response platform. **3.3. How relevant is this study to the review? (Surveys)** • Medium one of the findings was that privacy was hardly mentioned by the projects. This is an important findings, but means there is little relevant information on privacy concerns in the report **Overall, how reliable are the findings of the study (surveys)** • Medium
S10 Guerreiro (2015) –/+	**Making energy visible: socio–psychological aspects associated with the use of smart meters**
Study characteristics	**Outcomes**
Geographical location • Portugal **Theory** • Technology Acceptance Model • Theory of procedural justice • Theory of Reasoned Action **Geographical characteristics** • City/urban **Setting** • Home / microbusiness area	**Type of privacy concern** • Agency, choice and autonomy "The state or the private sector does not have the right to come into our home, controlling our behaviour; these are issues of privacy and sovereignty" • Discrimination • Distributive injustice **Psychological Measures** • Privacy concern • Risk of loss of privacy highlighted in 10 out of 80 blogs analysed • Qualitative themes (ie not numerical measures of current status, and hypothetical or real change) • State coming into home

S10 Guerreiro (2015) –/+	…continued
Type of participant • Residential **Sex of participants** • Male • Female 56.7 % women **Level of education** • Bachelors degree • High school/ College • Middle school **Age** • Adults Participants are between 19 and 92 years old (M = 56.45, SD = 16.65)	• Quote from blog: "The state or the private sector does not have the right to come into our home, controlling our behaviour; these are issues of privacy and sovereignty.""Spy meter" or "Gestapo meters" here smart grids are compared to the Nazi secret police (B it would be a concentration camp, an eternal imprisonment at home. The use of this type of metaphor is based on pathos as a communication technique (Leach 2000) or, in other words, is trying to persuade other people not to accept smart meters by appealing to their emotions, namely, fear and even horror. **Factors** **3.3. How relevant is this study to the review? (Surveys)** • Low • Ultimately very little on privacy **Overall, how reliable are the findings of the study (surveys)** • Medium
S11 Hansen (2017) +/+	**Scripting, control, and privacy in domestic smart grid technologies: Insights from a Danish pilot study**
Study characteristics	**Outcomes**
Geographical location • Denmark **Theory** • Scripting– in–scription / de–scription A strong script would not allow charging in periods with–out 'wind–electricity' on the grid, whereas a weaker script would also allow the user to charge during other periods, which can be accomplished by an override function **Components in intervention** • Electric vehicles n=17 • Geothermal Heat pump Hybrid air/ water HP with gas, air/water HP, • Home energy monitoring device • Internet access • Photovoltaics PVs • Real time information • SensorsSmart meter • Sun Wells	**Type of privacy concern** • Agency, choice and autonomy **Qualitative themes (ie not numerical measures of current status, and hypothetical or real change)** • What are the advantages? … I have been wondering, since we are talking about control, is anyone keeping track of our consumption? Are they saying, 'this looks all wrong'? Right from the beginning I had the feeling that we were really being 'watched' with the different technologies, but as my mum says, if that was the case then the technologies should have worked" I: "So you would have liked more focus on finding the problems?" M: "Otherwise, what are all the measuring devices for?" (B2xx) "It was pure luck that he (a technician) came that day. Because if 2–3 weeks had gone by and the HP had been running on the heating element during all that time, then we would have received a huge electricity bill. It would have been nice if some–one surveilling the system would pay attention to when we all of a sudden used the double amount of electricity." (P7) "We have those sensors in the rooms; then I see it as natural that they look if it runs alright. Or are they just letting everything run without even keeping an eye on what is going on? There must be a reason for why we have sensors in various rooms." (P7) **Findings** • Mixed effects Giving up control depends on the technology: .. consumers were more interested in the remote control of their HPs than the remote control of their EVs, as the participants reported feeling safer when experts controlled their HP. The remote control of the EV, however, was not linked to an increase in reliability; rather, the opposite view point was held: the remote control of the EV was linked to a decrease in reliability. Consumers felt that they lost control over something on which they were entirely dependent

S11 Hansen (2017) +/+	…continued
Geographical characteristics • Village **Setting** • Homes **Children** • Yes =8 • No =12 **Type of participant** • Residential **Sex of participants** • Male =10 • Female =10 **Level of education** • Bachelors degree =4 • High school/ College • Middle school =8 • Vocational education =12 **Work status / income** • Retired =5 • Self–employed =5 • Sick leave =2 • Unemployed =1/40 **Wage earner** • 23 (/40) **Age** • 31–45 • 35–44 =13 • 46–60 • 45–54 =11 • 55–64=8 • 61–80 • 65+ =4 **Other characteristics** • Regulatory context PVs in Denmark became especially favourable after the 'solar agreement' in 2012, which included a lucrative deal for prosumers, in which they were paid by the state for delivering electricity to the grid.	**Findings** • Mixed effects Giving up control depends on the technology: .. consumers were more interested in the remote control of their HPs than the remote control of their EVs, as the participants reported feeling safer when experts controlled their HP. The remote control of the EV, however, was not linked to an increase in reliability; rather, the opposite view point was held: the remote control of the EV was linked to a decrease in reliability. Consumers felt that they lost control over something on which they were entirely dependent • Negative With the current structure of the energy system, the increased desire to control the technologies due to the PVs is not compatible with the planned remote control that Insero had in–scripted. Some participants became more aware of the actions required to consume their generated electricity, which enforced their desire to gain control of the timing of the consumption. This finding was counterproductive to the main idea of the remote control and the aggregator in Insero Live Lab, who preferred that consumers not be concerned with their energy consumption. **Factors** **Technical Factors** Energy management The external control also made some participants feel safer because other people with more technological skills could also detect problems within the household. **Social factors** • Habitus The significance of the home and the importance of residents in the trial to feel in control, as the setting for the smartgrid and the remote control access is the home. The experience of feeling in control at home will rely on well–known technologies and routines. Although Akrich [18] suggested that man–made technologies prescribe. **Individual/ inter–personal level factors** • Control and autonomy In general, the participants did not approve of the idea of having their EVs remotely controlled. This opinion was partly linked to the driving range of the EVs: • Expectations The participants were significantly motivated by reliability in relation to remote control, whereas Insero was more focused on flexibility issues; this discrepancy revealed a mismatch in the script regarding control. Some participants reported that their self–production of energy was connected to a wish to control the devices; thus, they rejected the script of remote control. • Lifestyle "I couldn't live with the EV not being charged between 4 and 6pm. Because I'm often at home an hour before I have to pick up the kids from football practice. Then it needs all the electricity it can get." (F6) Because the script of remote control was normative and induced actions of leaving the control of the charging to Insero, it proved to be unwanted by many participants, who were entirely dependent on their cars because they resided in the countryside. • Security Although the participants expected to have an increased perception of safety as a part of being increasingly monitored, they discovered that this expectation was not always fulfilled, which caused frustration.

S11 Hansen (2017) +/+	…continued
Tariff • Old tariff 5, new tariff 15	• Security Although the participants expected to have an increased perception of safety as a part of being increasingly monitored, they discovered that this expectation was not always fulfilled, which caused frustration. • Trust The remote control of the charging failed in a few cases, which caused the participants to become suspicious. • Understanding The informants were dissatisfied with the issue of not being able to control the EV according to the PV's production of electricity. Because the informants had changed their routines to consume as much of their produced electricity as possible, they were annoyed when Insero began to externally control their EV, although this process was consistent with the initial project plan and agreement. • Values and preferences Thus, the script and the setting of the boundaries seemed to give many of the participants the feeling of being in control because they were able to set the boundaries. **Risk of verification bias (case study)** • Low **3.2. How relevant is this case study to the review? (Case study)** • Medium Privacy trade off decisions are assumed, as participants are taking part in the trial. But there is little direct mention of privacy in the study. Privacy in this context is interpreted by the review to be "right to be left alone" and relational privacy and to have control and autonomy over energy decisions
S12 Hess (2014) +/++	**Smart meters and public acceptance: comparative analysis and governance implications**
Study characteristics	**Outcomes**
Geographical location • Canada Listings taken from whole country, news reports from British Columbia only. • USA Listings taken from whole country, news reports from 7 states only: California, Maine, Maryland, Michigan, Nevada, Oregon, and Vermont.	**Type of privacy concern** • Agency, choice and autonomy opposition may be higher where the roll–out of smart meters is rapid and without an opt–out provision; n three cases, there was an initial phase of local government resolutions against mandatory installation, which preceded a policy response at the state or provincial level. In all cases discussed below, there was a policy response that enabled customers to opt out of mandatory smart–meter installations. The response came from the utility (British Columbia, Michigan), state government legislation (Vermont) or the public utilities commission (other states). In Vermont, the opt–out arrangement also includes a no–fee clause. In British Columbia, the provincial government adopted a rapid installation approach, setting a deadline of 2012 for the installation of smart meters, and the energy utility responsible for the installation did not allow an opt–out provision. These decisions stimulated a strong opposition movement In Nevada, the right–wing Nevada Constitution Alliance (2013) opposed smart meters primarily on grounds of privacy and government intrusion, but it also listed health and other concerns In Oregon, a 100–member group formed the Families for Safe Meters to oppose smart meter installations. In one article, they cited vulnerability to cyberattack and health effects as their primary concerns (Dietz 2012) owed customers to opt out without incurring a charge (Vermont State Legislature 2012). In Vermont, the opt–out rate in 2013 was 4%, whereas in Maine, where the opt–out fee is 40 US dollars for the initial rate plus 12 dollars per month, the opt–out rate as of 2013 was 1%

S12 Hess (2014) +/++	…continued
Theory • Theory of "phantom risk" I do not attempt to evaluate public concerns as either well founded or ill founded with respect to science Rather, I treat health concerns as Durkheimian 'social facts' that have social and political effects it seeks to understand the pattern of bundling of health concerns with other concerns, and it seeks to understand the political effects of these bundles of concerns **Type of participant** • Business • Expert **Other characteristics** • Regulatory context News report search and case studies undertaken on the "seven states that have passed legislation or have public utility commission decisions that support opt–out policies (California, Maine, Maryland, Michigan, Oregon, Nevada and Vermont) … [plus] British Columbia because it has the most active anti–smart–meter movement in Canada, and the provincial utility allowed an opt–out provision after a long public mobilisation."	• Surveillance There is pervasive anger at being forced to accept devices that can report on activities by appliance in a household and can lead to 'Big Brother' knowledge about what people are doing in their homes. . In the seven cases, the websites focussed on privacy and government intrusion issues and were often critical of Local Agenda 21 (the United Nations effort to build sustainability at the local level) and of alleged government plans to spy on individuals. In Michigan, individuals who experienced health effects formed the Smart Education Network, whereas Tea Party members formed the W4AR, which focused on privacy issues and government spying • Trade off people supported the claimed benefits of smart meters but were often sceptical that they would see the benefits (Lineweber 2011) **Psychological Measures** • Reasons for opposition of smart meters Qualitative themes (ie not numerical measures of current status, and hypothetical or real change) • Public policy response to opposition of smart meters **Findings** • Positive [Smart meters and public acceptance comparative analysis and governance implications. pdf] Page 11: Public opposition is heightened where there is no opt–out provision, as in the cases of British Columbia, California and Maine." "Such rules are likely to reduce opposition based on privacy and security more than on health, because opponents concerned with health risks are also concerned with spillover effects from meters installed in neighbouring homes. [Smart meters and public acceptance comparative analysis and governance implications. pdf] Page 12: When a government or utility allows an opt–out provision, opposition may dissipate somewhat, but it tends to move on to related issues. The comparative analysis shows that opt–out rates range from 1% in Maine to 4% in Vermont to 18.3% in one part of British Columbia (Skelton 2013). **Factors** **Technical Factors** • Installation British Columbia adopted a "rapid installation approach" with no opt–out, which "stimulated a strong opposition movement". **Social factors** • Perceptions and public beliefs Reasons given by organisations or sites opposing smart meters "nearly always included privacy", except where the organisation or individual was entirely focused on health risks. From the analysis of news reports, "health concerns were paramount" in all of the states included, with privacy generally the second or third most stated reason. News reports discussing reasons for opposing smart meters: Total = 120 Health = 94 Costs = 39 Privacy = 38 Security (theft) = 12 Fire hazard = 7 Other = 4 • Individual/ inter–Personal level factors • Consumers' perception beliefs in the health risks of electromagnetic fields

S12 Hess (2014) +/++	…continued
	• Control and autonomy CM: British Columbia adopted a "rapid installation approach" with no opt–out, which "stimulated a strong opposition movement". Authors: "When a government or utility allows an opt–out provision, opposition may dissipate somewhat, but it tends to move on to related issues." • Politics 7 of the 75 organisation/sites opposing smart meters were right–wing groups focusing on privacy and government intrusion issues. Authors: "Although there is evidence for a relationship between right–wing political views and opposition to smart meters among some organisations in the United States, the likely general pattern with respect to party politics is that opposition is associated with out–of–power or marginal political parties and groups." [Smart meters and public acceptance comparative analysis and governance implications. pdf] Page 7: Public opposition in British Columbia was linked to provincial party politics, because the roll–out of smart meters was supported by the governing Liberal Party (the right–wing or neo–liberal party). **Organisational factors** • Policy environment CM: In British Columbia, the lack of provincial response led opponents of smart meters to target city governments but despite 59 municipalities passing resolutions in favour of a moratorium or opt–out law, BC Hydro ignored these resolutions until they had completed 95% of their planned installations. • (Organisational) Trust [Smart meters and public acceptance comparative analysis and governance implications. pdf] Page 7: The government's decision not to let the British Columbia Public Table 1. Reasons for public concern in news reports*. Public concern British Columbia California Other states Number of articles 49 37 34 Cost (overruns, accuracy) 16 (33%) 15 (41%) 8 (24%) Fire hazard 3 (6%) 1 (3%) 3 (9%) Health 37 (76%) 31 (84%) 26 (76%) Privacy 11 (22%) 11 (30%) 16 (47%) Security (theft) 3 (6%) 3 (8%) 6 (18%) Other 1 (2%) 0 3 (9%) Note: *Percentages are the number of articles mentioning the concern divided by the total for the regional category (e.g., 16/49 for cost for British Columbia). Because some articles identify more than one issue, the percentages total to more than 100. 248 D.J. Hess [Smart meters and public acceptance comparative analysis and governance implications. pdf] Page 8: Utilities Commission review and oversee the project fuelled public opposition and anger. **Risk of verification bias (case study)** • Medium • Multiple case studies compared **3.2. How relevant is this case study to the review? (Case study)** • High
S13 Hmielowski (2019) ++/++	**The social dimensions of smart meters in the United States: Demographics, privacy, and technology readiness**
Study characteristics	**Outcomes**
Geographical location • USA	**Type of privacy concern** • Data misuse Smart meters could "allow energy companies to increase electricity prices during peak use times"

S13 Hmielowski (2019) ++/++	…continued
Components in intervention • Information • Description and picture of smart meter (and mechanical meter). **Setting** • Homes **Type of participant** • Residential **Political affiliation** • Conservative – see below • Liberal– see below • Moderate/ not sure M=2.76, SD=1.58, on 7 point scale from 'very conservative' (0) to 'very liberal' (6). **"Race", ethnic group identity** • Non white categories =24.9% • White =75.1% **Sex of participants** • Male =44.6% • Female =55.4% **Level of education** • High school/ College Median = some college **Work status / income** • Income bracket Median $30,000 to <$40,000 a year **Age** • Adults All 18+, M=43.02, SD=16.33	**Psychological Measures** • Acceptability [1–s2.0–S2214629618311101–main.pdf] Page 3: Support for smart meter installation. Our measure of support for smart meter installation included two items. The first asked respondents, "How likely would you be to oppose the installation of a J.D. Hmielowski, et al. Energy Research & Social Science 55 (2019) 189–197 191 [1–s2.0–S2214629618311101–main.pdf] Page 4: smart meter in your home?" Using a seven–point scale of "very unlikely (0)" to "very likely (6)" (reverse coded). The second asked respondents the extent to which they would oppose or support the installation of a smart meter in their home using the scale of "strongly oppose (0)" to "strongly support (6)." Higher scores indicate more support for installation of smart meters. The two items were averaged together to create our measure of this concept (M = 3.67, SD = 1.46, Spearman– Brown Coefficient = 0.71). • Interest in environmental issues [1–s2.0–S2214629618311101–main.pdf] Page 5: we included interest in environmental issues in our analyses. This was assessed by asking participants to respond to the statement, "In general, I am very interested in environ– mental issues." Response options ranged from "strongly disagree" (0) to "strongly agree" (6) (M = 4.17, SD = 1.42) • Privacy concern [1–s2.0–S2214629618311101–main.pdf] Page 4: Privacy concern. Three items were used to assess smart meter privacy concerns. These items were adapted from existing measures of this concept [54]. This index included the following questions: "A smart meter will make me vulnerable to an invasion of privacy from third parties who get a hold of information from the smart meter;" "Smart meters decrease the security of personal information collected by electric companies from my smart meter;" and "Smart meters know what appliances are being used in your home." All three items utilised the same seven–point scale of "extremely unconcerned (0)" to "extremely concerned (6)". Higher scores indicated a greater concern about invasion of privacy. The three items were averaged together to create our measure of privacy concerns (M = 2.51, SD = 1.41, α = 0.84). • Privacy violation experience To measure the extent to which respondents have been a victim of an improper invasion of privacy, we used items developed by Malhotra et al. [Higher scores indicated a person has been the victim of an invasion of privacy. The three items were averaged together to create our measure of privacy violation (M = 2.11, SD = 1.58, α = 0.76). • Technological readiness **Social measures** • Technological norms Social norms regarding technology adoption, specifically injunctive norms (e.g. 'people should be up to date') and descriptive norms (e.g. 'most people have x technology'). ["My friends want me to find information about the latest technologies;" "My friends want me to purchase the latest technological gadgets;" "My friends want me to use the most advanced technologies available."

S13 Hmielowski (2019) ++/++	…continued
Other characteristics • Smart meter installed? [1–s2.0–S2214629618311101–main.pdf] Page 5: we accounted for whether people have a smart meter installed in their home. We included this variable because research has shown familiarity is an important variable when examining people's use of new technologies [57,58]. In essence, it is important to account for people's familiarity with new technologies. Therefore, we included this additional control in our analyses. Participants were asked, "Do you have a smart meter in your home?" Respondents were presented with three choices: Yes (25.5%), no (58.4%), and I don't know (16.1%).	**Findings** • No effect/ neutral Demographics do not seem to play a critical role relative to support for this technology among our sample of people living in states with higher numbers of smart meters. Of particular note is the weak relationship between ideology and support for smart meter installation. People's perceptions of what others think regarding new technologies (injunctive norms) has not impacted perceptions of smart meter installation.""Social norms focused on general technology use do not seem to play an important role in shaping opinions about this technology. Positive concern about Environmental issues significantly associated with acceptable of smart meters, in all models • Negative The first set of variables are measures of privacy concern and being a victim of privacy intrusion. Results found that both variables were associated with lower support for installing smart meters in one's home (Model 3: Table 3, Column 3)."Moreover, these two variables accounted for the most variance in our outcome variable, accounting for about 9.6% of the variance. **Factors** **Individual/ inter–personal level factors** • Consumers' perception [1–s2.0–S2214629618311101–main.pdf] Page 5: even with all of the variables in the model, the more people said they were concerned about privacy issues, the less likely they were to support installing smart meters in their home (B = –0.343, SE = 0.030, p < 0.001). [1–s2.0–S2214629618311101–main.pdf] Page 6: A particularly noteworthy finding in our study is the potential importance of beliefs about technology. Our findings show that factors from the Technology Readiness Index correlated with support for smart meters. Indeed, those who generally hold optimistic views about technology were more likely to support the installation of smart meters in their home, while those who were concerned about the potential harmful effects of technology were less supportive of installing smart meters. [1–s2.0–S2214629618311101–main.pdf] Page 7: For now, our results suggest that individual beliefs and characteristics regarding the technology may be more important in determining perceptions of the technology. For example, messages could emphasise positive aspects of the technology or alleviating concerns about data breaches. • Experience We found the same pattern of results for those who reported being a victim of privacy violations [CM: that they were less likely to support installing smart meters in their home] (B = –0.072, SE = 0.025, p < 0.001) (Model 5: Table 3, Column 5). **Social factors** • [1–s2.0–S2214629618311101–main.pdf] Page 6: results suggest that norms may not play an important role in people's support for smart meter technology. **Overall, how reliable are the findings of the study (surveys)** • High **3.3. How relevant is this study to the review? (Surveys)** • High

S14 Hoenkamp (2012) +/+	Good Standards for Smart Meters
Study characteristics	**Outcomes**
Geographical location The Netherlands **Components in intervention** • Compulsory roll out Bill for changes of the Electricity Act, which contained the compulsory rollout of smart meters • In home displays • Real time information • Smart meter	**Type of privacy concern** • Surveillance Fear of privacy and security infringements as the meter could potentially expose personal information about the user to other parties. Qualitative themes (ie not numerical measures of current status, and hypothetical or real change) • Who benefits? Mostly the main driver in standardisation is commercial benefit for the companies involved. Without a framework to support the safeguarding of public interests, it will be highly unlikely that the standard for smart meters actually express a balancing of interests in which the interests of the market stand in proportion with the public interest. **Findings** • Mixed effects The process took a considerably long time, seven years, until the rollout could finally start. The positive side of it is that eventually most wrongs were righted. • Negative • Adverse events Many important aspects of the functionalities of the meter were overlooked by the NEN. This meant that the first standard was futile, and several issues had to be solved through the Order.
	Factors
	Social factors • Research A report conducted by the Tilburg University pointed out that the function of the meter to automatically communicate values every 15 minutes, and the possibility of access to usage information to third parties created possible privacy infringements [This report strengthened already intense parliamentary discussion concerning the privacy of the meter. **Organisational factors** • Institutional and socio–political contexts The Ministry of Economics finally decided that the standard meter architecture would only encompass functions on external data communication [4]. Again this set of functions was already determined in the first standard, and was therefore established before the parliamentary discussion ended. This meant that the institution, which is responsible for safeguarding the public interests, the people's representatives, did not have a say in the standard. • Public policies The Senate amended the Bill containing the rollout of the smart meter, and changed the mandatory acceptance of the meter for consumers into a voluntary acceptance. This amendment avoided privacy infringements by demanding explicit consent from the consumer to distribute information on energy usage to third parties.

S15 Horne (2015) +/–	Privacy, technology, and norms: the case of Smart Meters

Study characteristics

Geographical location

- USA

Theory

- Social norms
  Technological innovation has created unprecedented potential for invasions into individuals' privacy. That these threats will produce a demand for norms as well as norm expectations opposing Smart Meters. Horne (2009) argues that people "try to identify those behaviours that others will approve or disapprove" and suggests that when a behaviour causes harm, people are likely to think that others will disapprove of it.

Components in intervention

- Real time information
- Smart meter

Type of participant

- Internet user

Political affiliation

- Conservative
  S1 19% S2 19% S3 16%
- Liberal
  S1 58% S2 57% S3 28%
- Moderate/ not sure
  S1 23% S2 24% S3 28%

Sex of participants

- Male
  S1 164, S2 176, S3 128 (59%)
- Female
  S1 189, S2 179, S3 88 (41%)

Outcomes

Type of privacy concern

- Agency, choice and autonomy
- Data over–collection
- Unauthorised data use

Social measures

- Social norms
  How willing people thought their friends would be to have the meters and how good or bad their friends would think the meters would be for society

Findings

- Negative
  S1,2 the utility company's ability to control appliances in the home had a strong negative effect. .. To the extent that consumers understand that information gained through Smart Meters can be sold or used to intervene in the home, demand for and expectations of norms against Smart Meters are will increase. As consumers become more informed about the potential uses of Smart Meter data for analysis and control, negative reactions are likely to increase.

Factors

Technical Factors

- Data collection
  S1,2 results suggest that utility ability to collect detailed information about electricity use does not produce demand for or expectations of norms against Smart Meters.
- Value (of data)
  if power use information can be analysed to reveal details about home life, if that information can be sold to third parties, or if utility companies can remotely control appliances within the home, then demand for and expectations of anti–technology norms increase

Individual/ inter–personal level factors

- Consumers' perception
  S3 participants expected others to care most about their own ability to control their appliances.
- Demographics
  S1,2 Older participants expressed more demand for and expectations of norms against Smart Meters. While older people may be more suspicious of new technology than younger people, people of all ages are equally concerned about privacy. Interactions between education and the experimental conditions were not significant. Political ideology and its interactions were not significant, nor were gender and its interactions. This lack of interaction effects suggests that there is some level of normative consensus across demographic groups.
- Knowledge
  S1,2 when people are aware of the kind of information that might be gleaned from their electricity use patterns, demand for and expectations of norms against Smart Meters increase. S3 , information aimed at increasing participants' understanding of the relevance of the technology for mutual goals, led to weaker demand for norms against the technology.

S15 Horne (2015) +/–	…continued
Level of education • Average years education S1 14 years S2 13.9 years S3 15 years • Graduate/ masters level 6% more than 4 year degree • High school/ College S1 15% high school • Middle school 1.4% less than high school 1.3% less than high school **Age** • 16–30 • 18–71 S3 18–70 • 31–45 Mean age 31 S3 mean age 32 • 46–60 • 61–80 **Other characteristics** • Prior knowledge/ experience S1 (39%) had never heard of Smart Meters. 143 (41%) had heard of Smart Meters, but did not know much about them. Sixty–four (18%) had heard of Smart Meters and knew something about them. Eight (2%) said that they knew a lot about Smart Meters. S3. Ninety–five (44%) had never heard of Smart Meters. Eighty–four (39%) had heard of Smart Meters, but did not know much about them. Thirty–one (14%) had heard of Smart Meters and knew something about them. Six (3%) said that they knew a lot about Smart Meters.	**3.3. How relevant is this study to the review? (Surveys)** • Medium • US, tech–savvy liberal young internet users **Overall, how reliable are the findings of the study (surveys)** • Low

S16 Huang (2016) ++/+	Incentive mechanisms for privacy–sensitive electricity consumers with alternative energy sources
Study characteristics	**Outcomes**
Geographical location • Not stated **Theory** • Non–cooperative game theory • Components in intervention • Alternative energy source • PV • Battery • Smart meter	**Type of privacy concern** • Interest privacy The adversary can make inferences about consumers' energy consumption behaviour via data collected from smart meters [2]–[4]. • Trade off Each consumer faces a trade–off between masking consumption from the electric power grid for privacy reasons and revealing consumption patterns to the electricity provider for energy cost reduction. **Performance measures** • Add Cumulative imbalance loss **Economic measures** • Add Cumulative consumer reward, cumulative net profit **Findings** • Positive The proposed mechanism can successfully incentivise data sharing from privacy–sensitive consumers to both increase net profit of the electricity provider and reduce loss incurred by supply–demand imbalance consumers also benefit from this mechanism for electricity cost reduction. **Factors** **Economic factors** • Incentives • For a given set of electricity demand Dt, the amount of electricity that each consumer consumes from the grid** and the incentive price** strongly impact both the profit for electricity provider and rewards for consumers. **Social factors** • Behaviour the strategy of each consumer also affects other consumers' strategies indirectly by influencing the strategy of the electricity provider. **Individual/ inter–personal level factors** • Consumption For a given set of electricity demand Dt, the amount of electricity that each consumer consumes from the grid and the incentive price strongly impact both the profit for electricity provider and rewards for consumers. • Privacy **Overall, how reliable are the findings of the study? (Modelling)** • High **Overall, how relevant is the study to this review? (Modelling)** • Medium Very shallow understanding of privacy concerns

S17 Jakobi (2017) +/+	The catch(es) with smart home – experiences of a living lab field study

Study characteristics

Geographical location

- Germany

Components in intervention

- An App
- Dashboard
  customisable dashboard serves as a homescreen where all chosen components are presented in widget–style fashion.
- Diary
  home log book
- Feedback
- Information
  (1) gaining an overview of the current and past state of the home (2) managing existing and adding new devices, and (3) managing automation rules and groupings.
- Internet access
  with at least 2 kbit/s download according to the carrier contract were included
- Rmote controls
- Sensors
- Smart meter
- Smart plugs
- Smartphone
  only households in possession of at least one smartphone could participate, so households could be provided with tablets.
- Web Portal
- Z wave

Geographical characteristics

- City/urban

Outcomes

Qualitative themes (ie not numerical measures of current status, and hypothetical or real change)

- Functionality vs expectations
  Our initial interviews showed that most of the households already had informed themselves about smart homes via the internet or magazines. However, participants planning to include smart home technology in their newly built or modernised home were overwhelmed by the number of existing products and their implications for future interoperability.

Findings

- Mixed effects
  Even though comfort, security and energy savings might motivate households to have an interest in a smart home on a global level, concrete use cases are highly individual and changed noticeably depending on seasonal factors, changing infrastructure or (ir–)regular events and households' evolving routines. Many use cases only arose in a later phase after households had the systems installed.
- No effect/ neutral
  Related to system awareness, users showed relatively little concerns in privacy, though some users wanted to know what information was being transferred to the vendor (or 3rd parties). That is, they demanded a degree of awareness: "For now, I don't see any way of misusing my data that could turn out to be my downfall. […] It would be nice, however, to see what data is transferred or stored. If I can control this, its on me to decide what may be transferred or used." (Single–person household)

Factors

Technical Factors

- Complexity
  "I haven't decided on anything yet because I know there are many solutions. It is well known that [product A] is pretty expensive. [Product B] is more for hobbyists […]. Maybe those plug and play systems are better. […] Investing hours of time reading through forums, writing scripts – which I cannot do myself – or programming something via copy and paste, I simply don't have the nerves for that right now." For use cases where only a single (kind) of sensors was needed, such as heating, the complexity grew strongly with the number of different sensors included in a scenario. The most common problem touched on that of pairing devices with the gateway – a necessary step for Z–wave based components. The whole process raised serious issues and was a task many participants felt uneasy accomplishing. "For me, installation was very … complicated. I mean you always think its like plug and play. Meaning: I will just try reading the instructions. And that didn't work at all. Then I read the manual and thought I had understood it. But this still wasn't the case and looking closer to the manual, you found half a sentence you missed and then it worked." (Multi–person household) "If you haven't ever done this before and you don't know [how to], you would probably search, search, search. In this way, it is prescribed to you: Oh yes, you have to click Smart here, to start the timing. I think that actually is quite okay." (Multi–person household) P1: "I find it especially hard to set up rules…And setting them the way I want them to work. I don't manage to do this myself." Interviewer: "So what did you do?" P2: "I always try. Let's look [into the system]. A rule is for example: In case the thermostat measures 23 degrees Celsius, shut down the heating. That's a rule, right?" P1: "If one thing happens, the other thing must follow. That's a rule. I never manage to do this."

S17 Jakobi (2017) +/+	…continued
Children • Yes =5 • No =5 **Type of home** • Single person household =2 • Multi–person household =5 **Housing tenure** • Home ownership =10 • Flats =4 **Age** • 16–30 between 21–67 • 31–45 • 46–60 **Other characteristics** • Prior knowledge/ experience smart home–related foreknowledge.	• Installation Items need to be future proof, especially (but not only) when flush–mounted and thus more permanently installed **Economic factors** • Affordability Varying payment models requiring considerable financial investment, further discouraged households from deciding to buy. **Individual/ inter–personal level factors** • Expectations Users also naively thought that other systems they used would be interoperable with a smart home, especially the ones promising "smartness". – some households had smart meters installed, which they thought would easily go with a smart home system – in fact they were considered a vital part of it. • Experience if–this–then–that style posed major challenges to households not familiar with algorithms in their everyday life. **3.2. How relevant is the phenomena explored relevant to this review? (Qual)** • Medium Minimal engagement with privacy issues or concerns, mainly because the participants were unaware of them, Privacy was not the main focus of the study **Overall, how reliable are the results? (Qual)** • Medium
S18 Jakobi (2019) +/++	**It is about what they could do with the data: a user perspective on privacy in smart metering**
Study characteristics	**Outcomes**
Geographical location • Germany **Theory** • Theory of social practice **Components in intervention** • An App for Android • Customer choice of level of disclosure Customer can choose the level of disclosure based on the presentation of risks and benefits	**Other characteristics** • Prior knowledge/ experience consumers in Germany are largely unfamiliar with Smart Metering [38] • Regulatory context In Germany, a "soft" rollout of Smart Meters has recently begun. Smart Meters are mandatory for new buildings and for existing structures that choose to make renovations. Legal privacy compliance is an important consideration since Germany has strong data protection and privacy laws in comparison with other countries. • Type of privacy concern • Anonymity A majority of respondents wanted to set boundaries for the data related to their power consumption and customer accounts. Most often, addresses and account details were understood to be private and were not to be disclosed. • Discrimination Participants feared that they could face price discrimination without their knowledge or have their electricity bills go up if their power consumption patterns lacked flexibility. "Less flexible households must consume power at peak price times." "[…]One could see who is lying in front of the TV all day … that guy could maybe receive a higher bill or something."

S18 Jakobi (2019) +/++	…continued
• Information The user was shown a list of benefits and risks corresponding to the respective services. For each chosen service, users were presented with the implications of the data disclosure at five levels (every 15 minutes, daily, weekly, monthly, and never), each corresponding to a different granularity of data disclosure. • Internet access • Smart meter **Geographical characteristics** • City/urban Mid sized city **Setting** • Homes **Type of participant** • Residential **Sex of participants** • Male survey:17 App: 105 • Female survey:14 App: 100 **Work status / income** • Students **Age** • 16–30 between 20–76 • 31–45 App: average age 30, mean 26 • 46–60 • 61–80	• Identity privacy Individuals operationalised the privacy risks of Smart Metering in relation to what third parties could know or infer about their everyday lives. "I don't want my power consumption information or customer data to be passed on in any way, used for advertising purposes, or the amount or time of consumption passed on to third parties. I do not want any kind of 'offers" due to my consumption data." — P21 (F, age unspecified) "The main problem is again, as already mentioned, the creation and possibly criminal exploitation of when someone is absent from home." — P11 (M, 53) "Others could even 'see' when you are going to bed [by seeing when you] switch off the lights." — P21 (F, age unspecified) • Relational privacy Participants indicated a principled desire to be in control of their Smart Metering data such that they would be able to decide, for instance, which parties could access the data under which circumstances • Surveillance "Additionally, my private sphere needs to be maintained, which is why information regarding the use of the sauna and solarium as well as the TV and the Internet should be considered off limits." — P11 (M, 53) • Trade off Keeping data private was a relative value with respondents being open to trade–offs based on perceived benefits • Qualitative themes (ie not numerical measures of current status, and hypothetical or real change) • What are the advantages? The perceived individual benefits included control over specific appliances, savings achieved via flexible tariffs and reduced prices, comparisons with the power consumption of other households, facilitation of environmentally friendly habits, and personalisation of advertisements and offers. One of the most commonly mentioned benefits was a flexible tariff structure that could help optimise power consumption and lower electricity costs. Participants desired that the utility provider help shift the power load to periods of low tariff. "Utility provider could provide added value in allowing the control of air conditioning or heating according to peak loads." Participants found it beneficial that a Smart Meter could be read remotely, thus eliminating the need for an in–person appointment for meter readout. Benefits: Feedback – Consumption data could be available online anytime, anywhere. (31/4) Consumption data could be compared and shared with family and friends. (10/4) Consumption data could be collected anonymously for comparison with similar households / appliances. (13/4) Savings – Tariffs could be made flexible. (3/1) Tariffs could be optimised for individual households. (2/2) Flexibility – Tariffs could be simplified. (1/1) Meters could be read remotely (without an in–person appointment). (0/1) When moving, account changes can be processed faster. (0/1) Sustainability – People could be incentivised to engage in environmentally friendly habits. (6/2) Independence – People could manage how other parties access the data. (2/3) Advertising – Advertising could be optimised through personalisation (e.g., showing ads for a more efficient fridge based on meter readings). (6/2) Infeasible – People could remotely (e.g., via mobile applications) switch appliances on/off. (3/0) People could separate the consumption of individual households in buildings with a Smart Meter shared across all apartments. (1/0)

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S18 Jakobi (2019) +/++	…continued
	• What are the disadvantages? Perceived risks – Actions of utility providers. The utility provider could engage in price discrimination. (1/3) The utility provider could get sensitive information. (20/2) The utility provider could switch off power. (3/1) Exposure of life practices – One may become a 'transparent citizen" and have privacy violated. (31/4) Home presence could be deduced. (8/2) Third parties could derive behaviour patterns and create profiles. (11/3) Employers could engage in employee surveillance (e.g., coffee maker/computer use). (1/0) Others could know of one's purchases. (1/0) Advertising – Advertisers could personalise ads. (21/4) Salespersons could know when someone is home. (1/0) Abuse – Power could be disrupted by bad actors. (7/2) Consumption data could be modified by hackers. (11/2) Private information could be collected by malicious actors. (4/0) General concerns – Smart Metering systems might be hard to handle. (8/0) • People may waste electricity when it is cheaper. (0/1) Consumption sharing may create moral exposure by the need to justify choices. (7/1) Infeasible – Manufacturers could analyse the use of specific products. (1/1) The agency that collects fees to support public broadcasting could check for the existence of specific appliances. (1/0) Movie industry could target people based on their content consumption. (1/0) Neighbours in apartment buildings could control each other's power consumption. (1/0) • Who benefits? With regard to third parties, institutions like grid operators, utility providers, and appliance manufacturers were believed to gain the most from the rollout of Smart Meters. Similarly, another participant feared gaining nothing from Smart Metering and was not willing to have a Smart Meter installed because she perceived the current circumstances as unfair to consumers such as herself. "Consumer will not have benefits while service providers get sensitive information." • **Findings** • Positive Given the choice, participants chose to change their disclosure settings or cancel their subscriptions in more than 86% of the cases, strong support for the relevance and usefulness of the implications we included to facilitate more informed privacy decision making. "[…] Just watching the pros and cons was helpful for me, when it showed me that they could know when I get up, when I do something and so on. I didn't think it would be so clear based on when I use electricity." — E13 (M, 24) connecting data disclosure and its potential real–world consequences is a promising design technique for usable privacy. About one–third of the participants made privacy decisions based primarily on the options for setting the temporal granularity of data disclosure. "I really kept my mind on the intervals in question. Annually or monthly would be okay, or maybe semi annual or quarterly, but certainly not more often." — E108 (F, 53) • Mixed effects The most subscribed service (N=137) was Smart Control, followed Family Comparison (N=85). Few respondents mentioned issues of trust within the family context, though some were concerned with surveillance by others in the neighbourhood. • Negative Personalised Advertising (N=43) was the least popular For most of the services, between 7% and 9% of the initial subscribers decided to cancel the service altogether during the subsequent step of examining the disclosure implications.

S18 Jakobi (2019) +/++	…continued
	Factors
	• **Technical factors** • Data collection About one–third of the participants made privacy decisions based primarily on the options for Setting the temporal granularity of data disclosure. "I really kept my mind on the intervals in question. Annually or monthly would be okay, or maybe semi annual or quarterly, but certainly not more often." — E108 (F, 53) • Ease of use Respondents wanted usable interfaces. For example, they wished to control Smart Meters and check consumption via personal computers or smartphones. • Security of data The worries respondents expressed about the data getting lost or falling into the wrong hands underscore the need for safeguarding the data. "A reservation for me is the high threat of misuse of data, such that the data will fall in the wrong hands." – P23 (F, 20) **Economic factors** • Billing feedback In contrast, power consumption data was perceived largely as a resource to be traded for value–added services that provided individual or societal benefit. "If it was for a certain benefit, such as reducing power consumption costs or promoting sustainability, that'd be okay." – P24 (F, 23) • Costs Potential Negative Consequences. Respondents often feared that the installation and/or use of Smart Metering could result in higher costs. When considering the most important factors, costs typically played a major role: "The success of a project to spread intelligent electricity meters will in any case be measured by the potential savings achieved by the customer, not by means of politically allocated subsidies, but by the saved kWh, and therefore by the customer's Euros, as well as by the benefit to the environment." – P11 (M, 53) **Individual/ inter–personal level factors** • Demographics Those without a professional or technological educational background reported that they found the additional information useful for privacy assessment. In contrast, those who indicated they were privacy–sensitive or technically savvy, reported comparatively lower benefit from the presented benefits and risks. These participants mentioned that they already knew the information provided. • Knowledge Few respondents had personal experience with Smart Metering. Therefore, it could have been difficult for them to evaluate how the new technology could impact their privacy. Respondents admitted not knowing enough to understand why and to what degree the data in question might be sensitive. "In principle, I would prefer savings [over privacy]. However, I am probably lacking information on what utility providers or other parties can do with my data. The extent [of what might be done] is not clear to me." – P32 (F, 53) • Lifestyle In terms of usability, the success of Smart Meters was seen to depend on their integration with everyday life. "An important feature is ease of use, which allows one to have an overview of power consumption quickly and easily. In addition, failure and disruption rates should be as low as possible. Usability should be managed such that one feels safe with the Smart Meter after a short time." – P23 (F, 20)

S18 Jakobi (2019) +/++	…continued
	• Trust Respondents commonly suggested allowing consumer control over Smart Metering data distribution. "Trust always plays a big role with regard to data. As long as each person can decide who gives what data about his or her own power consumption, I think Smart Meters can be a great thing." – P23 (F, 20) • Understanding Communication of best practices and possible advantages. "A lot of education with the people, savings for the customer, environmental aspects/CO2 savings." – P6 (M, 37) "First, the benefits to the consumer must be clarified. Just creating yet another gadget for a smartphone will not be enough [to make Smart Metering attractive]." – P8 (M, 45) **Organisational factors** • Regulatory environment Regulatory agencies and utility providers were frequently perceived as responsible for data protection, but respondents recognised their own responsibility as well. "The legal framework, the general terms and conditions of the utility provider, and thus ultimately myself [are responsible for data protection and privacy in Smart Metering]. I have to read the terms and either object to the disclosure of the data or prohibit it." – P21 (F, age unspecified) **3.2. How relevant is the phenomena explored relevant to this review? (Qual)** • High **Overall, how reliable are the results? (Qual)** • Medium
S19 Kapade (2017) +/+	**Credit based system for fair data sharing in smart grid**
Study characteristics	**Outcomes**
Geographical location • Not stated **Theory** • Game Theory **Components in intervention** • Area networks • Building (BANs), Neighbourhood (NANs) and Wide Area Networks (WANs) • Smart meter **Setting** • Home / microbusiness area • Modelled, classified by power consumption area: Low < 15,000kWh/year [this was the only area studied in experimental example].	**Type of privacy concern** • Data misuse Example given is of a criminal using energy data to determine when a resident is not at home in order to rob it. • Economic measures Costs Modelled, for the data collector: big data maintenance, storage, energy and credits. • Revenue Modelled – of the data collector and third parties. **Findings** • Positive Consumers given incentives are more likely to sharing data than those unincentivised. This is even true for highly private data (privacy level 1) which consumers were willing to share without reward. See fig 3: roughly 50 share level 1 data if rewarded, 0 if not. Roughly 700 share level 10 data if rewarded, 200 if not. NB: Level of incentive not specified. **Factors** **Economic factors** • Incentives Level of incentive rises with privacy level to encourage sharing of more private information.

S19 Kapade (2017) +/+	…continued
• Large business area • Modelled, classified by power consumption AREA: High ~ 100,000kWh/year [not studied in experimental example]. • Small/medium business area • Modelled, classified by power consumption AREA: Medium 15,000–50,000kWh/year [not studied in experimental example]. **Type of participant** • Residential – modelled • Business – modelled **Other characteristics** • Energy consumption Modelled, classified by power consumption: High >1000kWh/month, Medium 600–1000, Low <600. Types of activity also classified "as a reference for different home appliances use". Experimental data for the model taken from the UMass Trace Repository	
S20 Melville (2017) –/++	**The electric commons: A qualitative study of community accountability**
Study characteristics	**Outcomes**
Geographical location • United Kingdom **Components in intervention** • Consumption data Via energy monitors in homes that recorded demand on the substation and some indication of the "collective action" undertaken by participants to reduce demand, i.e. all neighbourhood data, no individual data.	**Type of privacy concern** • Agency, choice and autonomy Horne et al. (2015) conclude that privacy concerns may lead to public rejection of smart meters. However, this may depend on context, and the acceptability of smart meters could be greater if the wider societal benefit of the smart grid is clearly communicated, and if individuals feel that they have control over the technology installed in their home (Buchanan et al., 2016). • Anonymity Interviewer: And if you could identify who the people were that were logging on, would you have felt more or less inclined to do it yourself? Clara: I think I preferred the anonymity of it. I think if people were identified by house number it would be a bit, not voyeuristic but a bit too much information almost. Interviewer: And what if the website told you the names of people? Josie: Don't think that's particularly a good, no I wouldn't really be bothered about that and I don't think I would want my name there either. • Data misuse For targeted marketing or research, and potentially creating unequal power relations (through big data).

S20 Melville (2017) –/++	…continued
• Feedback Alerts to householders when the substation was under pressure (peak demand) • Incentives **Geographical characteristics** • City/urban **Setting** • Homes **Type of participant** • Residential **"Race", ethnic group identity** • White • All identified as white–British **Sex of participants** • Male =1 • Female =11 **Housing tenure** • Mixed • Not specified further **Age** • Adults 22–55	• Non–Intrusion e.g. Allowing burglars to identify when the home is empty. • Relational privacy To understand how respondents' sense of community and level of social trust affected their concern about free riding behaviour and desire to monitor others' participation, and their energy consumption patterns and perceptions of time of use flexibility. Most respondents had mixed feelings about the idea of mutual monitoring, expressing concerns about embarrassment and fear of retribution, and hope for mutual support and sharing of knowledge. • Reputational privacy Respondents' views on sharing individual energy consumption data with their neighbours were mostly negative (with some ambivalent or neutral), particularly if this was for the purposes of holding each other accountable • Surveillance Freedom from state surveillance. Key vertical privacy concerns in a smart energy system include the risk to political rights and freedoms from state surveillance; 'vertical' privacy of individuals relative to large organisations such as energy companies, data companies and the state, and the 'horizontal' privacy of individuals relative to their peers **Qualitative themes (ie not numerical measures of current status, and hypothetical or real change)** • Accountability Most respondents had mixed feelings about the idea of mutual monitoring, expressing concerns about embarrassment and fear of retribution, and hope for mutual support and sharing of knowledge. Respondents' views on sharing individual energy consumption data with their neighbours were mostly negative (with some ambivalent or neutral), particularly if this was for the purposes of holding each other accountable. Interviewer: If there was a blackout, would you want to know who did it? Clara: No, because if it had been us then I would be terrified of being lynched. Interviewer: And if it tells you the names of people? Anna: I think that'd be horrible. I'd hate that I wouldn't want to participate if that was how it was going on, it would be a bit like Hitler Youth or something wouldn't it. Interviewer: And if [a blackout] were to happen because a few people were just using huge amounts of power would you want to know who it was? Frances: Well, now that's kind of more like one big brother watching and it's also kind of scary like picking on one people, I mean … I don't know, I think that could go terribly wrong. Interviewer: And if [a blackout] did happen, because a few people were really maximising their power consumption, would you want to know who it was? Louise: Oh no, that's a local witch–hunt! We're far too nice round here. Interviewer: What if it gave you the names of the people who were joining in? Clara: I think I'd be quite embarrassed [laughter], I think it's quite, you wouldn't want it to be like a name shame thing but you'd have the house numbers but then again how personal does it get. Obviously it's all for awareness and not to name and shame but it's like I think it'd be quite interesting. If you do it by street that would be quite anonymous or at least let you feel that there's something going on, yeah." Frances also pragmatically recognises that "there's always going to be people that don't participate", a finding supported by Burchell et al. (2016), who note a 'pyramid of participation', in their project. This acceptance of free–riding, and potentially willingness to compensate for those who do not contribute, might be different in a context where the community provided the only mechanism of accountability, rather than an additional layer alongside the contractual relationship of buying energy.

S20 Melville (2017) –/++	…continued
	Respondents saw mutual monitoring positively as an optional way of mutually supporting each other to choose ethical energy consumption behaviours. However, it was seen negatively in the context of enforced neighbourhood accountability here! • Actors involved Kelly saw the time needed to manage a community energy system as requiring a paid position: Kelly: Well it gives you more control but, again, you'd need people to do that and they'd cost. I don't think people have got enough voluntary time to do it, it would have to be paid, proper salaried posts to do all that • Roles and responsibilities Clara: If it's a decision making process people might find that quite frustrating. So, for example, if we had to vote for particular items or aspects of the system then that might be quite problematic Interviewer And why do you say the decision making process would be frustrating and problematic? Clara: Maybe it's time consuming for people and slows the processes down. And I suppose when you … I don't know if we partly pay certain companies like energy companies for making decisions that we don't have to think about. And that's what people, that's maybe part of the premium • What are the advantages? Would devolution of enforcement of fair energy consumption behaviour to a local community result in more or less fair, compassionate and desirable outcomes? • What are the disadvantages? ….But I wouldn't but not to the point that it clearly – disrupting my relationships with my neighbours– I don't think it's not the first thing I would launch into talking to them about because it might seem a bit mean although I do feel it's really, really important and would be really good if whoever moves in on either side got involved. I'd be really happy to chat to them about it but it would be yeah I don't know if it would feel it's unfair, I'd just feel a bit like, "Oh that's a shame." **Findings** • Positive Several participants, including some of those who had concerns about privacy discussed above, identified a number of positive aspects of sharing information about energy consumption within the community. These included making individual actions feel more worthwhile, social motivations of meeting others, and the potential for support through sharing tips and information. Clara: sometimes it feels a bit futile if you don't think anyone else is doing it. So I think if you know that other people are doing it, it makes you feel you're having a bigger impact. (With similar comments made by Gloria, Kelly and Josie). LiM respondents were generally interested in having access to detailed information about their own electricity consumption, in order to learn how to adjust their behaviour: "being able to see your own usage and when your own peak times are and make adjustments" (Emma, with similar comments made by Kelly, Anna and Clara). The idea of knowing how their energy consumption compared with others, particularly others who were similar to them, in terms of number/age of children, type of heating system, house occupancy patterns etc. was discussed enthusiastically in the focus group. • Mixed effects "Regarding the applicability and usefulness of a commons approach to electricity in urban Settings, this study is inconclusive." [Benefits found in social interaction and support, negatives in creating a potentially unfair and unpleasant mutual monitoring environment.]

S20 Melville (2017) –/++	…continued
	• Negative Respondents' concerns about horizontal privacy point to a fear that community based enforcement of acceptable energy use behaviour may be unpleasant, and less desirable than the bureaucratic, centrally administrated system of billing and metering currently in place
	Factors
	Social factors • Community buy–in Concerns about enforced accountability (duty to monitor neighbours) may be lessened where neighbourhoods have full responsibility for their infrastructure, but this was a novel concept for most participants. Some potential community–led approaches were suggested but respondents doubted whether peers would be willing or able to devote the time needed. • Inclusiveness Imogen: I think if someone can only do a tiny bit but they've actually done that tiny bit, it's all part of the bigger picture isn't it Frances: It's also really hard because you don't know the situation of the people in the house. Like you don't know ability wise, you don't know anything about these people. So just to switch off, pick and choose to switch off someone's electricity it's like yeah … I know that we could make do and we'd be fine. We might be a bit cranky but we'll be fine. But there are other houses maybe they couldn't or maybe there's something about them that we don't know on multiple levels. This acceptance of the diversity of the population supports the idea that community groups could develop their own sense of fairness and be compassionately responsive to individual needs. • Justice Respondents feared that a system that allows peers to identify (and punish?) Transgressions would not be calm, fair or rational. Authors: "Respondents were accepting of the diverse needs and capabilities of individuals in their community, in relation to the flexibility of their energy consumption … [which] supports the idea that community groups could develop their own sense of fairness and be compassionately responsive to individual needs." NB: Attitudes may be gendered or subject to self–selection bias. [1–s2.0–S0301421517301799–main.pdf] Page 7: Respondents' concerns about horizontal privacy point to a fear that community based enforcement of acceptable energy use behaviour may be unpleasant, and less desirable than the bureaucratic, centrally administrated system of billing and metering currently in place. • Social interaction Benefits stated, even by those with privacy concerns, "included making individual actions feel more worthwhile, social motivations of meeting others, and the potential for support through sharing tips and information." • Trust It is also possible that respondents' attitudes to different people's needs may be gendered, or subject to self–selection bias, with more socially minded people choosing to respond to research interviews. Levels of social trust of respondents were moderate to high, with the greatest social trust for colleagues, people working in local food shops, and people in the neighbourhood, and the lowest for the local councillor and local council. There was a stronger association between trust in people in the neighbourhood and motivation to save energy if others were doing so than between general social trust and community motivation. This high level of social trust may be related to respondents' accepting attitudes to the diverse energy needs within the neighbourhood. Attitudes may be different in another neighbourhood or with different demographics.

S20 Melville (2017) –/++	…continued
	Individual/ inter–personal level factors **Social factors** • [Page 6: Most respondents had mixed feelings about the idea of mutual monitoring, expressing concerns about embarrassment and fear of retribution, and hope for mutual support and sharing of knowledge." "Respondents' views on sharing individual energy consumption data with their neighbours were mostly negative (with some ambivalent or neutral), particularly if this was for the purposes of holding each other accountable. In particular there were negative feelings about identification of individual names. **3.2. How relevant is the phenomena explored relevant to this review? (Qual)** • High **Overall, how reliable are the results? (Qual)** • Low Few participants, little methodical detail regarding conducting the interviews and focus group.
S21 Moere (2011) –/+	**Comparative feedback in the street: Exposing residential energy consumption on house façades**
Study characteristics	**Outcomes**
Geographical location • Australia **Components in intervention** • Feedback • Internet access • Outside home display • A chalk board on the outside of the house showing energy consumption data • Sensors • Wireless network • A wireless transmitter and wireless receiver **Geographical characteristics** • City/urban A neighbourhood of mainly terraced houses	**Type of privacy concern** • Location privacy • No or very low usage data could show the resident is not in the house **Findings** • Positive While the private display affected the awareness of energy consumption on an appliance level, we found that the public display allowed participants to understand their consumption on a more general level. Most participants reported how the public display prompted many conversations on energy consumption and environmental issues with other household members or people visiting and noticing the public display. During the post–study interviews, households generally stated that they perceived the private display as more influential to their behavioural changes than the public display, mostly because of its real–time nature. • Mixed effects Overall, the ranking aspect worked well to encourage people to 'start' with changing their behaviour, although the behaviour seemed to decline after people got used to its competitive aspect • Negative Gaming: Behaviour change was often triggered by the competitive nature of the public displays, and in particular by the neighbourhood ranking. However, the neighbourhood ranking also led to less sustained behaviour, like strategically clustering washing cycles in time, in order to end up first in the ranking the day after (e.g. H2). "One day we were [away] and got a message from our housemate saying 'we are number five…, the people next to us are number one!' And I sent back a text [telling them] to quickly switch of all our power points!" (H5).

S21 Moere (2011) –/+	…continued
	Factors
	Individual/ inter–personal level factors • Consumption None of the households was regularly checking their electricity meter to monitor consumption. • Environmental Concerns During the pre–study interviews, all households stated they were well aware of the climate crisis. Everyone expressed some opinion on global warming and most participants stated that they were trying "to do their bit", which included switching off lights (n=11), switching off appliances at the power plug (n=6), replacing bulbs with energy– efficient lighting (n=3), replacing electric water heating or stoves with gas ones (n=2), and partly switching to green energy (n=2). **Overall, how reliable are the findings? (Controlled)** • Low **3.1. How relevant are the outcomes to this review (controlled)** • Medium Privacy is mentioned only briefly in this study, however it offers a perspective on privacy trade off other than monetary, a more positive framing of motivations for data sharing
S22 Naus (2015) ++/++	**Households as change agents in a Dutch smart energy transition: On power, privacy and participation**
Study characteristics	**Outcomes**
Geographical location • The Netherlands **Theory** • Social practice Everyday life, then, can be understood as a web of interwoven practices that are loosely or more tightly interconnected in time and space. How do forms of cooperation and meanings of privacy and autonomy contained in established practices shape participation in new energy management practices? These three points can be summarised as follows:	**Type of privacy concern** • Agency, choice and autonomy Questions on the application of – and control distribution over –smart washing machines generated varied responses as well. 30% of the respondents opt for full control over the timing of this laundry practice, 35% allow the energy provider to pre–select options, while17% allow the energy provider to decide on the timing within self–defined limits.8Respondents who selected the 'full control' option value the "freedom of choice" or do not entrust energy providers with this task. • Data misuse They oppose the use of smart meter data "for commercial purposes" extending scope: "[Energy providers] all want to give us the impression that they are thinking along with us… That's positive in the sense that they are better able to see where the [energy] peaks are, so they can resolve things. But they can also see, for example, that Mr. X has been using the same hair dryer so many times that it is not working properly anymore. Then they will send him an advertisement saying: buy a new one! Surely they are going to extend the scope." • Data ownership These respondents express their concern about a lack of ownership over their data, • Discrimination "I have nothing to hide. It is just that connections will be made between different databases. That will result in a profile… For many that profile will be just fine, but for a small minority this profile will mark them as terrorists! Simply because [they can see]: here I have bought some chemical fertiliser and there I do something that requires a lot of energy." • Non–Intrusion "A castle where the individual enjoy(s) freedom from government intrusion", can find "peace of mind, cultivate intimate relationships, and engage in personal activities of self–development".

S22 Naus (2015) ++/++	…continued
• While householders have always participated in energy systems through their practices, consciously or not, the home is also becoming a more explicit site for environmental participation. • The dominant understanding of the home as a private and autonomous place is a pervasive but ultimately malleable social construction. • Forms of cooperation and meanings of privacy and autonomy invested in existing practices can serve as a frame of reference **Components in intervention** • Consumption data Many of the householders have already adopted monitoring practices to keep track of their own energy consumption. 95% of the respondents read their annual energy bill. Furthermore, 26% performs energy meter readings every month, while 25% does this at least every week • Domestic production • Mainly solar panels • Energy meter • Device–specific energy meter (42% • Real time information • Variable rates	• Peaceful enjoyment • Relational privacy One participant illustrated the type of drawbacks that peer–involvement can elicit:" You can also see it as an invasion of your privacy. Someone is going to meddle in. You might experience some sort of social pressure on the way you do your housekeeping." • Surveillance Respondents who are not interested in new forms of energy advise state similar things; they are afraid of being watched, • Trade off They felt that, to some extent, "privacy has already disappeared" with the widespread use of social media The use of smart meter information for what is considered to be a public benefit (balancing demand and supply) is thus seen in a different light than the use of the same information for commercial purposes. **Findings** • Positive Survey–respondents are also eager to explore new forms of monitoring that can extend existing practices: 64% (+19% more tentatively) welcomes the assistance of experts in sorting out smart meter data, 52% (+28% tentatively) is open to tailored energy saving tips, 70% (+15% tentatively) is positive about receiving notifications in case of unusual energy use, and 28% (+34%tentatively) is open to tailored advertisements. Especially consumer organisations (72%), environmental organisations (70%) and energy providers (58%) seem to be in a good position to provide these services. Opportunities for information sharing with other householders are initially met with enthusiasm. Many survey respondents have engaged in information sharing practices before, for instance by comparing energy consumption levels with family members (57%) or with neighbours (34%). It may therefore not be surprising to find that many respondents would share their energy–performance through social media, with family and friends (60%) and with neighbours (59%) in case they were asked to do so. 69% would enrol in a local energy–saving program, while participation in an online discussion forum (51%) or an energy saving competition (32%) is less appealing • Mixed effects Initial enthusiasm for sharing information with people in close proximity declines: Participant 1: "The ideal situation, I think, is that everyone has a [carbon] footprint [that is visualised] near the front door of their house. Then everyone can see: this is how I did today" Researcher: "Visible for others as well or. . ."Participant 2: (laughing) "A big cross; misbehaving household!"(Laughing) Participant 1: (laughing) "No, not on the outside! No, no. Only when you enter your house… Only for yourself." Even though participants were clearly more inclined to cooperate horizontally than vertically, it was shown how, on second thought, practices of information sharing became subject to discussions about peer pressure, The potential for social judgement that comes along with information sharing is thus seen as an undesirable side–effect or even limiting feature to such practices, especially for those householders with a relatively high carbon footprint. Arrangements with friends, finally, are appreciated for the "personal contact" and the "absence of commercial interests". On the other hand, several respondents worry about conflict situations that can arise in the absence of formal rules and with "a lack of authority over someone else's roof". dispositions on horizontal privacy impede participation in arrangements with friends and in large–scale arrangements, while this is not the case for local energy cooperatives (items).

S22 Naus (2015) ++/++	…continued
Sex of participants • Male =FG 8 Survey 73.5% men • Female =FG 4 **Level of education** • Average years education The survey data reveal that, compared to Dutch averages, a particularly high level of education • Bachelors degree • Survey =43.5% university level **Work status / income** • Income bracket The survey data reveal that, compared to Dutch averages, there are particularly high income levels [41].33.1 **Housing tenure** • Home ownership The survey data reveal that, compared to Dutch averages, a relatively high number of homeowners. 81.9% home–owners,67% over 1.5 times modal. **Other characteristics** • Prior knowledge/ experience • Understanding of energy system	• Real–time pricing is considered most "honest" and "transparent" by proponents, while opponents construe this mechanism as "complicated", "opaque" and "a new means for the provider to make profit". Multiple tariff blocks, finally, seem to provide a practical middle ground, being more "understandable" and "manageable" than real–time pricing, while still putting householders "in a position to influence energy consumption". • Negative Commercial third parties (10%)and smart meter manufacturers (18%) are much less favoured Among the survey respondents with an analogue energy meter (74%), a noteworthy 32% would refuse a smart meter, or has actually refused it when the meter was presented to them. Both vertical privacy and horizontal privacy are shown to negatively affect the attribution of control to service providers. **Factors** **Social factors** • Citizen's initiatives As opposed to expert advice, citizen–led initiatives are praised for the absence of a profit–orientation and for the possibility of "generating innovative ideas". On the other hand, they are also perceived as problematic precisely because of the expected lack of expertise, and the time and effort required to organise such initiatives. Social and spatial proximity seem to make local initiatives particularly attractive. • Cooperation Arrangements in which "user–patterns" are only visible at an aggregate level, and arrangements in which "contributions to a common goal" are optional rather than imposed. While such privacy measures may alleviate peer pressure, they also condition the possibilities for horizontal cooperation around time–shifting. • Proximity Dispositions on horizontal privacy negatively affect a householder's inclination to share energy performances through social media (item). The specific group of peers to share this information with seems important here as other forms of information sharing (items) remain unaffected by this measure of horizontal privacy As regards the local energy cooperative, respondents appreciate especially the spatial proximity, the "social cohesion" that it can create and the more professional, business–like character compared to arrangements with friends or acquaintances. • Social pressure One participant illustrated the type of drawbacks that peer–involvement can elicit: "You can also see it as an invasion of your privacy. Someone is going to meddle in. You might experience some sort of social pressure on the way you do your housekeeping." **Individual/ inter–personal level factors** • Control and autonomy Focus group participants concluded that a major advantage of information sharing practices is the fact that such practices are voluntary and "originate from the users". • Lifestyle Those householders who are generally more private towards friends and acquaintances(horizontal), or more private towards governments and companies(vertical), tend to be less open to new feedback and advisory practices by third parties • Values and preferences Respondents mention a wide range of requirements including the possibility to exclude times of the day or practices that are deemed "essential", an obligation to provide early notifications and "proof of environmental gains", and a guarantee to not use the mechanism "to the advantage of customers that generate most profit".

S22 Naus (2015) ++/++	…continued
	Organisational factors • Governance "For me the reason to keep considering service providers is a financial one. If you have the ambition to become energy–neutral, then you need to have an element of exchange. And if you exchange, you need an institution to organise that."Such a facilitating role, they argued, requires "another type of service provider" that better understands how to "work based on the power of people". So, rather than outright antipathy towards service providers and striving for radical autonomy, focus group participants were looking for "a new balance" that allows for more decentralised and democratic control over energy production local energy cooperatives provided a middle ground between forms of cooperation that are considered either as too personal or as too distant. • Regulatory environment "Even when you have submitted and approved everything. . .[the government argues that] the wind turbine should be light–green instead of dark–green. Then you need to do it all over again! Another six years! By the time you have a turbine up and running, the system is out–dated.' Progressive insights' they call it… Just go and built it!" • Policy environment Aspirations to become more autonomous as a household, or as a group of households, coincide with an increasingly critical view of government policies.
S23 Ofgem Year 9 (2018) +/++	**Ofgem Consumer First Panel, year 9, wave 3, half–hourly settlement**
Study characteristics	**Outcomes**
Geographical location • Great Britain **Components in intervention** • Smart meter **Type of participant** • Residential **"Race", ethnic group identity** • Non white categories a wide range of ages, income levels, and ethnicities. • White **Sex of participants** • Male =28 • Female =34 **Work status / income** • Income bracket a wide range of ages, income levels, and ethnicities.	**Type of privacy concern** • Data misuse Many took a stance of automatic distrust of companies when sharing or handling their data, feeling it was safer to assume that it may be misused unless they had read details about the companies' use of their data in more depth. • Unauthorised data use However, due to past experiences where they had been contacted by companies they had never heard of, most felt that it was inevitable that their data would somehow be shared further. • Qualitative themes (ie not numerical measures of current status, and hypothetical or real change) • Actors involved Most consumers that we spoke to felt that there was always a level of uncertainty with data sharing. Many were unsure of who used their data, but felt there was no option but to share it. • Some consumers, who were more sceptical, were less keen to share data with any organisation, unless they had established a level of trust with them (potentially through a recommendation from a friend or family member.) • Some were sceptical of having a smart meter as they felt it benefited the supplier more than themselves, most were still interested in the benefits a smart meter could offer them. Panellists were more trusting of governmental bodies, regulators or parties without a vested interest in energy to handle their data. These parties were seen to uphold a certain standard and have an official interest in their data and therefore be less likely to misuse data compared to other organisations. Consumers were generally happy for their supplier to be the sole party responsible for handling smart meter data. Having too many parties involved in the process raised concerns of data breaches and misuse. Some consumers questioned why any other party would have use for the data accessed through their smart meter, except for Ofgem as the regulator.

S23 Ofgem Year 9 (2018) +/++	…continued
Age • Adults • 18 – 24: 6 x Consumers • 25 – 34: 14 x Consumers • 35 – 54: 25 x Consumers • 55 – 64: 11 x Consumers • 65+: 6 x Consumers	• Information attributes Some questioned what use their energy consumption data would be to a third party if it were to be shared. Consumers generally felt that the data they shared through their smart meter was harmless and wasn't of any significant value to them. • Principles of transmission Most had an expectation that the rationale for getting a smart meter was to allow suppliers to access their data and didn't mind if half–hourly data was accessed. This was particularly relevant for those who already had smart meters and they were happy for suppliers to access their data – particularly considering the potential benefits discussed. Consumers also perceived that one of the primary reasons for having a smart meter was so energy suppliers had access to their data automatically and were confused when asked about different options for data sharing. Positives of using opt–out approach to data sharing here: • More likely to get more consumers' data Consumers don't have to take an action and give their data passively without doing any 'work.' • Negatives: Concerned about a lack of clarity in why the data is being used and what for. • Potentially taking data without consumer understanding or awareness. • What are the advantages? Sharing data was deemed 'okay' by consumers if there was some benefit to them in the long run e.g. specialised services and offers. Most were happy to share their data for settlement purposes and saw this as beneficial for the supplier, wider society, and potentially for themselves. Consumers felt that sharing their data for billing purposes could lead to a positive change in their energy behaviour, which some had begun to change upon having a smart meter. • Some consumers who already had a smart meter were already changing their consumption behaviour and didn't mind the notion of billing on half–hourly data, as they felt they could save money. Many consumers were generally still interested in having a smart meter. They saw it as a positive tool in helping them manage their energy consumption and ultimately the price they pay for energy. • What are the disadvantages? Some consumers were worried that sharing their data for settlement purposes could lead to a potential increase in their energy bill, due to on/off peak rates. It should be noted that using data for billing purposes1 was a topic in each session, but was discussed after data sharing for settlement purposes. BUT For most consumers, the potential long–term benefits outweighed this concern, with some consumers thinking that potential savings made by suppliers were to be felt positively by consumers. Consumers generally preferred to pay for what they use as opposed to when they use energy. However, consumers could recall times when they had changed their energy behaviour in the past. (e.g. the Economy 7 scheme). Furthermore, some consumers also recalled changing their behaviour in similar instances with other providers.
	Factors
	3.2. How relevant is the phenomena explored relevant to this review? (Qual) • High **Overall, how reliable are the results? (Qual)** • Medium

S24 Pournaras (2016) +/+	Self–regulatory information sharing in participatory social sensing

Study characteristics

Geographical location

- Germany
  – Smart phone evaluation
- Ireland
  – Smart Grid evaluation

Components in intervention

- Authorisation
  Can make automated decisions on behalf of the citizen based on these preferences.
- Budget information
- Data aggregators have a budget that can use to incentivise and reward citizens
- Customer choice of level of disclosure
- Citizens' preferences of data sharing. The summarisation function is exclusively and privately selected by citizens and can differ among them. This limits the inference opportunities by data aggregators. The rewards received by each citizen depends on their selection of a summarisation level.
- Granularity of data collection
- Weekly or daily data collection
- Rewards
- Software tools
  A software agent is managing the high granularity time–series data

Type of participant

- Business
- Small to medium business

Outcomes

Type of privacy concern

- Discrimination
  Discriminatory actions that may result in segregation phenomena in society.
- Surveillance

Behaviour measures

- Data sharing
- Privacy: Privacy–preservation is measured by averaging the entropy and diversity of the shared information over the total time period.

Performance measures

- Accuracy
  The accuracy of two aggregation functions, the summation and average, is measured with the global error between the raw and summarisation data. Given that both local and global errors are relative metrics, the relation of the local error with the global error can show how the local citizens' selections of a summarisation level affect the global outcome of the accuracy in the summation and average.

Economic measures

- Costs
  Costs: This is the amount of rewards provided by the data aggregators to each citizen given a total budget, the summarisation selections of citizens and the distribution of rewards among different levels of summarisation.

Findings

- Positive

Factors

Overall, how reliable are the findings of the study? (Modelling)

- Medium

Overall, how relevant is the study to this review? (Modelling)

- Medium

S25 Sexton (2018) –/–	The role and nature of consent in government administrative data
Study characteristics	**Outcomes**
Geographical location • England **Theory** • Social Contract Theory A social contract theory seeks to show that citizens 'comply with the fundamental social rules, laws, institutions, and/or principles of that society', 'by rational agreement' even though individual reasons for complying differ… but contemporary social contract theory has moved towards agreement and the question of justification (Rawls, 1958). This aims to model the reasons and conditions which citizens would agree, if they were properly informed about an issue and acted in a reasonable manner. **Components in intervention** • Consumption data The statutory basis for DECC's acquisition of the data at the heart of the NEED framework – energy consumption data derived from utility meter readings – lies in the Statistics of Trade Act 1947, as amended by subsequent legislation, such as the Electricity Act 1989 and the Utilities Act 2000. Unsurprisingly, given that the underpinning legislation is 70 years old, it does not anticipate contemporary data uses.	**Type of privacy concern** • Data misuse Fair use: In place of consent by individual householders, NEED relies on a privacy impact assessment (PIA) in conjunction with the energy suppliers and the regulator to address transparency concerns • Qualitative themes (ie not numerical measures of current status, and hypothetical or real change) • Actors involved The type of data being collected and the relational context in which it is created has an impact on the role that consent plays in governing research access. • Who owns the data? "Ownership over the data that you use in your business and your home is becoming more personalised and it has been decided under government processes that you, the homeowners or the person who controls the meter will own that data, and that the suppliers will not own that data at all. And you will be the one that grants access to it. (A27)" So any use of the data for research purposes must gain specific consent' (A30). **Findings** • No effect/ neutral … The Statistics of Trade Act, and that allows the government to use, for statistical and research purposes, information from businesses which is considered to be useful to the government… . we cannot disclose that information in such a way that any individual business or any individual entity within the data can be identified. So we can only publish aggregated figures and we can't pass the data on without the express permission from the people that have supplied the information. (A26)…risk is highly contextual, and actually individuals are reasonably good at understanding the benefits and rewards of different things. • Negative (We) asked their permission for us to share their data with academic research partners… We put lots of caveats around everything to say that we'd ensure that all the appropriate safeguards were put in place and all the appropriate protocols were followed to ensure the data is held securely. But unfortunately, a number of the suppliers declined, and said they weren't happy for that to happen. (A26)

S26 Snow (2014) ++/++	Privacy in the new era of visible and sharable energy–use information
Study characteristics	**Outcomes**
Geographical location • Australia **Components in intervention** • Feedback • In home displays **Sex of participants** • Female S1 n=18 **Housing tenure** • Home ownership S1 n=17 **Age** • 16–30 • S2 ages 25–44 • 31–45 • 30s – 40s **Other characteristics** • Prior knowledge/ experience ll SG2 participants were aware that their soon–to–be installed eco–feedback systems would provide them with detailed visual information on their electricity **Smart meter installed?** • 18 households had a monitor as part of a subsidised government initiative 2s wall mounted eco–feedback display **Married or in a relationship** • S1 n=20	**Type of privacy concern** • Relational privacy Two Settings in which eco–feedback may be a potential source of privacy concern, are: (1) within the home (for instance one family member activities being made visible to other family members) The introduction of a new technology such as eco–feedback into a family constitutes a breach of the order of the home and something that will be used and appropriated in different and potentially conflicting ways by different household members (Hargreaves et al., 2013, Strengers 2013). Underscored throughout the interviews was the role that the home played as a physical boundary between public and private information; between controlled and uncontrolled. • Reputational privacy Qualitative themes (ie not numerical measures of current status, and hypothetical or real change) • Behaviour and intentions Almost all participants from both groups mentioned they routinely discussed their electricity bill with their husband or wife. • Functionality vs expectations Many participants enthusiastically discussed their electrical appliances without inhibition. Where appliances were discussed, it was not their energy consumption that was important, but their functionality, aesthetic appeal and others peoples experiences of them. People are poorly placed to anticipate potential privacy concerns before they occur. Energy consumption information is not often considered private unless it exposes actions or patterns of living that are considered private by specific users. • Roles and responsibilities Highlighted how her family's eco–feedback system had caused her previously private actions to become visible to her parents: I don't really seem to be that fond of it [the eco–feedback] because it picks up when I put the air conditioning on, every second of every day, which Dad and Mum then come home to see what's been going on and they can obviously very clearly see when I've used the air con (Daughter, SG2P7) In this family, the energy–conscious father enjoyed being able to better attribute energy use and educate the rest of the family (Father, SG2P7). what was a useful analytical tool for the father, was an unwelcome breach of privacy for his daughter. • What are the advantages? This research also found that sharing energy–related information among friends in a trusted environment represented a source of learning and enjoyment among participants. This exemplifies a promising case for design in this Setting, namely, how can design best realise the benefits of sharing energy–related information without compromising the heterogeneous privacy expectations of users? • What are the disadvantages? One participant from Group 1 spoke of the distress her friend Kay (name changed) had experienced due to a loss of control over her electricity information data. In this case, Kay's husband had improvised a system such that he could monitor the household electricity consumption real time from his computer at work. So he monitors it all on his thing (computer) and it drives her insane! So she thinks its dreadful, she feels violated all the time, cos his workmates will be walking past his desk. One even called her one day saying Wow Kay, your power is going through the roof!– (SG1P14)

S26 Snow (2014) ++/++	…continued
	• Who sees the data? The purpose of sharing with friends or neighbours generally represented a means of comparison, particularly if they had an unexpectedly high bill. Only five participants from both groups considered energy bills as a private matter and for three of these five, the dollar value of the bill represented more of an issue than the kilowatt hour consumption amount. Yeah I guess I wouldn't want people to know how much the bill cost, but I wouldn't mind them knowing around about how much energy we use. I suppose they could go to the trouble of working it out themselves, but its just one step removed (SG1P15) of trust placed in the online community by its users. Privacy concerns did not surface during discussions around this Facebook group and people accessed it as part of their everyday Facebook use. This type of community Facebook page does not currently exist for SG2 participants and social media was not identified as a medium for sharing information related to energy consumption by anyone from SG2. Instances of participants explaining the system to interested visitors, friends or colleagues when it came up in conversation. Responses suggested that sharing information related to the eco–feedback systems generally mirrored that of sharing information related to other household appliances. Namely, that the eco–feedback may come up in conversations in the context of everyday life, explaining what their new toy did to friends and how useful it was, but no SG2 participant mentioned sharing or comparing actual readings from their eco–feedback with others. • Status A conversation starter or something to show off: When we had our eco–system installed we had it installed centrally located to the front door, so it captivates the visitors eye as they come on in and we explain the system to them. They're pretty impressed that it can read the power sources. We give them a little bit of a demonstration (Wife of SG2P13– self–authored video) • Context From answers to this question, it became apparent to us the highly contextual nature of privacy and thus the importance of examining lived experiences rather than asking (as we had ourselves in this case) more hypothetical. I don't know how Id use that information. Knowing that Joe Bloggs or whoever is similar to us, knowing that their washing machine uses less electricity… I would find it hard to consolidate that information into something useful (SG1P16) This finding provides further support for the argument that privacy is best approached through the study of lived experience as opposed to temporally static preferences or asking questions around willingness to share. **Findings** • Negative Misuse and loss of control over data One participant from Group 1 spoke of the distress her friend Kay (name changed) had experienced due to a loss of control over her electricity information data. In this case, Kay's husband had improvised a system such that he could monitor the household electricity consumption real time from his computer at work. So he monitors it all on his thing (computer) and it drives her insane! So she thinks its dreadful, she feels violated all the time, cos his workmates will be walking past his desk. One even called her one day saying Wow Kay, your power is going through the roof! (SG1P14)#

S27 Horne (2019) +/++	Technology use and norm change in online privacy: experimental evidence from vignette studies
Study characteristics	**Outcomes**
Geographical location • USA **Components in intervention** • An App **Political affiliation** • Conservative =30% • Liberal =28% • Moderate / not sure =30% **"Race", ethnic group identity** • Non white categories • 29% • White • 71% identified themselves as white. **Sex of participants** • Male =S2 46.9 • Female =S2 female (53.1%). **Level of education** • Bachelors degree S2 39% had completed at least two years of college education. **Age** • 46–60 S2 Mean age was 46.4 (S.D. = 16.8).	**Type of privacy concern** • Agency, choice and autonomy Initiatives that rely on consumers sharing private information and data with their utilities should not take voluntary participation for granted (see, e.g., Bode, 2018; Kiger, 2016 for media accounts of consumers' concerns about privacy in the electricity context and Balta Ozkan, Boteler, & Amerighi, 2014 • Not stated **Psychological measures** • Behaviour expectations • Trustworthiness expectations • Willingness to use app **Social measures** • Add • Normative expectations **Findings** • Positive From S1: popularity (of app) has a statistically significant, positive effect on normative expectations (b = 0.78, SE = 0.16, 95% CI = [0.46, 1.10]) As app popularity increased, people expected others to be more approving of privacy violations. App popularity also has a statistically significant, positive effect on trustworthiness expectations – the more popular the app, the more participants trusted the app provider (b = 1.26, SE = 0.19, 95% CI = [0.89, 1.63]) Frequency of privacy violations has a statistically significant, positive effect on behaviour expectations (b = 0.71, SE = 0.21, 95% CI = [0.30, 1.12]), normative, behavioural, and trustworthiness expectations are all associated with willingness to use the app (b = 0.32, SE = 0.06, 95% CI = [0.21, 0.43], β = 0.26; b = –0.10, SE = 0.04, 95% CI = [–0.17, –0.03], β = –0.10; b = 0.66, SE = 0.05, 95% CI = [0.55, 0.76], β = 0.63; respectively), with trustworthiness expectations having the strongest and behaviour expectations the weakest association ***from S2 app popularity has a statistically significant, positive effect on normative (approval) (b =1.05, SE = 0.23, 95% CI = [0.61, 1.50]) app popularity has a statistically significant, positive effect on trustworthiness expectations (b = 1.02, SE =0.21, 95% CI = [0.62, 1.43]). frequency of privacy violations has a statistically significant positive effect on behaviour (violation) expectations (b= 0.46, SE = 0.20, 95% CI = [0.06, 0.86]). trustworthiness expectations have the strongest association with willingness to use the app (b = 0.51, SE = 0.04, 95% CI = [0.43, 0.58], β = 0.56), followed by normative expectations of approval (b = 0.37, SE = 0.04, 95% CI = [0.29, 0.45], β = 0.44). • No effect/ neutral From S1**Frequency of privacy violations does not have a statistical positive association with trustworthiness expectations (b = 0.24, SE = 0.19, 95% CI = [–0.14, 0.61]). From S2 results do not support the prediction in Hypothesis 2b that frequency of privacy violations affects trustworthiness expectations (b = 0.14, SE = 0.21, 95% CI = [–0.27, 0.55]). From S2 The experimental conditions have no direct effect on willingness to use the app.

S27 Horne (2019) +/++	…continued
	Factors
	Methodological factors • Research methods A limitation of our study is that it does not measure behaviour. Because we rely on vignette experiments, we can only get at individuals' intentions – their willingness to use a technology. Thus, it is possible that normative (approval) expectations, behaviour (violation) expectations, and trust will have different associations with actual use **Social factors** • Awareness (From other research) Research suggests that people do not have a good understanding of online privacy (Acquisti, Brandimarte, & Loewenstein, 2015). In the face of such uncertainty, other consumers' behaviours are a concrete source of information. If others use a technology, then that is good evidence that the downsides are not that big (Cialdini et al., 1990). • Acceptance "Widespread adoption of ICT changes people's normative expectations about the social acceptability of privacy invasions and affects people's trust in technology providers." • Trust Results show that descriptive norms affect… trustworthiness expectations **Methodological factors** • Research methods A limitation of our study is that it does not measure behaviour. Because we rely on vignette experiments, we can only get at individuals' intentions – their willingness to use a technology. Thus, it is possible that normative (approval) expectations, behaviour (violation) expectations, and trust will have different associations with actual use **3.3. How relevant is this study to the review? (Surveys)** • High **Overall, how reliable are the findings of the study (surveys)** • Medium Although well designed, the outcomes measures are still hypothetical
S28 Toft (2015) ++/–	**Exploring private consumers' willingness to adopt Smart Grid technology**
Study characteristics	**Outcomes**
Geographical location • Denmark **Theory** • Innovation adoption Theory **Components in intervention** • Geothermal Heat pump	**Type of privacy concern** • Agency, choice and autonomy Reviewers' interpretation: there is a loss of control by being flexible: from study: for participants who had adopted SGT for a trial period: loss of comfort in terms of too low indoor temperature and not enough hot shower water: • Trade off …I doubt that it will involve any real saving for us. It depends on how much the price of electricity is going to fluctuate; if it's only 2 or 3 or 5 per kWh then it isn't that interesting. If there were real savings in it, something with a real impact, but I doubt that is the case. HP1 (male)

S28 Toft (2015) ++/–	…continued
Children • Yes • Between 1 –5 children at home **Type of home** • Single family home • Farm	**Psychological measures** • Add Code: Problem awareness scores Code: Universalism (priority) Code: Achievement (priority) Code: Innovativeness **Factors** **3.2. How relevant is the phenomena explored relevant to this review? (Qual)** • Low **Overall, how reliable are the results? (Qual)** • High
S29 Valor (2019) –/–	**Effective design of domestic energy efficiency displays: A proposed architecture based on empirical evidence**
Study characteristics	**Outcomes**
Geographical location • Multiple locations **Components in intervention** • An App • In home displays • Web Portal	**Type of privacy concern** • Agency, choice and autonomy "This monitoring of daily habits has been perceived as too intrusive, controlling, restrictive, 'big brother–like'…""With interactive devices, utility companies could know which appliances are being used or even make decisions to turn off appliances without the consent of an owner. Thus, privacy concerns arise in relation to load and feedback disaggregation" • Peaceful enjoyment "This monitoring of daily habits has been perceived as […] engendering paranoia" **Factors** **Technical factors** • Data collection [1–s2.0–S136403211930509X–main.pdf] Page 8: McKenna et al. (2011) [107] suggests that the use of appropriate "privacy friendly" techniques for appropriate data selection and/or processing for different types of devices may overcome the privacy barriers identified by other authors. **Individual/ inter–personal level factors** • Control and autonomy [1–s2.0–S136403211930509X–main.pdf] Page 8: Actual experiences have shown how privacy concerns can be a major barrier for using and interacting with interactive devices. For instance, data security and privacy were a major reason for the introduction of a clause allowing consumers to opt–out of the installation of a smart meter [104], thus effectively hampering energy efficiency programs for these users. Under European legislation, metered data are considered personal data and thus subject to the corresponding protections under the General Data Protection Regulation (GDPR) that came into force in 2018 [105]. Moreover, the recast European Electricity Directive, which is part of the Clean Energy Package, states that any party wishing to access metered data from end consumers must have the users' explicit consent [106]. • Information [1–s2.0–S136403211930509X–main.pdf] Page 8: P10.2. Domestic displays should include the privacy policy and specify the use given to the different levels of disaggregation of in– formation, express consent and revocable consent. Stricter policies may be necessary in certain cultural Settings.

S29 Valor (2019) –/–	…continued
	3.2. How relevant is this review to the EnergyRev review's questions? (SR) • Low Relevant privacy findings not strongly linked to the evidence. **Overall assessment of reliability of the findings (SR)** • Low Reliable that these parameters were identified in the literature but no indication of how, so it is unclear how strongly these feature in the literature or whether other parameters may exist.
S30 Van Aubel (2019) ++/++	**Smart metering in the Netherlands: What, how, and why**
Study characteristics	**Outcomes**
Geographical location • The Netherlands **Components in intervention** • Central administration The Dutch DSOs have set up Energie Data Services Nederland (EDSN) as a central organisation to smooth the administrative processes. EDSN's responsibilities include providing metering data to energy suppliers and ISPs, • Home energy monitoring device • In home displays	**Type of privacy concern** • Data misuse There have also been data leaks where an ISP or energy supplier accidentally or deliberately abused their access to data kept by EDSN • Identity privacy Any individual can contact an ISP while claiming to live at some address to then obtain meter readings of that household via this ISP. • Interest privacy • Relational privacy Concerns and some resistance was towards to obligatory nature of the roll out, this was changed to needing consent from customers • Trade off The debate surrounding smart meters has not only been about security and privacy, but also about whether the costs outweigh the benefits. The benefits of smart meters (outweighing the privacy costs) are not clear **Findings** • Mixed effects Amendments removed the obligation to have smart meters: people could refuse installation and, if a smart meter had already been installed, they would be able to have it 'administratively turned off'. The amendments also included regulations on the collection, storage, and forwarding of metering data, and required explicit consumer consent for 15–min and daily measurements, instead of this being the default metering regime. Reducing the amount of fossil fuels consumed is a worthwhile goal. However, the smart meter rollout has so far not resulted in the predicted energy savings [2]. For the broader EU, research suggests that dynamic tariffs need to be adopted in order to ensure a net positive benefit [35]. , the relative ineffectiveness in terms of power saving compared to the UK, discussed in Section 4.4, suggests that the decision to leave the rollout of in–home displays to market forces may not have been the best possible one. The options for more granular grid management within neighbourhoods and price incentivisation described in Section 5 are promising possibilities. Unfortunately the current design of Dutch smart meters does not allow for this to be done securely this data is unauthenticated and must be provided over a separate connection to the ISP. This raises availability and security concerns, which cannot be truly solved without a redesign of the smart meters

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S30 Van Aubel (2019) ++/++	…continued
	Factors

Technical factors

- Remote off switch
  A remotely operated off–switch in a smart meter can be convenient: if a household needs to be disconnected, it can be done without having to send out an engineer. However, it is also a security risk ..The DSOs recognised this risk, and the remote off–switch was abolished when the large–scale rollout of smart meters started

Economic factors

- Costs
  Meters that could not be updated (with removal of the remote off switch) are considered in a periodic risk analysis. Presumably the cost of replacing them was deemed to outweigh the security risk.
- Market
  That the decision to leave the rollout of in–home displays to market forces may not have been the best possible one.

Individual/ inter–personal level factors

- Consumers' perception
  Analysis recognises that large deviations are possible in benefits, for example if more than 20% of consumers refuses the remote meter reading, or if the energy savings turn out significantly lower than projected. Consumer support is therefore a crucial aspect,
- Engagement of participants
  Most consumers do not see any feedback from the smart meter, other than their yearly energy bill or a bi–monthly usage summary. Such an historic overview of the past two months turns out not to be useful for energy saving purposes [36,37,39]. Rather, consumers should be informed of their energy use at the moment it happens

Organisational factors

- Procurement factors
  Taking security into account requires special care in the public tendering process for smart meter. One issue is how security requirements are expressed in tenders. If the description of security requirements is too vague, suppliers may be able to argue that less secure meters meet them, resulting in a race to the bottom. If requirements are too detailed or specific, there is the risk that only a single supplier can meet them, who can then set a very high price.
- Regulatory environment
  Initial proposals of laws for smart meter roll–outs did not consider consumer privacy beyond complying with the Dutch data protection act, and ran foul of article 8 of the European Convention on Human Rights. Mainly for that reason the First Chamber of Parliament blocked them from passing in their initial form.
- Policy environment
  The amendments also included regulations on the collection, storage, and forwarding of metering data, and required explicit consumer consent for 15–min and daily measurements, instead of this being the default metering regime.

Risk of verification bias (case study)

- High

3.2. How relevant is this case study to the review? (Case study)

- High

S31 Vermont Trasco LLC (2014) ++/+	Customer participation in the smart grid – lessons learned

Study characteristics

Geographical location

- USA

Components in intervention

- Advertising
  Reliant
- Community outreach
  ENO, SVE, and CMP projects
- Critical peak rebate
- ENO Customer training
  ENO offered three types of customer training: face–to–face, over–the–phone, and mail.
- Day ahead notification
  SVE, ENO notified its peak time rebate participants of critical peak event days by calling them the day before the event.
- Email information
  CMP weekly updates with billing information on their electricity use and cost.
- Incentives
  SVE To encourage participation, SVE offers "door prizes," and about 15% of their customers typically attend. One of the issues is finding ways to expand participation in the meetings to include more young adults
- In home displays
  ENO, SVE
- Partnerships with local organisations
  ENO (targeted for low income customers)
- Programmable Communicating Thermostat PCT
  ENO

Outcomes

Type of privacy concern

- Trade off
  Not directly made, but assumes that financial incentives overcomes any privacy concerns
- Not stated

Findings

- Positive
  CMP About 70% of participating customers stated that bill alerts caused them to take action to manage their electricity usage, and participants reduced their annual electricity usage by 1.8%. – CMP email communication preferred. CMP's customer engagement strategy also included proactive communications with customers before smart meters were deployed and "rapid response" communications when customers raised questions and concerns during and after the deployment process. As a result, only one town imposed a moratorium on smart meter installations that was subsequently lifted. In fact, about 97% of the customers in this town eventually decided to participate in CMP's smart meter program. In almost all cases where ***customer devices(IHDs etc) were used, they strengthened customer acceptance and responses, particularly in the case of time–based rate programs. ENO and SVE customers appreciated the PCTs and IHDs, and these devices strengthened customer engagement. Results from ENO's SGIG project show successful outcomes when utilities partner closely with groups that have experience in serving vulnerable customers
- Small positive effect
  CMP About 49% said the alerts were at least "somewhat" or "very" successful in helping them pay their bills. This level of effectiveness was the same for both high–usage and typical–usage customers. More of the customers with histories of trouble paying bills on time (about 60%) found the alerts to have been "somewhat" or "very" successful in helping them pay their bills.
- Mixed effects
  Reliant– customers do not express a high level of interest in their load control devices or concepts like load management or demand response, but do participate and reduce demand when incentives are financially attractive.
- No effect/ neutral
  Projects have found that no single approach (email, phone calls) stands out as the most effective; instead, multiple channels are often necessary to ensure that the messages get delivered and understood. Many utilities deploying smart meters with web portals have experienced difficulties attracting customers to access and use their web portals, and the ultimate value of these tools is still an open question. About 22% to 28% of CMP customers surveyed said they visited the web portal, though high–usage customers and payment–troubled customers visited slightly more.

Factors

Technical factors

- Complexity
  Reliant is continuously refining its web portal offerings and boosting the site's capabilities for attracting new and retaining existing customers. A major aim is simplicity and ease–of–use, which is what customers say they want.

S31 Vermont Trasco LLC (2014) ++/+	…continued
• Phone calls SVE – including a free phone number CMP weekly updates with billing information on their electricity use and cost. • Public meetings ENO, SVE, and CMP projects SVE: Annual meetings in each of the 11 districts, held during March and April, typically begin with seminars on overall business issues such as power costs and supplies. Prior to installing smart meters, CMP contacted 320 municipalities by mail or phone and completed 140 briefings with town councils and the public efforts to understand and address specific customer concerns about data privacy, home security, and the perceived health effects of smart metering. • Smart meter Reliant, ENO • SMS Messaging SVE– text messages CMP weekly updates with billing information on their electricity use and cost. • Social Media Reliant • Software tools • Trained customer service operatives SVE ENO's dedicated call centre – the ENO Support Centre – along with a walk–in Customer Care Centre provided proactive outbound calls and support for participants when they called the dedicated toll–free number or came in with inquiries or technical issues.	**Economic factors** • Billing feedback Reliant: customers report that weekly emails are valuable because it helps avoid "bill shock" at the end of the month and gives them a sense of control over their consumption and costs. **Social factors** • Local coordination ENO credits its partnerships with the community groups for its success in recruiting target low–income customers for education, enrolment, and support activities for SmartView. **Individual/ inter–personal level factors** • Engagement of participants Reliant: Customers do not want to spend a long time getting answers to their questions. Reliant's customer service representatives are trained to anticipate questions and customise responses to address specific concerns • Values and preferences Reliant: One size does not fit all when it comes to sending information to customers; multiple approaches are almost always required. Some customers prefer self–guided channels and that customers often enjoy looking up their own information or accessing communications on their own schedules **Organisational factors** • Consumer engagement ENO's proactive customer education… about two–thirds of all calls were outbound. Reasons for call were: 2011 – enrolment and training – event notifications – schedule and to assess effectiveness of field visits – ensure customers know how to adjust thermostat controls 2012 – calls regarding swap out of thermostat – courtesy and reminders and check ins regarding device functioning – notification of events – encouragement to groups to complete post–pilot survey

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S31 Vermont Trasco LLC (2014) ++/+	…continued
Reliant's call centre is open 24 hours every day of the week. Call centre personnel receive training in Reliant's various product offerings and perform analysis on each incoming call CMP also operates call centres, but they were not a major factor in the bill alert pilot program. • Variable rates ENO, SVE • Web Portal SVP, Reliant, CMP **Work status / income** • Low income	

S32 Walter (2018) +/++	Losing a private sphere? A glance on the user perspective on privacy in connected cars
Study characteristics	**Outcomes**
Geographical location • Multiple locations • Germany Survey part of the study was conducted in German **Components in intervention** • Event data recorder (EDR) • Informative intelligent speed adaption (ISA) **Sex of participants** • Male =68 • Female =33 **Age** • Add • Mean age 36.74	**Type of privacy concern** • Agency, choice and autonomy People build a relationship towards their vehicles and from an emotional bond to their car [8]. This connection underpins the pursuit of safety, enjoyment and autonomy, but also the desire for a private refuge [9]. • Location privacy Specifically, privacy of behaviour was more important to respondents than privacy of location • Peaceful enjoyment Privacy as a retreat. The right to be left alone. **Psychological measures** • Acceptability of new technologies • Value Participants did not report any differences in perceptions that perceived privacy to be more critical in cars than in other connected devices like smartphones. (Binary response options; 61.4 % **Findings** • Positive Users were ready to disclose personal data like their location for advanced traffic information in real–time ($M = 1.74$, $sd = 1.13$, $t(100) = -11.20$, $p \leq .001$) as well as for an automatic emergency call system (eCall; $M = 1.56$, $sd = 0.98$, $t(100) = -14.73$, $p \leq .001$). Participants had strong trust in police ($M = 2.16$, $sd = 1.24$, $t(100) = -6.71$, $p \leq .001$), Participants had a strong trust in ambulance ($M = 1.85$, $sd = 0.95$, $t(100) = -12.04$, $p \leq .001$ Participants had a strong trust their own family ($M = 2.40$, $sd = 1.31$, $t(100) = -4.52$, $p \leq .001$).

S32 Walter (2018) +/++	…continued
	• No effect/ neutral Users were undecided whether they should release their data for automatic hotel reservations at their travel destination (M = 3.24, sd = 1.42, t(100) = –1.68, p = .24). there was no effect of monetary incentives on data disclosure. • Negative Participants declined data sharing with third parties such as: low trust in insurances (M = 3.79, sd = 1.30, t(100) = 6.05, p ≤ .001) and app providers (M = 4.63, sd = 0.71, t(100) = 22.84, p ≤ .001) were the least trusted parties
	Factors
	Technical factors • Data access • Data identity • Data usage **Economic factors** • Savings **Social factors** • Work/ home life Authors found that social context is an important predictor of acceptability of EDR systems–…most respondents accepted an implementation of EDR in their professional vehicles, most refused to equip their private car as they perceived this to be an invasion of privacy **Individual/ inter–personal level factors** • Privacy • Perceived privacy threat • Values and preferences • Perceived benefits of mobility and safety **Organisational factors** • Transparency The more transparent the informative intelligent speed adaption (ISA a driver assistant system dedicated to the support of speed control,) measures were the higher acceptability was, as ISA was preferred over EDR (event data recorder (EDR) • (Organisational) Trust From review: participants declined data sharing with third parties. From survey: identity of the data receiver as an important privacy factor. **3.3. How relevant is this study to the review? (Surveys)** • Medium
S33 Winter (2015) +/+	**Citizen perspectives on the customisation/privacy paradox related to smart meter implementation**
Study characteristics	**Outcomes**
Geographical location • USA • Hawaii	**Type of privacy concern** • Agency, choice and autonomy Smart meters can control smart appliances (turn off and on) Niele said that, "it's kind of horrible, because if I am using some type of medical device, then they'll be able to know as well. That's a lot of personal data!"

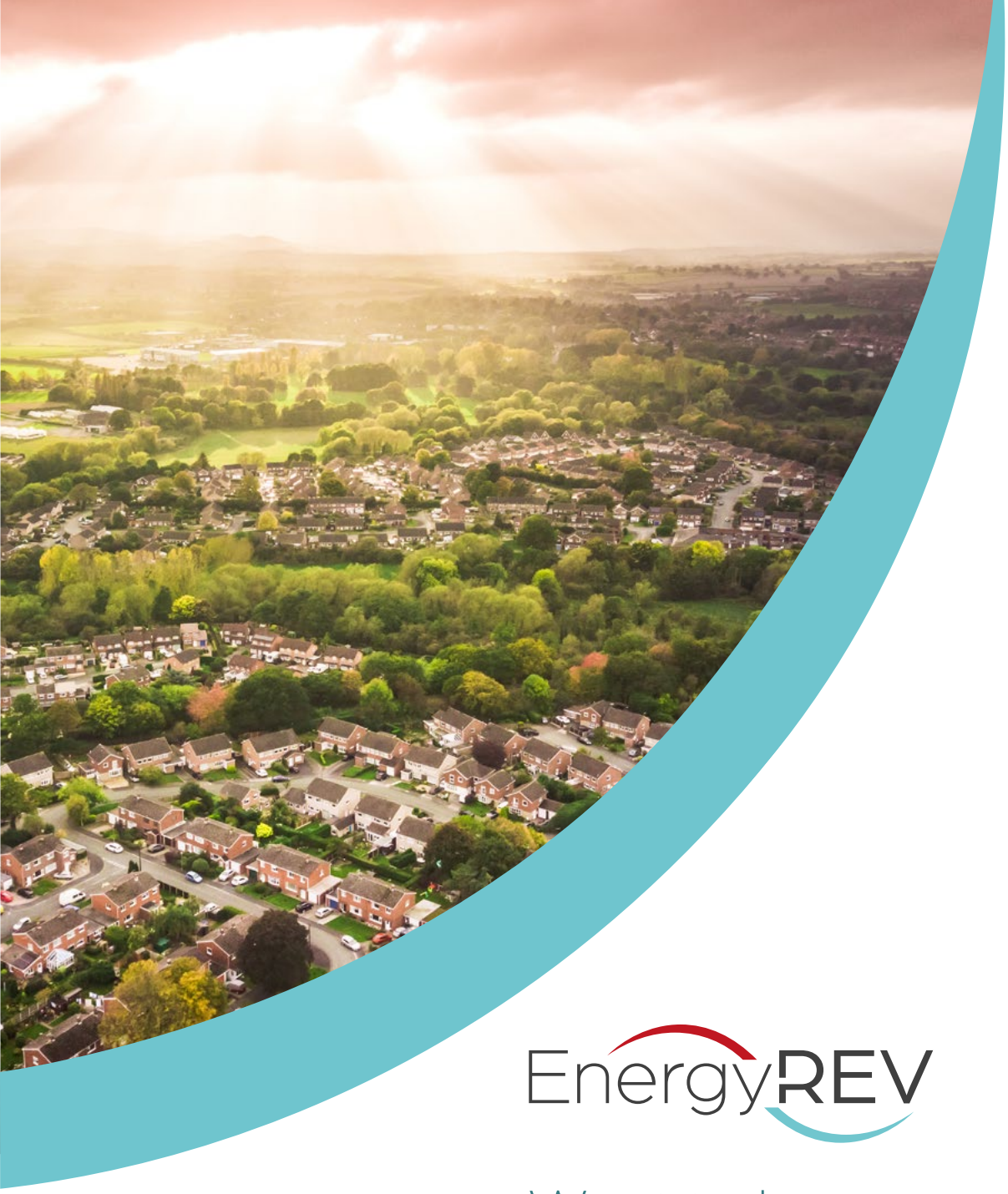
S33 Winter (2015) +/+	…continued
Theory • Technoethics • The Framework of Contextual Integrity **Components in intervention** • Feedback • In home displays • Personalised information • Real time information • Smart meter • Variable rates • Wireless network **Geographical characteristics** • Island **Type of participant** • Residential **"Race", ethnic group identity** • Asian =3 • African American =1 • Mixed =4 **Sex of participants** • Male =5 • Female =4 **Level of education** • Bachelors degree =3 • Graduate / masters level =2 • High school / College =3 • Middle school **Work status / income** • Professional • Service • Technical **Age** • 16–30 • 31–45 • 46–60 • 20s–60s	• Backward privacy Other data may include de–identified tracking information collected during web browsing and that may be re–identifiable when aggregated. • Data misuse Sharing of personal data, data leaks or spoofing via hacking, consumer data may potentially be transferred or sold, wilfully or not, and may be aggregated with other data about an individual • Discrimination Inferences made from new data types aggregated with other personal data that could be used to unjustly discriminate against individuals or groups. These new data types and the ways that they can be shared, stored, or mined may reveal patterns about personal behaviours or attributes that could be used to discriminate economically or politically. • Identity privacy Data creating an advertising identity They argue that an individual's place in this "new constellation of market segments" can be used to discriminate against them, as different groups will receive different commercial offers and communication. This "social sorting" (Lyon, 2002) enabled by surveillance results in classifications that are "designed to influence and to manage populations and persons thus directly and indirectly affecting the choices and chances of subjects. • Relational privacy The blurring distinction between the home and public space, data collection and sharing may also expose sensitive behaviours related to political belief or activity, or any other personal information that could be used to disadvantage certain individuals or groups by corporations or governments. • Right to rectification Niele, a foreign national who recently acquired U.S. citizenship via marriage… She emphasised that she and her husband had been living together for over fifteen years before they married, and they themselves would likely not have been affected, but she worried that data errors or incorrect inferences could be used to deny citizenship to others. • Unauthorised data use Qualitative themes (ie not numerical measures of current status, and hypothetical or real change) • Actors involved • Information attributes Of 1) what types of data may have been collected about them; 2) their presence at any given time, and the presence of any other individuals; 3) what appliances they used; and 4) any other information about their activities in their homes. • Principles of transmission Whether the participants thought that data was recorded and transmitted • Who sees the data? From what I have seen in the past, companies that collect information tend to share information with other companies. The selling of data –– particularly companies that are attempting to market certain things to people. So, if HECO were to sell their demographic information to marketing firms who would do things like send ads based on personal information that would disturb me. Hau'oli added that "I think when you do have data that's not restricted to paper documents, but things that are online, other people definitely have access to it, unfortunately."

S33 Winter (2015) +/+	…continued
Other characteristics • Energy consumption Hawaii is by far the most petroleum–dependent state in the United States, with almost 85% of total energy consumption in 2008 fuelled by petroleum, compared with a national average of 37.5% • Recent news coverage Recent news coverage revealing the existence of widespread Internet surveillance efforts by the National Security Agency in the United States may be a factor in this concern.	**Findings** • Positive Current understanding of smart meters and data sharing, Hau'oli mentioned that she would not have any concern if the information was "in the right hands… People who specifically need to evaluate, maybe the cost of the electricity or energy that we use." (it) would be appropriate to analyse this data as a way for HECO to offer improved service to consumers. Renting is common. Participants,. Recognise that the landlords would have access to their data, federal or non–profit agencies (e.g., the United States Department of Energy) to study energy use trends for the purpose of developing sustainable energy solutions . These were seen as unwelcome, but not particularly intrusive, instances and not likely to be shared in any fashion First, in all but two cases, there was enthusiasm for some of the promised benefits of smart meters – personalised feedback, coupled with behavioural changes, could lead to energy conservation and lessening reliance on imported oil. • Negative Consent: Participants expressed concern that other, possibly unknown, actors could use their personal data without explicit consent. Unseen actors: There was an awareness of increasing amounts of data and uncertainty about who might see it. Keala observed that companies already share data and that energy data might be used for targeted marketing. Loss of control of data : "Ideally, I hope there are constraints on the sharing of this information, that there is this wall of consent that you have to go through, even though it's annoying… but who knows? It's so hard to anticipate how information will move, because there are ways it can be leaked."
	Factors
	Technical factors • Cyber security "With everything I've seen… news stories or articles…about hackers and terrorists taking down our power grid or the Internet in the U.S. I'd assume anyone good with computers could get their hands on that information… The smart meter, if I was a homeowner, would kind of make me want to push towards getting my own solar system just to avoid as much of this as I could." • Data usage Data being used for purposes other than what was considered appropriate – (other than billing) • Security of data Spoofing energy data, severing connection to electrical power, or taking control of appliances in the home… where concern about negative consequences related to the security of private information led a participant to consider opting out, or resisting, the technology.
	Individual / inter–personal level factors • Health "I think something that would be troublesome is the type of devices that companies are collecting data from, the energy use itself would not be troublesome, but perhaps it could give clues to the types of devices that people have in their homes. So, for example, if you have a certain health problem, and a certain device is used in the home is used to help you, then companies could access or make assumptions or inferences into the types of health problems you have, then I see the trouble there." Companies would be interested in using this(health related data) to adjust health care premiums or deny coverage based on private behaviours that might indicate risk of higher health costs.

S33 Winter (2015) +/+	…continued
	• Knowledge This is a very relevant topic. As I was saying, I was watching the consumer electronics… [smart appliances] just such a huge part now,… so I mean right now for most people they are looking at the consumer side of it. They are very excited about the possibilities of electronics being more responsive and alert, and so I think that part of it is great. But I think in the long term, eventually, we have to think about how is energy data being used? What inferences can people make from it? What companies will be collecting data? That's also equally important, even if it's not as popular." • User behaviour I see this as an erosion of privacy, not a complete lack of privacy, but you would be able to infer certain things about a person, I think, by looking at this information. As an " you are seeing trends but you are not necessarily seeing what an individual is doing. But if you have my data you know what I'm doing when I am there. In the past, the amount of power we use in the home, that's a fairly general thing. I don't really see that as that much of an invasion because you can't really determine the sort of thing a person is doing other than using energy. In the smart meter, you can tell [a lot of things]; you can infer a lot about this person's personal life based on [this]. I think that's a little too much." **Organisational factors** • Governance "If they collect energy data and then, sort of, glean other data from the devices themselves, I could see that would be a troublesome aspect for me." The erosion of the private sphere is of particular consequence due to the fact that existing laws and regulations in the United States are based on this dichotomy. • Transparency There was uncertainty about the scope and granularity of data collection of data that was not specific to the purposes she had identified as appropriate (i.e., using it for billing). • (Organisational) Trust Makana, said that he was not concerned about abuse of his energy data: "I can see potential for concern with something like a smart meter or access to your electric usage, but overall I think it is good. I think concerns would be among those who think aliens exist or who think 9–11 is a conspiracy put on by the government." 70% of respondents believed that NSA surveillance data is used for reasons other than investigating terrorism. **3.2. How relevant is the phenomena explored relevant to this review? (Qual)** • Medium It does not get into whether these views impact on actual data sharing. Participants may be particular to the US experience – for instance, in terms of legal precedent , the separation of private and public spheres, subject to different rules and regulations on data sharing than the UK and Europe
S34 Yao (2019) ++/++	**Defending my castle: A co–design study of privacy mechanisms for smart homes**
Study characteristics	**Outcomes**
Geographical location • USA **Components in intervention** • An App In 12/25 designs • Co–design	**Type of privacy concern** • Data misuse • Identity privacy • Trade off • Qualitative themes (ie not numerical measures of current status, and hypothetical or real change)

S34 Yao (2019) ++/++	…continued
• Hardware devices In 10/25 designs • Policy / regulation In 6/25 designs • Sensors • System modes In 4/25 designs (e.g. offline mode) **Type of participant** • Residential • Mix of occupations and levels of experience with smart home tech (users, interested and non–users). **Sex of participants** • Male =12 • Female =13 **Age** • 16–30 • 61–80 • Older people **Adults** • 22 to 76, mean 41 **Other characteristics** • Prior knowledge/ experience Participants were divided into five groups (Group A, B, C, D, and E) primarily based on their schedules and levels of experiences with smart home devices.	**Information attributes** • System Intelligence Examples: Context detection, Personalisation • What are the advantages? Design factors: Security: examples – Authentication of multiple users – Access control – the app to control his smart home devices should have a local mode and a remote mode. He should have full access to all the functions and data only when he is physically at home, which triggers the local mode – Network intrusion detection P16 designed a smart door lock with a fingerprint reader to improve the safety of her home. Since the fingerprint reader collects her biometric information, she designed an additional privacy feature to protect her fingerprint data by only storing it locally in the lock. • Safety – examples: – Notification of physical break–in • Usability & UX – examples: – Considerations of user characteristics – Considerations of user effort • Who owns the data? a. Besides data localisation and disconnection from the Internet, nine participants (P5, 9– 10, 12, 15, 18, 21, 24–25) desired explicit controls of their data, from preventing data collection to deleting collected data "the user should have a hardware option to delete data. So they don't have to necessarily go to the software to delete it." (P5) • Who sees the data? Design factors: Data transparency and control: examples: – Transparency and user awareness – Data localisation – • Disconnection from the Internet "I think what people need is something like a lock that can be plugged into the security camera to lock our data like gender or activities. Now they [security cameras] are using cloud services like the iCloud to store my personal data, but I don't know whether they are secure or not…so if I have my own device without the Internet, that is safer. It's like a physical control and my things are stored only in my place." – Other user controls of data P15 designed a transparency feature for a self–driving car She considered the car part of the smart home because the car is often parked/charged at home and she can control the car (e.g., start the engine) remotely using voice assistants (e.g., Google Home). e. When she wishes not to be tracked, she can turn on the invisible mode (e.g., by plugging in a dedicated USB drive to the car) to hide her activities. In contrast, under the visible mode (default mode), her driving data can be tracked but she can use an app interface to see what data about her has been collected. P13 was concerned that other members in the household might be able to access her credit card information and order food from the smart fridge. To address this concern, she incorporated voice recognition in her design as an authentication mechanism for the smart fridge. She explained, "even if someone hacks your details about the credit card to make payment, but it will still need your voice to recognise and authenticate that transaction. **System attributes** • System Modality examples: – Hardware devices – Apps, modes, policies
	Factors
	Technical factors • Artificial intelligence 12/25 participants considered system intelligence in their designs, specifically context detection (6), e.g. automatically stopping audio recording during private conversations, and personalisation (12), e.g. allowing a user to choose what types of behaviour captured on camera are (and are not) automatically shared with a designated recipient.

S34 Yao (2019) ++/++	…continued
	• Data collection 7/25 participants' designs included data localisation: devices store and process the collected data locally as opposed to sending the data to a remote server. • Decentralised control 5/25 designs included a means disconnect from the Internet and work offline. 15/25 designs included other elements of local control over data, e.g. to stop data collection or delete data. • Safety and Health 12 participants addressed safety by including services such as break–in alerts, with some also addressing related privacy issues (e.g. warning visitors of security cameras). • Security of data 20/25 participants considered security as a factor in their designs, including aspects such as authentication of multiple users (11), access control of user data (16), and network intrusion detection (3). • Transparency and accuracy 17/25 participants considered "the transparency of data collections and user control over their data" a factor in their privacy concerns and 7 participants' designs were focused on increasing this transparency. • User experience 12/25 participants explicitly considered the usability of their privacy designs, 7 taking user characteristics into account (e.g. adjusting for people with mobility problems). While the majority involved automation, 11 required user effort, e.g. users must read privacy policies (that suppliers must provide and summarise). **Individual/ inter–personal level factors** • Household relationships Authors: "the complex social relationships and power dynamics in a home, such as parents and children, brothers and sisters, husband and wife, owners and guests, patients and remote doctors [15], can significantly affect whose privacy is at risk or how privacy can be enacted. Many privacy designs in our study supported multiple user accounts which have been explored for shared home computers [13], but also included multi–user authentication and access control." • Authentication of multiple users. Eleven participants (P1, 4–5, 10–13, 17, 21–23) spoke to the social relationships and power dynamics in homes where there could be multiple users sharing one device. They emphasised the importance of enabling proper authentication in order to protect each family member's privacy. • For example, P13 was concerned that other members in the household might be able to access her credit card information and order food from the smart fridge. To address this concern, she incorporated voice recognition in her design as an authentication mechanism for the smart fridge. [Some participants considered differing needs or expectations, e.g. of residents and visitors, leading the authors to question whose privacy should be protected and who should make privacy decisions.] • Trust Participants considered the data collector and purpose when designing the privacy controls, e.g. sharing car usage/location data with a trusted third party (e.g., for better navigation purpose) but would not with the car manufacturer. **3.2. How relevant is the phenomena explored relevant to this review? (Qual)** • High **Overall, how reliable are the results? (Qual)** • High



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About EnergyREV

EnergyREV was established in 2018 (December) under the UK's Industrial Strategy Challenge Fund Prospering from the Energy Revolution programme. It brings together a team of over 50 people across 22 UK universities to help drive forward research and innovation in Smart Local Energy Systems.

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INDUSTRIAL STRATEGY

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