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Shifts in the smart research agenda? 100 priority questions to accelerate sustainable energy futures

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ABSTRACT

Energy transitions are at the top of global agendas in response to the growing challenges of climate change and international conflict, with the EU positioning itself as playing a pivotal role in addressing climate risks and sustainability imperatives. European energy transition policies identify 'smart consumption' as a key element of these efforts, which have previously been explored from a predominantly technical perspective thus often failing to identify or address fundamental interlinkages with social systems and consequences. This paper aims to contribute to interdisciplinary energy research by analysing a forward looking 'Horizon Scan' research agenda for smart consumption, driven by the Social Sciences and Humanities (SSH). Reflecting on an extensive systematic Delphi Method exercise surveying over 70 SSH scholars from various institutional settings across Europe, we highlight what SSH scholars see as future directions for smart consumption research. Building from seven thematic areas (under which are grouped 100 SSH research questions), the study identifies three key 'shifts' this new smart research agenda represents, when compared to previous agendas: (1) *From technological inevitability to political choice*, highlighting the need for a wider political critique, with the potential to open up discussions of the instrumentalisation of smart research; (2) *From narrow representation to diverse inclusion*, moving beyond the shortcomings of current discourses for engaging marginalised communities; and (3) *From individual consumers to interconnected citizens*, reframing smart consumption to offer a broader model of social change and governance. Social Sciences and Humanities scholarship is essential to address these shifts in meaningful (rather than tokenistic) ways. This agenda and the shifts it embodies represent key tools to enable better interdisciplinary working between SSH and teams from the technical and natural sciences.

1. Introduction

1.1. Smart coordination plays an increasingly important role as energy transitions accelerate

For decades, scholars have indicated that climate and sustainability targets committed to through international processes (UNFCCC, 2022) cannot be met without the rapid transformation of the socio-technical systems that serve society (Geels, 2004). For energy systems – incorporating the vectors of electricity, heat and mobility – the transition required is profound and implicates all stages of increasingly complex production-consumption chains (Soutar, 2021). Supply-side innovations such as solar and wind power, energy storage, electric vehicles (EVs) and heat pumps, are perhaps the most visible motifs of change (Markard et al., 2020). However, the transition also involves infrastructural change such as upgrading energy networks, as well as shifts in consumption (demand-side) patterns and technologies. Further, the boundary between the realms of 'supply' and 'demand' is becoming increasingly porous as we see distributed energy systems with greater engagement of flexible consumers (as prosumers) changing the production-distribution-consumption chain (Bellekom et al., 2016; Kubli et al., 2018).

In this context, it is clear that the role of coordination is an essential part of the net zero transition – matching production supply, consumption demand and intermediate storage. Smart use of technologies – meaning digitally enabled and networked for monitoring and/or control – is widely seen as playing a central role in this coordination. Flexibility in all stages of the power system is a prerequisite to the continued expansion of renewables and managing new consumption requirements from the electrification of heat and mobility (Öhrlund et al., 2020; Ryghaug and Skjølsvold, 2021; Fjellså et al., 2021). This means that smart technologies are increasingly seen as central enablers of the fundamental system changes required in energy transition policies (Inderberg et al., 2018; Geels et al., 2021; Skjølsvold, 2014). Such strategies involve technologies such as new software, sensors, smart electricity meters, smart home devices, internet-of-things connectivity, and cloud services. However, this still leaves much room to determine what 'smart' should look like for society.

The impacts of moves towards smarter technologies are intertwined with new roles and responsibilities for actors across energy systems. In the energy sector, shifts in technical, behavioural, and economic expectations surrounding end consumers are rapidly becoming a point of debate. For example, recent new technological business models aim to transform consumption through providing consumers with real-time information about consumption (e.g. smart metering and in-home displays), enabling new forms of pricing (e.g. flexible tariffs), or enabling remote control or automation of consumption and storage (e.g. smart EV charging). The dominant concept of end consumption is thus shifting from 'passive' behaviour, motivated by the consumer's own interests and needs, towards 'active' behaviour including being more flexible to demand response signals from providers (Adams et al., 2021; Söder et al., 2018; Tveten et al., 2016).

In the EU, the mobilisation of such technologies is hoped to enable a new set of roles for citizens in energy systems, where they may be "[…] *Generating, consuming, sharing or selling electricity, or […] providing flexibility services through demand-response and storage"* (European Commission, 2020). A key question is whether citizens take on these roles and behaviours, and find these changes acceptable. Whilst political attention is often on domestic consumers, the social impacts go much further and include how society organises institutions such as power grids, energy markets and indeed jobs markets. However, much less attention is currently given to these issues in public discourse about smart energy systems.

1.2. The social nature of smart energy systems is not currently reflected in mainstream agendas

While the implementation of smart energy systems is often presented as a technical endeavour, it is fundamentally interlinked with social systems and holds significant social consequences. A growing body of research now demonstrates, for example, how smart (and flexible) domestic consumption can exacerbate inequalities associated with gender

(Johnson, 2020), age (Barnicoat and Danson, 2015), capital (Powells and Fell, 2019), and skills (Herrero et al., 2018). This raises substantial questions about the ethical, justice-related and legitimacy implications of smart developments. These are not merely abstract concerns. At a practical level, given how central smart initiatives are to proposed decarbonisation pathways (IEA, 2021), the failure to implement smart energy in a manner that maintains public trust will likely have significant negative implications for climate targets (Büscher and Sumpf, 2015).

At present however, policy and research agendas on smart still tend to focus funding and attention primarily on technology development, with a lack of critical inquiry into the implicit assumptions related to behaviours, social conditions, and social goals; for example how underlying power structures may disadvantage or oppress certain groups. Where social aspects are considered, these tend to focus on how public attitudes or acceptance may influence behaviours, and the roles of active consumers, market participation, and consumer engagement as being key to smart energy systems (Fox et al., 2017; Ambrosio-Albalá et al., 2019; Dwyer and Bidwell, 2019; Hope et al., 2018). Yet, the roles of professionals, democratic and political processes, or social histories are neglected, to name just a few areas. Improving the resourcing and prominence of research from the Social Sciences and Humanities (SSH) within smart energy debates and policies is essential in addressing these blind spots.

1.3. Funders need resources to better support interdisciplinary research directions

Research directions are strongly influenced by the design of funding mechanisms (Royston and Foulds, 2021). The recently launched European Framework Programme – Horizon Europe – does, like its predecessor Horizon 2020, attempt to address the issues of underrepresentation of Social Sciences and Humanities (SSH) in energy research through the use of 'SSH flagged' projects which should be evaluated for SSH expertise. Thus, the importance of strong SSH participation is to some extent being written into funding patterns. Nevertheless, evaluation has shown that where these kinds of requirements exist, SSH questions are often not placed at the forefront of interdisciplinary projects but rather as an 'add-on' once the main technological aims have been defined (Mallaband et al., 2017a, 2017b).

Even when SSH questions *are* foregrounded within funding calls, they tend to cover a narrow spectrum of SSH that can often only respond to and work within pre-existing agendas set by STEM[1] disciplines. Barry et al. (2008) refer to this as a 'subordination-service' role that serves to significantly limit the contribution SSH disciplines can make to interdisciplinary research agendas. This can be seen from the European Commission's (EC) annual monitoring exercise of SSH in Horizon 2020, which outlines both the continuation of a small share of funding allocated to SSH partners (just 8.5%) as well as the ongoing dominance of a small range of SSH disciplines (Economics, Business, Marketing, Political science, Public administration and Law) which account for almost two thirds of funded expertise (European Commission, 2019). This raises issues of epistemic justice (Fricker, 2003) and the need to craft new interdisciplinary narratives. The EC's funded pilot platform and innovation forum for energy-SSH (the SHAPE ENERGY and Energy-SHIFTS projects) have demonstrated significant interest from both the STEM and SSH communities to do more of this interdisciplinary work (Arrobbio et al., 2018; Royston and Foulds, 2019).

In summary, use of smart technologies is one of the primary tools being used to enable coordination between cleaner production and consumption, in order to achieve the rapid transitions sought to combat climate change. However, there is huge variation in how their design and implementation could be carried out, and these choices are fundamentally intertwined with social structures and social consequences related to justice, legitimacy, and efficacy. Past funding for energy research has significantly under-utilised SSH research, and programmes have struggled to effectively encourage interdisciplinary projects which centre SSH expertise and research questions. There is demand from both STEM and SSH researchers for more resources which aid this work, who recognise a gap in current ways of shaping research agendas which this paper aims to explore and address.

In this context, over 2019–2020 the Energy-SHIFTS project formed a Working Group (WG) on Smart Consumption made up of 31 SSH scholars from across disciplines and European contexts. The WG's aim was to systematically gather views from energy-SSH researchers across Europe and use these to collaboratively generate priorities for EC research on smart energy systems, through an extensive 'Horizon Scan' exercise (August 2019 - November 2020). This resulted in 100 priority SSH-led research questions for smart consumption submitted to the European Commission and published open access (Robison et al., 2020). This paper provides a novel analysis of these 100 questions, with our research objectives being to explore: 1) What do SSH communities see as the most important priorities in future European research on smart consumption? and 2) What shifts does the resultant SSH-led smart research agenda represent?

Importantly, we highlight that in seeking to better represent the diversity of SSH than previous agendas – and in recognition of the great variation in both technology implementation and relevant social structures – we deliberately remained open to diverse theoretical approaches underlying potential research questions throughout the Horizon Scan exercise. For our inventory and classification, therefore, we did not define one a priori theoretical framework; however, we do examine relevant theoretical frameworks in our analysis of the research agenda (Section 3).

The key novel contributions of the paper (outlined here and discussed further in Section 5) are threefold and represent recommendations for improving the environment in which smart consumption research takes place. First, this agenda represents a tangible resource through which research teams (including interdisciplinary teams) can embed SSH concepts early to shape project direction, enabling SSH to play a more leading role on smart consumption. Second, the agenda carries clear implications for how research on smart consumption could be evaluated more effectively by incorporating indicators that relate to political analysis, engagement with individuals and collectives, theoretical development, diversity and attention to marginalised places and people. Finally, the three shifts this agenda represents are timely. The crucial nature of socially informed research as the climate and energy crises deepen is increasingly recognised. It is vitally important that such research is dealt with in a non-superficial way, and the representation of a diverse set of social researchers is one way to help achieve this.

2. Horizon Scanning and analysis methods

2.1. Past smart research agendas

A number of previous smart energy agendas for Europe exist which have either aimed to steer strategic investment – for example within cities (EC, 2018; Innovate UK, 2018) – or identify how stakeholders such as universities or businesses can respond to these strategic investments (EUA, 2017; Smart Energy Europe, 2021). In this way they can be seen as playing a significant role in the process through which certain research areas or questions are seen as worthy of investigation (and therefore funding) or not.

There are a number of common assumptions across those agendas focussed on strategic investment. Firstly, many broadly accept digitalisation as an inevitable trend, the progress of which could be harnessed to the benefit of the energy system and net zero transition. This implies the main challenge with digitalisation is to *"unleash its potential to … accelerate the energy transition"* (Hübner et al., 2020, p. 38). This

[1] Science, Technology, Engineering, Mathematics.

significantly limits possibilities for critical research that challenges deeper aspects of the digital transition, such as vested interests or distributions of power. Even in studies where experts were specifically asked to debate the likelihood of 'smart transitions' (PwC, 2016), the resultant narratives tend to assume technological development as the main driver of change. Secondly, many of the existing agendas rely on established or 'traditional' energy sector institutions to both advance and govern technical change. This is reflected in common reliance on market-based approaches to technological development and adoption.

Furthermore, (smart) energy research agendas which have originated from EU policy bodies tend to have had limited SSH involvement in their development. Thus we see social elements assigned to 'cross-cutting' challenges (Hübner et al., 2020, challenge 8) rather than driving primary research questions, and social mechanisms positioned as at the service of technological targets in calls, for example, for *"societal innovation, social entrepreneurship and citizen participation … to spur the deployment of Positive Energy Districts"* (EC, 2018, p7). This means most smart-related agendas aimed at directing funding or research take techno-centric starting points and thus construct primarily technical goals. While these agendas may involve SSH disciplines, there is a tendency to frame them as supplementary considerations that are either explored in less detail, or construed primarily in terms of barriers or enablers of technological change. Acceptance levels, engagement and justice issues are the most commonly seen.

In contrast, and to fill the gaps outlined above, the exercise outlined in this paper sought to address the historical lack of deliberative opportunities for diverse SSH disciplines to come together to generate research agendas. The methodology undertaken to achieve this is outlined next.

2.2. Energy-SHIFTS Horizon Scan methods

The questions within our Smart Consumption research agenda were generated via a systematic process known as Horizon Scanning. These applied methods entail the production of foresight, typically to identify opportunities, risks and knowledge-gaps in rapidly developing fields, in order to set strategic priorities for policy makers, practitioners or researchers (Foulds et al., 2019). Such exercises have become an established tool amongst policy developers, but increasingly also in scholarly circles that seek to carve out the frontiers of a field. Building loosely on the Delphi method (Linstone and Turoff, 1975), many Horizon Scans have been conducted to generate and select questions (Ingram et al., 2013; Pretty et al., 2010; Sutherland et al., 2019), thereby producing research agendas that are relevant for application contexts or policy making (Cooke et al., 2010).

Previous Delphi studies on energy have tended to explore *what* experts believe the future of the energy system itself will look like (Winskel and Kattirtzi, 2020; PwC, 2016), rather than exploring *how* future research in energy should be directed. Thus, the way in which the (research) questions we choose to ask now will in fact *shape* those future energy systems has often been backgrounded.

The particular process followed by the Energy-SHIFTS Working Group (WG) was built on a pre-determined structure (used for four such WGs, see Krupnik et al., 2022; Foulds et al., 2022; Ryghaug et al., 2023) however with the flexibility to be responsive to our unique WG membership. In particular two participatory WG workshops were highly tailored and in themselves represent examples of how SSH methods can be used to work effectively with particular communities. Importantly, we note that qualitative data and analysis are central parts of Horizon Scan methods (notwithstanding the use of quantitative analysis to support some steps).

The process we followed is detailed in Fig. 1 and consisted of the following main steps: Ia. Recruitment of WG members; Ib. 10 Interviews on the smart SSH research landscape; II. Horizon Scan survey (online): *generating qualitative data in the form of 273 questions from 74 SSH scholars*; III. WG member quantitative scoring of the 273 questions (via online survey); IV. Two (online, live) workshops enabling qualitative finalisation of 100 questions and validation of the thematic groupings and overall agenda.

The recruitment process in Steps I and II was vital to the rigour of the results. Our Horizon Scan process began through careful recruitment of WG members according to the following criteria to achieve wide representation:

- SSH sub-disciplines (30 represented);
- interdisciplinary experiences (>8 STEM disciplines represented);
- gender (61% female);
- geographies (19 countries represented through either nationality or research organisation based at);
- research interests and career stages (42% 'frontrunners' working at the boundaries of conventional academic structures, and 58% established academic 'field leaders').

Drawing on the contacts of these WG members we then gathered submissions of priority research questions via the online Horizon Scan survey, thus achieving very wide geographical and disciplinary diversity in responses – from researchers based in 18 countries, representing 25 nationalities, and 45 SSH sub-disciplines.

During the prioritisation (Step III), the 273 questions which had initially been generated were organised by the Steering Committee under 17 categories, to aid the WG members' scoring and discussion. Table 1 lists these categories, ordered by mean score.

Whilst these inductively-generated categories were primarily an organisational tool, they nevertheless demonstrate quantitatively how certain categories were seen by WG members as being more in need of support (e.g. energy communities, methods, democratisation) or less in need of support (e.g. economies, behaviours, flexibility) in future research agendas – likely linked to the relative amount of attention already given to these topics. Seven inductively generated Themes under which the final questions were grouped are discussed in Section 3.

Extensive further details on the background and methods – including the peer-reviewed WG Terms of Reference, our definition of 'smart consumption'[2], detailed protocols and informed consent procedures, and key statistics related to the socio-demographics of both WG members and Horizon Scan respondents and the scorings of questions[3] – can be found in Robison et al. (2019), and Robison et al. (2020).

2.3. Analysis of shifts represented within the resulting agenda

For the current paper, additional analysis was undertaken to identify whether and how the final agenda of 100 questions represents 'shifts' for research on smart consumption. By shifts, we meant either reframings, whereby the point of departure or underlying assumptions are exposed or altered, or refocussings, whereby the aims and direction of travel are moved. This concept has resonances with 'paradigm shifts' as proposed by Kuhn (1962) who emphasised how science is organised according to paradigms which structure ensuing problem definitions (i.e. what is even worthy of investigation, let alone relevant for possible governance

[2] We define 'smart' as meaning related to energy technologies *"which are digitally enabled and networked for (usually real time) monitoring and/or control"* and 'consumption' as meaning a focus on *"homes, workplaces and communities"* rather than large-scale industry (Robison et al., 2019, p. 5).

[3] The procedure in brief was as follows, after all WG members scored every question from 1 ('definitely exclude') to 5 ('definitely include'): 1. The 50 questions (out of 273) with highest mean scores AND medians ≥4 were proposed to members for automatic inclusion. 2. The 80 questions with median ≤3 AND five or fewer 5s were proposed to members for automatic exclusion. 3. The remaining 143 questions were longlisted for deliberation at the online workshops. 4. Longlist questions were categorised into three groups to aid discussion as follows: the 7 highest scoring (ten or more scores of 5), the 54 lowest scoring (median ≤3.5), the remaining 82 questions mid-scoring.

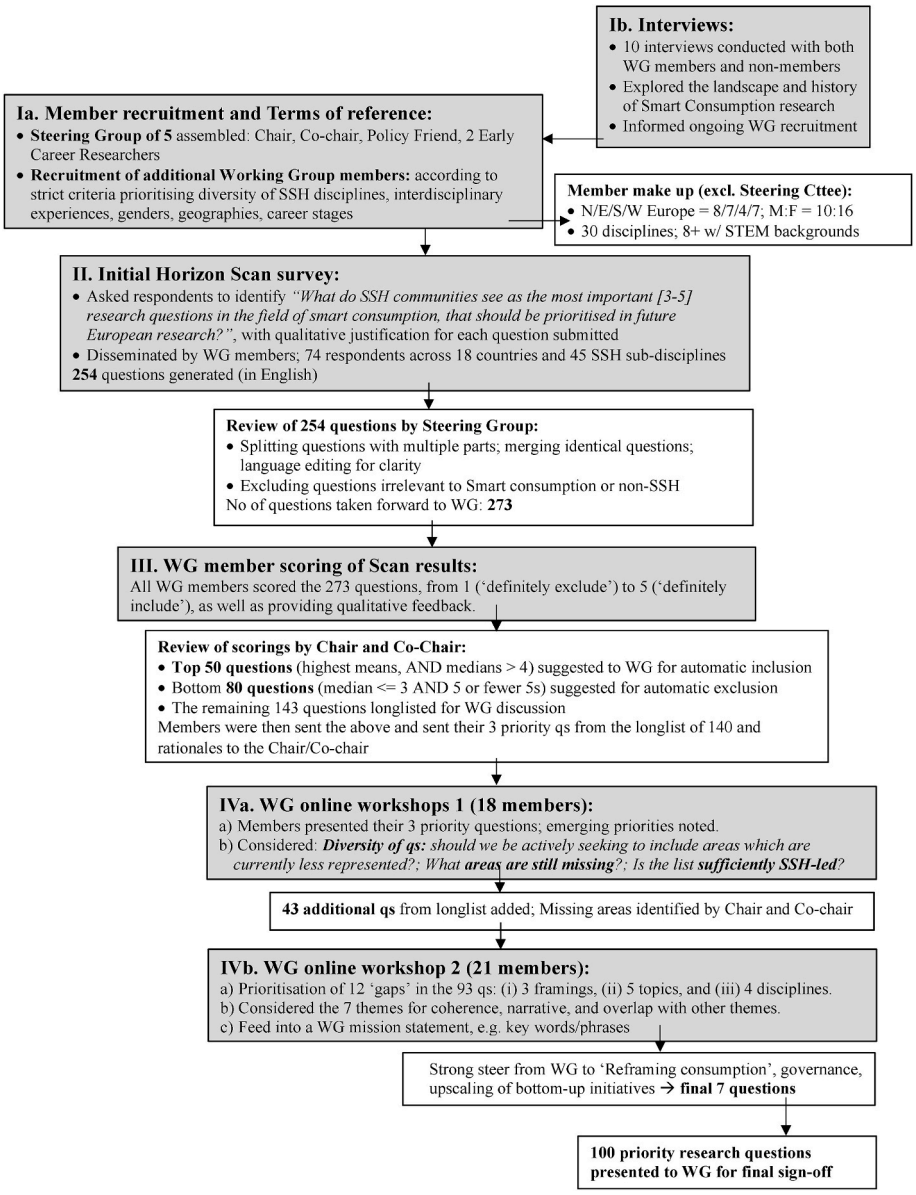

Fig. 1. Systematic Horizon Scanning method used by the Smart Consumption WG.

interventions) but that over time these paradigms can and do change. Since then, the paradigm shift has also been explored in policy, rather than scientific, contexts (Hall, 1993; Delputte and Orbie, 2020) as well as within energy systems specifically (Manfren et al., 2011).

We first ran an analysis on the agenda itself. This included: (i) the first nine authors of this paper assessing and discussing potential shifts when viewing the agenda as a whole; (ii) the WG Chair re-evaluating the notes taken live at the two online WG workshops to identify key debates between members on how to frame the final agenda; (iii) one of the first nine authors systematically analysing the 100 questions and assessing which individual questions represented any of the shifts identified through steps (i) and (ii), as well as inductively identifying additional shifts which were represented across more than one of the seven Themes.

To verify which of these did indeed represent 'shifts' from the previous smart research landscape we then (iv) gathered existing smart research agendas – outlined in Subsection 2.1 – and (v) analysed 10 semi-structured interviews with SSH experts representing a variety of disciplines which had supported the formation of the WG (see Fig. 1, box Ib).

The interviews (with 7 WG members and 3 non-members) provided contextual data related to the extant SSH research landscape against which to compare the new agenda by focussing on: (a) the evolution and history of smart (SSH) research to date, and (b) potential aspirations for the research agenda output from the WG. The interview data[4] did not directly feed into generation of the 100 questions but rather provided a means of assessing whether the Horizon Scan ultimately fulfilled the aspirations discussed at its outset. Three of the first nine authors analysed the interviews by deductively coding the text against the shifts identified in the 100 questions, as well as noting additional potential shifts alluded to in the interviews but not identified in the final agenda.

The three shifts identified from this analysis – (1) From technological inevitability to political choice; (2) From narrow representation to diverse inclusion; and (3) From individual consumers to interconnected

[4] Open access, anonymised, versions of the interview data are available here: https://figshare.com/articles/dataset/Energy-SHIFTS_Working_Group_2_-_Smart_Consumption/16692604. Interviewees were given the opportunity to check these for accuracy.

Table 1
WG members each scored a list of 273 SSH questions, on a scale of 1 ('definitely exclude') to 5 ('definitely include'), and provided other qualitative feedback.

Category	No. of qs (out of 273)	Mean score	Variance of means	% of qs with median ≥4
The many roles of contemporary and future consumers	19	3.92	0.24	53%
Collective action/energy communities	15	3.78	0.76	87%
Research methods	6	3.68	0.12	83%
Justice, access, and spatial disparities	23	3.65	0.09	61%
Democratisation, inclusion, and participation	23	3.61	0.06	74%
Critiquing the logics of 'smart'	14	3.61	0.07	64%
Unintended consequences	21	3.60	0.18	67%
Data/privacy	7	3.58	0.16	57%
Everyday life, lifestyles and technology use	21	3.53	0.19	52%
Risk, crisis, and security	11	3.45	0.08	45%
Miscellaneous	5	3.41	0.20	40%
Flexibility	17	3.38	0.08	24%
Institutions, industry, and innovation agendas	32	3.37	0.07	44%
Policy, politics, and power	12	3.37	0.12	33%
Design and new technologies	20	3.34	0.10	40%
Behaviour and behavioural change	18	3.14	0.11	22%
Economies and business models	9	3.10	0.11	11%

citizens – are discussed in Section 4.

3. The Energy-SHIFTS smart consumption research agenda of 100 priority questions[5]

The final list of 100 research questions which had been prioritised using quantitative and qualitative methods (see Section 2.2) were clustered into seven Themes according to boundaries defined at the second WG workshop; they are specifically ordered with each Theme feeding forwards to the next – see Fig. 2.

While past agendas have often been divided by technology application or sector (e.g. electric vehicles, home automation etc.,), our SSH-led Themes cut *across* technologies. This difference in approach is not trivial, since it can be an inhibiting factor for SSH involvement in formal advisory structures, since seeking experts in 'batteries' may exclude SSH scholars who work across technologies.

To emphasise the need to better integrate SSH concepts in interdisciplinary discussions about smart energy futures, we have indicated several key SSH concepts in italics alongside brief definitions and example references[6]. All questions were concerned with low-carbon transitions of the socio-technical systems around energy. Inspired by Rotmans et al. (2001), the WG defined *transitions* as transformation processes in which society changes in a fundamental way over a generation. The WG was committed to the view of innovation and transformation of energy systems as concerning *socio-technical systems*, in which social and technical elements are interrelated and cannot be understood as separate entities (Köhler et al., 2019; Geels, 2018).

Fig. 2. The seven Themes of the Energy-SHIFTS Smart Consumption research agenda.

3.1. Theme 1: Power relations and smart energy transitions

Theme 1 (comprising 12 questions available here) asks how the use of smart energy technologies affects power relations across policy, business and industry, and across scales (from local to international). Within this Theme, questions touch on: pre-existing power relations **[Q1, Q2, Q9, Q12]**, empowerment, i.e., the redistribution of power to new groups **[Q4, Q5, Q7, Q8]**, as well as the distribution of benefits and costs **[Q6]**.

Several questions directly concern *governance* – decision-making amongst actors involved in a collective problem beyond formal state institutions (Rhodes, 1996; **[Q3, Q11]**). They highlight how the implementation of smart consumption through digitalisation may require the dismantling of both technical lock-ins, but also *institutional lock-ins* associated with vested interests and existing infrastructures (Wolsink, 2020) and informed by technical, institutional and behavioural path dependencies (Seto et al., 2016). This interpretation highlights the role of *socio-political acceptance,* decision-making on issues concerning the transformation of current energy systems (see also further discussion of acceptance issues under Theme 2).

Theme 1 expands on dominant understandings of consumption by insisting that smart consumption is an element of a broader, system-wide socio-technical transition, which entails transforming power relations through implementing more distributed systems of provision (Wolsink, 2018b), and new accompanying roles for citizens (Ryghaug et al., 2018). Here smart energy systems may facilitate alternative bottom-up transitions co-produced by grassroots and civil society groups (Smith et al., 2017; March, 2018). This includes dealing with control and data ownership, the ethics of privacy **[Q10]** and trust in institutions, as well as how the benefits and burdens of implementing smart grids are distributed amongst different socio-economic groups (Powells and Fell, 2019; I.F. Fjellså et al., 2021).

Theme 1 also highlights relationships between consumption and the political ecology and economy of smart technologies (Colding and Barthel, 2017; March, 2018). This showcases how power relations across

[5] Note for the reader: The 100 questions represent part of the qualitative data upon which the analysis for this paper is based. As per project commitments to open science, Robison et al. (2020) made this data available open access together with meta-data of how it was collected. For the reader's convenience, and in liaison with JCLP editors, we also include hyperlinks to the specific sets of questions below.

[6] See also Robison et al. (2020), p31 for a Glossary of specialist SSH terms used within the 100 questions.

society sustain transitions, opening up alternative trajectories or reinforcing ongoing privatisation processes over the control of environmental resource flows. These questions relate to the inclusions and exclusions that smart consumption transitions may enable, as explored in Theme 3.

3.2. Theme 2: Engagement and trust in relation to smart technology roll-out

Theme 2 (14 questions) focuses on how smart technologies impact and are impacted by patterns of societal engagement and relations of trust.

For smart technologies to deliver on their potential, they must be broadly accepted and adopted across society (Darby, 2010; Martiskainen and Coburn, 2011), as must their associated policy and institutional changes (Wolsink, 2012). Many SSH scholars have studied consumer understandings of the benefits and risks of smart technologies, and how this affects their diffusion (Balta-Ozkan et al., 2014; Wilson et al., 2017; Paetz et al., 2012; Ellabban and Abu-Rub, 2016). Conclusions often stress the importance of countering perceptions that smart technologies will be intrusive and disruptive, or will increase vulnerability, deskilling and exclusion (Sovacool et al., 2021). This framing points to key challenges around educating, communicating and incentivising different societal groups to increase their energy literacy and use of smart technologies **[Q20, Q21, Q22]**.

Other SSH disciplines have studied the innovative ways that societies already engage with smart technologies[7]. This work has emphasised how smart technologies are appropriated as part of household routines that often confound designers' original expectations (Hargreaves et al., 2018), the many 'workarounds' that users adopt to maintain a sense of control (Nyborg, 2015; Bulkeley et al., 2016; Larsen and Gram-Hanssen, 2020), as well as recognising resistance through activism and protest (Hess, 2014), giving voice to wider public concerns around justice and equity (Thomas et al., 2020; **[Q16]**). These approaches have led to new, more *participatory* methods to engage diverse and often marginalised groups, in earlier stages, to meaningfully influence smart technology design. Methods include co-design processes (van Mierlo, 2019) and provocative forms of speculative design (Wilkie et al., 2015) that seek to creatively open up societal engagement **[Q13, Q17, Q18, Q19, Q26]**. Such work remains experimental. Integrating such ideas in policy and business decision-making is challenging **[Q24, Q25]**.

Trust is another core issue related to societal engagement with smart energy **[Q14, Q15]**. This includes trust in the reliability of new technologies, trust in the responsible use of data, and trust in institutions to act in consumers' best interests (Balta-Ozkan et al., 2013; Fell et al., 2014). Some note that trust must be addressed through technical and policy solutions (encryption, strong regulation and transparent communication) (Véliz and Grunewald, 2018), while others note that concerns about trust result from a wider lack of control and should be addressed as part of democratising technical systems more broadly. This challenge demands upstream participation of diverse groups to strengthen their agency and meaningfully inform the trajectory of smart energy transitions (Sadowski and Levanda, 2020; Szulecki and Overland, 2020; **[Q23]**).

[7] We note the important related work led by disciplines such as science and technology studies and human geography, moving from *public* acceptance - adoption rates - towards *social acceptance* - the bundle of processes of decision-making on issues concerning the promotion of – or counteraction against – new phenomena and new elements in the transformation of current energy systems (Wolsink, 2018a). The role of engagement for trust in these processes is discussed in Subsection 4.3.

3.3. Theme 3: Exclusion and unevenness in smart futures

Theme 3 (11 questions) situates research on smart consumption in discussions about achieving just and inclusive energy transitions (Jenkins et al., 2016; Jasanoff, 2018; **[Q27]**). The 'unevenness' experienced both in processes, and outcomes, of smart transitions was repeatedly highlighted by WG members throughout discussions.

Transitions fundamentally change societies (Schot and Kanger, 2018; Skjølsvold and Coenen, 2021), in ways that can be both just and unjust. Energy justice research often focus on the 'three tenets' of justice (Schlosberg, 2013) and questions in this Theme can be linked to *distributional justice* – how benefits and burdens of transitions are shared in society **[Q28]**, *recognitional justice* – which actor groups are seen as having legitimate concerns related to transitions **[Q37]**, and *procedural justice* – ensuring due process for relevant actors **[Q29, Q30]**. The Theme asks for new ways to democratically govern energy (Szulecki, 2018), for example, through participatory design processes **[Q35]**. Other questions are concerned with avoiding further entrenchment of vested interests, or asking how smart energy transitions could break historically built-up injustices and concentrations of wealth and power **[Q31, Q32]**. This extends to an interest in how imaginaries and visions of the future could open up alternatives **[Q36]**.

SSH scholars have critiqued a tendency of smart technologies and price mechanisms to re-enforce social, spatial and economic unevenness, and exclude social groups from potential benefits (Strengers, 2014; Graham and Marvin, 2001; **[Q33, Q34]**). New tariff structures often benefit those with access to large thermal and electrical loads (Powells and Fell, 2019), but may exclude others including those who rent, live in shared spaces (Fjellså et al., 2021), or lack technological literacy such as elderly citizens (Barnicoat and Danson, 2015).

Theme 3 further asks about systematic patterns of justice and injustice across countries and territories **[Q34]**, pointing towards research which links energy transition issues with north-south questions, urban-rural, de-colonialism and historical injustices, as has been called for in recent scholarship (Sovacool and Furszyfer Del Rio, 2020), particularly energy geography. Related to this, WG members reflected on the very 'western' origin of the questions, and felt a strong need to bring comparative perspectives and experiences from beyond Western Europe to the table (such as Bilous, 2020).

3.4. Theme 4: Building communities for smart consumption and prosumption

Theme 4 (14 questions) focuses on the ways that smart is enacted locally, shaped by local contexts, and the relationship between local, national and international communities in transitions. *Community energy* and *energy communities* are central in this Theme. These concepts describe community initiatives in energy systems, e.g. co-producing renewable energy, energy saving or peer-to-peer- sharing, or other distributed assets (Sousa et al., 2019; Gui and MacGill, 2018), as well as the establishment of communities around energy, e.g. cooperative solar power installations (Mihailova et al., 2022). While community energy is often praised as integral to achieving a just transition, SSH research has illustrated that this is contingent on how processes are designed (van Bommel and Höffken, 2021) and that involvement in decision-making and benefit-sharing directly impacts on community energy outcomes (Walker and Devine-Wright, 2008). Thus, questions in this Theme probe how community energy and smart consumption can be developed inclusively to strengthen each other **[Q38, Q42]**.

A related discussion concerns how prosumers – actors producing, consuming and sometimes sharing energy (Parag and Sovacool, 2016; Korsnes and Throndsen, 2021) – can contribute to smart transitions, as well as which new institutions are needed to enable such contributions **[Q41]**. This potentially aligns with a shift from the consumption of energy as a private commercial good to collective production as a common-good.

This Theme asks further, how the social and technological elements of community energy might empower citizens (Frantál et al., 2018; **[Q39]**). Thus, it asks how citizens might become resources in innovation, enabling the successful up-scaling of local initiatives **[Q48]**. Further questions probe how to achieve challenging institutional shifts related to energy communities, such as enabling new forms of citizen co-operation, and co-production, management, and control of their own distributed energy systems **[Q43, Q44]**. An important element of this entails probing which institutional lock-ins might be hampering development **[Q40]** as well as how past narratives of citizens can be better understood to affect current understandings **[Q45]**.

Scholars have noted that community energy is entangled with the interaction of actors within at least three spheres: the private sector, the government (local, national, international), and civil society (Creamer et al., 2018). Questions in this Theme critically probe the role of these spheres, as well as about the effect of EU-level governance **[Q49, Q50, Q51]**. Relatedly, they highlight how shifts might be enacted differently in rural and urban contexts (Antonelli and De Liso, 2016; Barns, 2018; **[Q46, Q47]**).

3.5. Theme 5: How smart can become part of, or disrupt, everyday life

Theme 5 (18 questions) asks how smart technologies enter, transform, or disrupt everyday life and shape relationships to energy consumption or production. It also probes how the everyday influences the discourses of smart technologies (Hielscher and Sovacool, 2018). Interestingly, discussions within the WG about the term 'disruption' prompted expression of a desire for the agenda to avoid being solely a critique of technical-led smart agendas, and to ensure a focus on the enabling aspects of smart technologies as well.

Important topics are how smart technologies shape transformations towards more (or less) low-carbon lifestyles [**Q52**], e.g. enabled by home energy management (Foulds et al., 2017; **[Q55]**). This relates to questions about the new roles that homes and workplaces take on as part of the energy transition, how these affect the lives within them **[Q53]** and broader questions of how smart technologies instigate or respond to radical transformations in society [**Q62, Q63, Q64**].

Smart technologies have been criticised for promising energy savings but running the risk of resulting in more energy-intensive lifestyles (Sovacool and Furszyfer Del Rio, 2020). The questions within this Theme address this contradiction. First, most smart technologies do not embrace the messiness of everyday life (Strengers, 2014), such as everyday dynamics, relationships, and emotions [**Q54, Q56, Q57, Q61**]. Second, smart technologies can result in sustained or even raised lifestyle expectations (Herrero et al., 2018; [**Q59**]). This extends to an interest in studying how everyday *practices,* routinised everyday actions that are repeated by individuals across societies (Shove and Walker, 2010), are disrupted and reconfigured or can be integrated with demand response **[Q60]**. The study of how practices themselves change across society is thus fundamentally different to the evaluation of how the behaviour of specific individuals might be influenced by smart technologies. Third, the challenge of *domesticating* smart technologies (Hargreaves et al., 2018), integrating them into everyday life, can be explored through longitudinal studies **[Q58]**. Fourth, the introduction of smart technologies can result in unintended consequences, such as rebound and spill-over effects (Horner et al., 2016; Sovacool and Furszyfer Del Rio, 2020; [**Q69**]) and entanglement with other low-carbon practices that are necessary for '1.5° lifestyles' **[Q68]**, a reference to the target set out in the Paris Climate Agreement.

Finally, this Theme also addresses temporal questions, by asking how consumer history might be a source of inspiration for contemporary work **[Q65]**. It also extends a link to the future, where SSH scholarship has illustrated that the widespread adoption of electric vehicles and batteries could significantly change everyday lives and society (Henriksen et al., 2021; **[Q66, Q67]**).

3.6. Theme 6: Beyond smart: evaluating assumptions and alternatives

Theme 6 (15 questions) questions the premise that smart technologies in themselves provide societal benefits, while discussing alternative low-tech and no-tech options for decarbonising energy systems. This Theme was originally presented to the WG at their second meeting, as two separate Themes[8], but discussion led to them being merged.

This Theme takes an interest in identifying unintended consequences of smart for citizens, as well as ensuring that such consequences can be measured **[Q70, Q71, Q76]**. Scholars have shown that indirect and unintended consequences of the use of smart technologies might include economic power concentration and have illustrated how smart might be used to trigger behaviour change through manipulation (Morozov, 2013). Questions in this Theme ask what further unintended consequences might exist across different social arenas **[Q74, Q75, Q78]**. However, since many SSH scholars reject the idea that technology dictates social outcomes (Wyatt, 2008), the Theme is also concerned with asking questions about how smart technologies can be mobilised in the pursuit of different goals and improve the quality of human lives and societies **[Q77, Q80, Q81]**. Beyond this, there are questions in this Theme which seek to look beyond smart technologies to see what alternatives there are to addressing the challenge of decarbonising society (Kerschner et al., 2018; Rommel et al., 2018; **[Q72, Q73]**).

As discussed already, many actors believe that the introduction of smart technologies will lead to new energy consumer roles. SSH studies have illustrated that in most accounts, these roles are assumed to strengthen efficiency goals, but also goals that underpin a neoliberal agenda of perpetual growth (Rommetveit et al., 2021). As a contrast, this Theme asks if smart can play a role in facilitating *energy sufficiency*, enabling practices that emphasise having enough, while recognising and respecting the environmental boundaries on consumption (Darby and Fawcett, 2018). Further, there are questions that ask if smart technologies can be mobilised in the quest for broader societal transformation, e.g. by enabling alternative forms of energy supply that fit within wider trends of economic organisation and practices **[Q79, Q82, Q83, Q84]**.

3.7. Theme 7: Citizen, worker, parent: different roles involved in smart

The final Theme 7 (16 questions) situates 'smart' as involving more than discrete acts of consumption. Instead, smart is enacted through a range of actors and networks beyond that of the consumer. In WG discussions, this was vital to what the group saw as a 'reframing of consumption'.

Where Theme 6 highlighted that the use of smart technologies might entail unintended negative consequences, Theme 7 notes the generative potential of smart in mobilising consumers as *energy citizens* (Wahlund and Palm, 2022; Ryghaug et al., 2018). This involves mobilising awareness, skills and practices to engage with the energy system and transition. However, as noted earlier, a narrow conceptualisation of citizens and their rationales and motivations can serve as an exclusionary mechanism. SSH scholars have often worked to expand conceptualisations, both in terms of the roles that citizens might have, and in terms of the elements that define and constitute particular roles (Ingeborgrud et al., 2020). Questions in this Theme advance on such issues by probing how broader interests than those associated with consumption can be activated **[Q85]**, which roles exist beyond the consumer – such as members of families, households, communities, professional colleagues [**Q90, Q91, Q93**], as well as how attributes such as gender affect the enactment of smart **[Q94]**.

Further, this Theme takes cue from decades of SSH research (Lutzenhiser, 1992) to note that energy consumption is constituted by

[8] These previous iterations were entitled: (1) The limits of high-tech: smart and other means of changing consumption; and (2) Questioning the assumptions, business agendas and logics of smart.

elements beyond individual choices. This results in an interest in understanding the types of actors and forces that SSH scholars have described as shaping or orchestrating the ways citizens engage with energy (Pallesen and Jenle, 2018; Skjølsvold et al., 2018). On the one hand, questions in this category ask about the role of social structures, institutions, policies and knowledge in shaping new forms of citizens and citizenship **[Q86, Q87, Q88, Q89, Q92]**. On the other hand are a series of questions that more concretely probe the worldviews, practices and understandings of developers **[Q95]**, planners **[Q96]**, network operators **[Q97]**, markets **[Q98]**, global corporations **[Q99]** and the media **[Q100]**.

4. Key shifts of the Energy-SHIFTS SSH-led research agenda

Following the discussion above on the wide diversity of SSH-led questions of relevance to the design and implementation of future smart consumption initiatives, we focus now on our second research aim: to explore the key shifts this new SSH-led agenda represents and thus how this set of questions could support new strategic research directions. In this way, we explicitly compare and contrast our agenda with previous results, through the additional analysis of past agendas. Drawing on previous smart research agendas (Subsection 2.1), 10 expert interviews focussing on recent trends in the smart consumption research landscape (Subsection 2.3) and the 100 questions emerging from the Energy-SHIFTS smart agenda (Section 3), we introduce three cross-cutting shifts which we believe should inform all future research on energy and smart consumption which aims to impact on society – summarised in Table 2.

Table 2
How the Energy-SHIFTS agenda contrasts with the smart landscape to date.

Previous agendas	What's new in the Energy-SHIFTS agenda	Strategic shift
Assume digitalisation/ technological advance to be an inevitable trend	• Embracing political dimensions explicitly • Foregrounding how research choices actively shape future energy systems • Asking what is beyond smart • Challenging the benefits of smart, whilst remaining part of the agenda-setting conversation	**From technological inevitability to political choice**
Construct primarily technical (rather than social) goals, meaning acceptance is key	• Moving from the narrative of acceptance being mere technology adoption, towards participation • Raising up voices of underrepresented consumers • Democratising smart transitions • Seeing smart as a lens 'in' to people's energy interactions as well as social practices	**From narrow representation to diverse inclusion**
Rely on 'traditional' institutions to govern technical change for consumers	• Embracing a system-oriented view of everyday life (in contrast to a de-mographic variables focus) • Exploring a decentralised energy future • Expanding into research on governance structures • Considering prosumerism as a social movement	**From individual consumers to interconnected citizens**

4.1. From technological inevitability to political choice

Previous research agendas on smart technologies have often adopted a technologically deterministic approach in which ongoing trends towards 'digitalisation' and 'smart' are treated as inevitable and unavoidable. In sharp contrast, the SSH-led agenda outlined here points to a more critical questioning of smart that recognises it as deeply political in the way it can reflect and protect powerful interests, thus shutting out alternative voices or possible futures.

Our expert interviewees pointed to three key aspects of smart technologies around which SSH future research could develop wider political critique.

First, much research on smart technologies was observed as being fundamentally about the continuation of economic growth through instrumental eco-efficiency and green growth agendas. As one interviewee stated, *"smart consumption is doing less … and that is a topic which is not addressed at all. I'm pretty sure the European Union will never fund any kind of research going to this direction because this … will contradict any kind of economic growth"* (Interviewee 2 - Sociology[9]).

Second, smart technologies were critiqued as potentially anti-democratic in the ways that they can be used to increase the surveillance and control of citizens through a vast and opaque system of data gathering that preserves and obscures the interests of powerful groups whilst citizens *"have no idea what is actually happening with our data, who is observing, who is using data,* [and] *for what purposes"* (Interviewee 2).

Third, and relatedly, smart technologies were criticised for diverting attention away from the development of meaningful solutions to sustainability problems by being too often focussed on insignificant and trivial concerns. It was seen as focussed on developing *"a smart thing on my fridge that will solve all my problems except the ones that matter"* (Interviewee 5 - Development), whilst failing to open up discussion about the systemic nature of contemporary issues and the need for alternative understandings of progress.

In response, the SSH-led research agenda presented here seeks to divert research attention away from approaches that uncritically promote the diffusion of smart technologies, towards work that recognises and challenges the political choices embedded in smart technologies and which develops and strengthens alternative systemic changes. For example, our agenda suggests that future research on smart consumption should explicitly explore the negative and unintended consequences of smart technologies **[Q75]**, such as how it can spur conflict **[Q9]**, be used in abusive ways **[Q12]**, or divert attention from low-tech initiatives that might better address societal concerns **[Q71]**. It seeks to pursue research that exposes the behind-the-scenes lobbying of powerful interest groups **[Q4]** and think critically about the winners and losers from current smart agendas and how costs and benefits might be distributed more equitably **[Q6]**. It also seeks to advance research on how smart technologies might be used in different ways to develop alternative futures **[Q79]** that might better promote human welfare and wellbeing **[Q80]**, such as around sufficiency **[Q82]**, degrowth **[Q84]** or the sharing economy **[Q43, Q68, Q83]**.

4.2. From narrow representation to diverse inclusion

The second cross-cutting shift our agenda calls for is to diversify and deepen the inclusion and engagement of different communities, particularly previously marginalised groups, in the development of and research on smart technologies. Whilst previous research agendas have touched upon social concerns – such as around societal engagement or social justice – this has too often been a supplementary consideration to the primary aim of achieving technical goals. This has led to the role of SSH being often as a subservient add-on to more technical disciplines to

[9] The SSH disciplines which interviewees were particularly selected to help represent are given in brackets.

help increase public acceptance through better communications and behaviour change to try and "unleash the potential" of smart technologies (Hübner et al., 2020, p.38). By contrast, social justice, well-being and the inclusion of marginalised interests are seen here as a vital and *primary* aim of research on the use of smart technologies, even if this means that non-smart and low-technology solutions may end up being prioritised.

The WG discussions and expert interviews identified numerous ways in which past research has failed adequately to include diverse and marginalised voices. Interviewees pointed towards the overwhelming focus of smart consumption research on the experiences of US and Northern European citizens and a significant lack of focus on perspectives from Eastern Europe, Africa, Latin America or Asia. Interviewees emphasised, with a hint of irony, a tendency to explore the views of affluent *"metropolitan, urban consumers … consumers that are strangely very like the researchers themselves"* (Interviewee 6 – History and Philosophy) and a lack of focus on lower income and rural groups. This was explained as potentially resulting from the green growth focus of much smart research meaning that these poorer consumers *"wouldn't be interesting"* (Interviewee 6) to technology companies as they are an unlikely source of profit. Other exclusions were identified around the lack of explicit focus on different ethnicities, elderly and disabled groups. In general there was a call across interviewees to include more *"plural and diverse worldviews"* (Interviewee 5) and to decolonise smart research by explicitly critiquing the often presumed universalism of white western perspectives.

Accordingly, and in line with broader discussions in the scientific community, our new SSH-led smart consumption research agenda suggests it is no longer appropriate or sufficient for research to focus only on the western middle classes without explicit reflection on the partialities and exclusions this entails. Instead, future research should focus on identifying and mapping different types and patterns of exclusion **[Q27, Q33, Q94]**. It should attempt to uncover the often hidden mechanisms of exclusion embedded in smart technologies such as in their algorithms, supply chains or business models **[Q7, Q29, Q31]**. It should work actively to develop new methods and strategies that promote greater inclusion in the development, use and governance of smart technologies **[Q28, Q35, Q50, Q85]**, including work that experiments with how smart technologies themselves might be used to change rather than reinforce existing patterns of marginalisation **[Q30, Q47]**.

4.3. From individual consumers to interconnected citizens

The third and final cross-cutting shift our agenda calls for is the need to move away from research approaches that focus on the role of 'end users' or 'final consumers' and towards approaches – particularly governance approaches – that recognise society as comprised of actively engaged and interconnected citizens. This is perhaps more salient than ever in a world that is increasingly reliant on digital interconnection. Previous research agendas have tended to focus on traditional and dominant institutions (e.g. energy companies, centralised power supply) as the primary sources of agency and, in so doing, have often left only a narrow set of subject positions available to wider societal actors. In contrast, our agenda points to the need for a broader recognition of the diverse roles and forms of engagement that citizens already, and will continue to, play.

Our expert interviewees argued that too much research on smart technologies has adopted a narrow model of social change in which publics are given little option but to play the role of isolated individual consumers who can make private decisions about whether or not to purchase and use new smart technologies, but little else besides. In contrast, interviewees emphasised that *"we need to rethink smart consumption, smart feedback … and [ask] different questions, and [think] about the multiple different roles that publics, citizens, can play in these sorts of issues around energy futures"* (Interviewee 1 - Geography). Interviewees called for greater recognition that publics are not only consumers and increasingly prosumers, but also that they are already engaged in diverse ways (variously accepting, hacking, modifying, resisting etc.) in their local communities and workplaces. For example, Interviewee 8 (Science and Technology Studies) suggested the need for more work that explores how marginalised communities in particular could repurpose smart technologies to better serve the needs of their own local areas rather than the interests of large companies and private individuals.

Many of the 100 questions focus on consumption, but our agenda further demonstrates that in order to understand consumption, other phases in the production chain must also be investigated to make the entire system sustainable and stable. For example, the question "What are the potential roles of households and workplaces as participants in the future smart energy system?" **[Q91]** also requires research into the sustainability of such participation and into shifts in the role of others in the production chain. The issue "How can the socio-technical system of power supply move away from centralisation, to be transformed into a smarter system where energy may be co-produced and consumed as a common good?" **[Q39]** also entails research into the changing roles of current power producers, distributors and network managers.

The agenda thus calls for research to identify and map diverse publics and collectives engaged with smart technologies **[Q85]** and to explore the dynamics of ecologies of public engagement in smart futures (Chilvers et al., 2018; **[Q16]**). This includes a focus on prosumerism, cooperation and co-production, new modes of peer-to-peer interaction **[Q41, Q42]** and provision of energy as a common good **[Q39, Q44]**. However it goes beyond this (and beyond energy) to call for work that examines how smart technologies might disrupt practices in homes and workplaces [**Q53,** and Theme 5**]**, how they might serve to generate new modes of engagement **[Q13]** as well as how they might both shape and be shaped by new kinds of governance.

5. Final remarks on study implications

In this paper, we have presented and analysed a novel agenda for smart consumption research. Whilst this is certainly not the *only* possible research agenda which could be produced of contemporary SSH-led questions, it is the first such agenda to be developed with significant and systematic involvement from European energy-SSH communities. Further, the iterative process of question refinement with the same expert group over the course of a year increases their robustness significantly. We have addressed the research objectives of this paper by emphasising three ways in which funders and researchers can shift their targets to better include these critical SSH themes, and thus produce more valid results. We conclude this paper by highlighting how our study has demonstrated both the relevance and timeliness of adapting research agendas to better incorporate SSH contributions.

Firstly, this agenda can be a resource whereby research teams embed SSH concepts early enough to help shape project direction. Our analysis shows this is critical in order to achieve the objectives of a zero-carbon future. The agenda also highlights how SSH can play a leadership role in research projects on smart consumption, and not simply fill a supporting role. The many interlinkages between different themes point to the importance of recognising that several different types of SSH expertise[10] may be needed within a single project: the spectrum of research disciplines from which colleagues may be drawn can and often should be widened.

As a significant example of the potential for diversification and inclusion, the agenda emphasises that questions of individual agency cannot be adequately addressed if they are not investigated alongside looking at social structures and collective processes. Previous agendas

[10] As an example, selected disciplines represented in our WG included: Anthropology; Business; Communication Studies; Economics; Education; Environmental Social Science; Ethics; Gender; Geography; Law; Management; Political Science; Psychology; Regional Studies; Sociology; STS; Urban Studies.

have tended to focus exclusively on the former. Whilst aspiring to include both perspectives, our agenda rebalances towards the latter.

Secondly, the agenda presented here has clear implications for how research on smart consumption could be evaluated more effectively by incorporating metrics and indicators that relate to political analysis, engagement with individuals and collectives, theoretical development, diversity and attention to marginalised places and people. We thus hope to see equal and early integration of SSH research in joint SSH-STEM research projects and an equal number of SSH-led and STEM-led teams.

This integration has the potential to create better solutions for a decarbonised and just future, as envisaged through international ambitions such as the Sustainable Development Goals. Indeed, smart energy technologies are also an excellent example through which to illustrate how wider societal issues relate to technological innovations and their subsequent politicisation. This agenda thus has applications well beyond energy.

Finally, the shifts this agenda represent are timely as climate and energy crises deepen. As SSH scholars we have seen change in the funding landscape, and increasing support voiced for the integral nature of socially informed research. Nevertheless, it is vitally important that such research is dealt with in a non-superficial way, and are not the first items to be cut when budgets are tightened.

From a contemporary SSH perspective, the three shifts we have found are increasingly self-evident as being needed – indeed future studies could explore how participatory processes aimed at consensus building might preclude the inclusion of more radical ideas – however, this is part of the point we wish to make. Despite the decades-long history of energy-SSH research, the shifts that we recommend have not yet been made in 'mainstream' research agendas. Engagement with these shifts should therefore be seen as a requirement for any serious research programme that seeks to avoid 'tokenistic' approaches to SSH and instead aims to solve the pressing societal challenges at the heart of energy transitions.

CRediT authorship contribution statement

Rosie Robison: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Project administration, Writing – original draft. **Tomas Moe Skjølsvold:** Conceptualization, Data curation, Formal analysis, Investigation, Writing – original draft. **Tom Hargreaves:** Formal analysis, Investigation, Writing – original draft. **Sara Renström:** Formal analysis, Investigation, Writing – original draft. **Maarten Wolsink:** Formal analysis, Investigation, Writing – original draft. **Emily Judson:** Data curation, Investigation, Writing – original draft. **Viera Pechancová:** Data curation, Investigation, Writing – original draft. **Melike Demirbağ-Kaplan:** Investigation, Writing – original draft. **Hug March:** Investigation, Writing – original draft. **Johanna Lehne:** Data curation, Investigation, Writing – review & editing. **Chris Foulds:** Conceptualization, Methodology, Funding acquisition, Project administration, Writing – review & editing. **Zareen Bharucha:** Methodology, Writing – review & editing. **Liliia Bilous:** Investigation, Writing – review & editing. **Christian Büscher:** Investigation, Writing – review & editing. **Giuseppe Carrus:** Investigation, Writing – review & editing. **Sarah Darby:** Investigation, Writing – review & editing. **Sylvie Douzou:** Investigation, Writing – review & editing. **Mojca Drevenšek:** Investigation, Writing – review & editing. **Bohumil Frantál:** Investigation, Writing – review & editing. **Ângela Guimarães Pereira:** Investigation, Writing – review & editing. **Andrew Karvonen:** Investigation, Writing – review & editing. **Cecilia Katzeff:** Investigation, Writing – review & editing. **Maria Kola-Bezka:** Investigation, Writing – review & editing. **Senja Laakso:** Investigation, Writing – review & editing. **Gudrun Lettmayer:** Investigation, Writing – review & editing. **Yael Parag:** Investigation, Writing – review & editing. **Fanni Sáfián:** Investigation, Writing – review & editing. **Mariusz Swora:** Investigation, Writing – review & editing. **Lise Tjørring:** Investigation, Writing – review & editing. **Ellen van der Werff:** Investigation, Writing – review & editing. **Bas van Vliet:** Investigation, Writing – review & editing. **Grégoire Wallenborn:** Investigation, Writing – review & editing. **Annemie Wyckmans:** Investigation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

We have shared links to our data in the manuscript

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