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Putting visions in their place: responsible research and innovation for energy system decarbonization

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ABSTRACT

Decarbonizing energy systems is an ambitious sociotechnical project, and will have significant implications for social justice, given the increasing dependence of societies globally on energy services. Eliciting non-expert values and perspectives to help reflect on the desirability of visions of socio-technical change has long been promoted within RRI. However, RRI has focused on specific technological proposals and visions, and not encompassed socio-technical systems. Decarbonizing energy requires systemic change involving socio-technical configurations that will vary depending upon geographical constraints and community needs in their host locations. Our case study from Wales, UK shows how findings from interpretative risk research and scholarship on energy and everyday life can help design upstream participatory processes that address simultaneously systems, effects on place, and everyday life. Engaging community residents through community mapping explores these dimensions of energy transition, enriching and enlarging understandings of both local and systemic aspects of the energy transition.

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Introduction

Decarbonizing energy systems (power, heating, and transport) globally is essential to reaching 'Net Zero' goals derived from the 2015 Paris Declaration. Technological innovation will be needed, but must also be accompanied by broader socio-technical regime change. Visions of future decarbonized energy systems often include processes in which societies move away from centralized, fossil fuel-based one-to-many energy systems towards increasingly decentralized, many-to-many systems based on renewable energy (RE) production assets distributed across many sites (Groves et al. 2021).

Such visions also often frame the transition as requiring urgency, sometimes invoking a 'climate emergency'. Transnational, national and sub-national governance actors have all engaged with the theme of transition in these terms (Ruiz-Campillo, Castán Broto,

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and Westman 2021). Reflecting this language, policy actors have announced a range of nearer-term staging points on the road to 2050. The UK Government, for example, has affirmed its goal that by 2035 'all our electricity will come from low carbon sources' (UK Government 2021, 94). In Wales, the devolved Welsh Government has recently announced a goal of replacing gas-fired central heating with low carbon alternatives by 2030 (Hayward 2021). Some argue that by framing action in terms of urgency and or emergency, visions for energy system decarbonization risk creating a state of exception in which potentially significant consequences for global social and environmental justice are not subjected to adequate oversight (Hulme 2019), reflecting earlier critiques of streamlining in planning governance reform (Cowell and Owens 2006).

As a counterweight to this tendency, upstream reflection (Wilsdon and Willis 2004) on the potential societal implications of such programmes has been called for (Skjølsvold and Coenen 2021), given that accelerating the pace of change may risk unanticipated consequences, perhaps even reinforcing societal assumptions (such as the overriding importance typically accorded to GDP growth) that may undermine efforts to tackle global heating. As examples of such upstream work, RRI approaches have been developed for individual energy decarbonization demonstrator projects (Koirala, van Oost, and van der Windt 2018). RRI has not, however, generally been employed in relation to more systemic visions of change. Partly this is because, apart from a few counterexamples (e.g. Pidgeon et al. 2014; Demers-Payette, Lehoux, and Daudelin 2016; Nulli et al. 2018), the appropriateness of RRI approaches for evaluating broader socio-technical regime change, as contrasted with specific technologies, has not been explored. Particular complexities are associated with energy system transition. Regime change is often represented as being dependent on demonstrator projects sited in specific places and communities. Such socio-technical niches are not just experiments in a technical sense. They are also experiments with everyday life, insofar as they recruit end-users with diverse needs and capabilities to take part in them. RRI is often thought of as enacting reflexivity towards the priorities and values embedded in innovation proposals as well as towards their potential risks and benefits. Given that energy regime change implies transformation of place and everyday life, there are multiple levels at which such reflexivity needs to operate, in addition to reflection on system-level implications (Cohen, Stilgoe, and Cavoli 2018, 260–261).

If we accept this is so then it is necessary to determine whether standard approaches to eliciting public values used in upstream RRI approaches are adequate to address these separable but interlinked levels, and if not, what kinds of approaches may be preferable. In this paper, we first show how standard approaches do not take account of important literatures which ground some key sociological approaches to place and everyday life. Second, we present a case study associated with the FLEXIS project (http://flexis.wales) based in south Wales, UK. This shows how an approach to values-elicitation appropriate for energy system transition can be developed, combining multiple interlinked qualitative methods. We show how this methodological innovation reflects the multidimensional implications of energy regime change, drawing on interpretative risk research, scholarship on place, and research on energy and everyday life. This approach, we demonstrate, avoids realist assumptions about what value elicitation 'reveals'. Instead, we show how an interpretivist and broadly constructivist approach to RRI can help enrich understandings of the place and social contexts in

which regime change will play out. The product of such an approach is a set of insights into how the complex interdependencies that characterize energy regimes may change, which can serve as substantive social intelligence for potentially-affected communities and policy actors alike.

Conceptual section

Technologies are always more than just 'equipment'. The 'objects' of reflexivity in RRI have been identified as 'future socio-technical configurations' (Grunwald 2020, 100), given that technical systems are embedded within socio-technical regimes comprising regulatory mechanisms, values, practices and beliefs alongside equipment, devices and infrastructures. Further, the fact that these configurations are anticipated and not actual means that RRI often operates upstream of realized change (Wilsdon and Willis 2004), and often at an early stage of research and development, in advance of deployment or emergent social controversy (Pidgeon and Rodgers-Hayden 2007). Consequently, RRI's objects are often ex ante representations of potential socio-technical futures, i.e. shared visions or socio-technical imaginaries (Jasanoff 2015).

Given that such envisaged futures are social and technological, and are surrounded by significant uncertainties deriving from both these aspects, more than technical and ostensibly predictive forms of expertise such as risk-cost benefit analysis are required to help understand their potential implications. Grunwald (2014) argues that making sense of the wider significance of socio-technical visions is an interpretative process, which requires a variety of forms of knowledge to enlarge and deepen the context within which the implications of visions and their inherent biases are understood. Such inputs should include specialist knowledges relating to how socio-technical systems operate and prospective forms of knowledge that delineate potential states of such systems (including for example risk-cost benefit analysis). But they should also include hermeneutic knowledge (relating to the social contexts in which technologies will be embedded) and normative knowledge (which relates to how to ethically evaluate potential gaps between aspirations and possible outcomes).

RRI has been interpreted as resting upon principles such as anticipation, reflexivity, inclusion and responsiveness (Stilgoe, Owen, and Macnaghten 2013). Hermeneutic and normative knowledge can therefore be seen as widening the lens of anticipation, increasing reflexivity, as well as requiring greater inclusion. They mean that the desirability of socio-technical visions can be assessed in relation to a wider set of values, priorities and purposes. However, there are important distinctions to be made between different 'species' of socio-technical visions that may influence what kinds of hermeneutic and normative knowledge become relevant. For example, visions of energy system decarbonization differ in crucial respects from visions of, say, nanotechnology-based molecular engineering or synthetic biology. First, the socio-technical configurations that are constitutive of visions of energy decarbonization are dependent on being sited in specific places, and may themselves reflect differences in socio-geographical conditions between particular places (such as rural and urban locations nation). Second, and given these characteristics of energy system visions, questions arise regarding who should be included, what contexts hermeneutic and normative knowledge should encompass, and how they can best be engaged with as part of RRI processes.

We need to unpack further these two observations. First, it is evident that visions of decarbonized energy systems feature changes to established socio-technical regimes that will unfold at multiple, simultaneous and overlapping spatial scales (Skjølsvold and Coenen 2021, 3). They may employ technologies that may not be currently seen as speculative or radically disruptive in themselves, although they may involve ones which are currently the subject of research rather than commercial deployment. Visions themselves may be radical or disruptive, however, to the extent that they represent regime transitions that depict the transformation of centralized, fossil fuel-dependent generation into more or even totally decentralized regimes dependent on distributed renewable energy production (Bakke 2016).

The central dynamic of change within these visions is not technological, but organizational – focusing on how energy supply and demand are balanced against each other. In fossil fuel-based regimes, this system flexibility is provided by bringing online or taking offline centralized dispatchable energy generating assets, such as coal and gas power stations. Transitioning to a regime based on distributed generation is often seen as requiring a complete change in how this flexibility is provided (Blue, Shove, and Forman 2020; Thomas, Demski, and Pidgeon 2019). Decentralized flexibility in a regime based on distributed renewables is typically depicted as depending on localized configurations of smaller distributed generation (DG) assets together with storage infrastructure. This is envisaged as allowing flows of energy to be managed dynamically across local, regional and national distribution networks (Groves et al. 2021). Place (including geography) thus represents an important part of the context in which the infrastructural networks of a decarbonized energy system will be embedded. What is possible and indeed necessary in one site might not be in another, with consequences for how wider systems are built.

Turning now to the second observation made above, it follows from the above-mentioned characteristics of energy system visions that an approach to inclusion somewhat different from standard approaches taken within RRI may be needed. The history of societal technology assessment affords examples of the assumption that 'the public' is composed of those citizens without an already-formed perspective on a given technology. In 2003, experiments in inclusive participation were undertaken in the UK as part of the 'GM Nation' consultation regarding genetically modified food. Activist groups were seen by some commentators as potentially capturing or subverting the consultation (Irwin 2006, 311–312). Legitimate participants were assumed to be members of the public with 'lay knowledge' that did not however should include any familiarity with the technology in question.

STS scholars have argued, however, that defining a legitimate public as 'innocent' of socio-technical 'matters of concern' (Latour 2004) is problematic. It cannot be assumed that 'engagement' with such matters can or indeed should be a discrete, formalized event for which engagement professionals or academics can act as gatekeepers. Engagement with technologies, both practical and reflective, can be seen as constitutive of everyday social life more generally (Michael 2015), creating in some cases frictions through which private troubles with technologies can mesh with or unfold into broader debates, and even controversies, shaped by discourses shared through social relationships and the media. Thanks to these engagements in which people are always already involved, participants in technology assessment inevitably bring perspectives on the potential implications of socio-technical change to the formally constituted

arenas in which it is staged. Documented examples include how high level narratives about technology in general shape responses to particular technologies (Davies and Macnaghten 2010) or public values which represent high-level concerns about socio-technical regime change (Butler et al. 2015). As a result, some researchers have argued that acknowledging and understanding participants' pre-existing 'proximal' engagements with technologies allows for engagement activities to be designed in ways that use this enriched social context productively (Macnaghten 2017).

In other words, technologies in general represent elements of social life that people are already engaged with, even if only indirectly: '[p]eople come to the issues through particular things that matter to them' (Macnaghten 2003, 80), which can include other matters of concern (such as the environment, global inequality, and so on). Experiences and knowledges linked to foregoing engagement with technologies and to wider issues can then be taken to represent relevant sources of Grunwald's hermeneutic and normative knowledge.

When it comes to energy system transition, the 'things that matter' which may be relevant to assessing their potential implications are influenced by the spatial aspect of decarbonization. Transformation of the organizational logics of energy regimes depends, as we noted above, on what socio-technical configurations are fitted to specific places. What is more, energy systems are reliance systems (Schafran, Smith, and Hall 2020), insofar as people depend on them as support for many essential capabilities and everyday practices. Consequently, citizens, being thoroughgoingly dependent on energy systems, are inevitably always already engaged with energy systems and what happens to them, and not only as consumers of energy services such as heating and lighting. They are intimately involved in everyday life with them as citizens with caring responsibilities (Groves et al. 2016), and also as citizens with political interests (Parkhill et al. 2015). Further, their involvement with them is additionally located at the level of place and community (Walker et al. 2011), via perceptions of polluting, hazardous or intrusive infrastructure and their understandings of the history of places.

Researchers have thus therefore argued that engaging citizens with visions of energy system change needs to acknowledge these aspects of the context in such change will be embedded. Bodies of scholarship which investigate the hermeneutic and normative knowledges people use to make sense of such contexts are found in interpretative risk research and qualitative investigations of energy use in everyday life (Groves et al. 2016; Henwood et al. 2011). Together, these disciplines have studied the ways in which people are already engaged with socio-technical energy regimes through relationships of dependence. Through these relationships are often manifested significant inequalities, both in terms of access to energy services adequate to support essential capabilities (Middlemiss and Gillard 2015), and in terms of differential exposure to hazardous and/or polluting infrastructure (Newell 2005). Consequently, regime transformation has implications for such structural inequalities, which position citizens as subjects concerned with justice and injustice as well as consumers of energy.

Societal assessment of energy transition visions would therefore benefit from encompassing particular extended communities of experience (Goodin 1998, 543) in its definition of 'the public'. It can then benefit from hermeneutic and normative knowledge of the different sites and contexts of energy regime change. But, as STS scholars studying the social career of participation have argued, we might then ask to whom these benefits

might accrue? There are important criticisms to be made of the ways in which discourses of participation may simply enact consultative mechanisms that become part of the legitimatory apparatus of dominant political rationalities (Moini 2011). The political effects of engagement, and particularly of bringing certain proposals and not others before selected, invited publics, have been much debated in recent years (Chilvers and Kearnes 2015). In addition, the dominant focus within participation discourse and practice on formal, invited participation tends to exclude conflict, protest and other 'uninvited' forms of engagement with socio-technical change from consideration, despite their being rooted in communities of experience and interest (Cuppen 2018).

However, uninvited participation tends to build on previous engagements of various kinds in response to some concrete proposal. Such proposals may concentrate concern, which may lead to the emergence of groups with particular identities tied to defending places or promoting particular alternative proposals (Callon and Rabeharisoa 2008). Where visions are not in general circulation, but nonetheless frame problems of general concern along with specific socio-technical solutions to them, upstream participation can therefore bring such visions into wider circulation as an 'early warning', with the alternative being that citizens may not be able to directly engage with these visions until innovation actors have established on their own terms whether these visions are desirable or not.

Nonetheless, some reflection is required regarding just what is being done by participatory processes which aim to elicit wider perspectives on 'what matters' in relation to socio-technical visions. If it is accepted that invited, upstream participation has a legitimate role to play within a broader 'ecology' of participation (Chilvers, Pallett, and Hargreaves 2018) as a means of value elicitation, it cannot be maintained that what an approach achieves is simply to reveal what public perspectives really are. If, as in the case of protests, engagement between citizens and visions results in the co-production of matters of concern and specific collectivities, then participation should perhaps be regarded as a constructive endeavour which cannot do other than help to produce a (perhaps temporary) public for some socio-technical configuration. It can do this by drawing on participants' experiences and understandings of the context(s) in which socio-technical transformation will unfold.

Recognizing that people come to participation via 'things that matter' and indeed making use of this route to engagement allows citizens to engage with technical information with which they are presented in terms that reflect their own relationships with technologies. Participatory methods can therefore be understood as 'using artifice to craft experience, to accumulate experiences and turn them into expertise applicable to the benefit of others' (Beck 2015, 10), rather than simply revealing what people think. Developing engagement methodologies for the contexts and issues we are concerned with her should aim support participants' capability to articulate familiar contexts as resources for making sense of the broader implications of socio-technical change, creating a temporary space in which diverse conscious or tacit forms of engagement with technologies are brought together in co-productive activity. It follows that it cannot therefore simply be assumed beforehand where the boundaries of the object of reflection and assessment actually lie. For example, what might be included within the concept of 'energy system' or the socio-technical configurations described as part of visions of energy transition may well, as part of participatory activity, come to overflow across other social realms and contexts (Chilvers, Pallett, and Hargreaves 2018).

These conceptual and methodological considerations are reflected in our research, conducted by the social science team working on FLEXIS. We developed for this project an interpretivist approach to engagement and values elicitation able to encompass place, everyday life and system dimensions of socio-technical transition, as discussed above. We now set out the approach we took, highlighting how it responded to the issues identified above and what aspects of it could be considered novel developments in values-elicitation for RRI.

Methodology

The proximate aim was to engage publics with potential energy system decarbonization pathways in the industrial town of Port Talbot (PT) in south Wales. PT has been identified by FLEXIS as a site for the development of linked demonstrator projects. The project vision is to use these demonstrators to explore what forms flexible energy systems based around DG may take, both in locations with specific place characteristics and in general. The research took place across two phases. The first of these used an STS-based analysis of interviews with FLEXIS engineering experts and project partners to construct four socio-technical scenarios for PT. The second undertook multi-methods workshops with PT community members to explore the implications of these scenarios for the energy system, and for everyday life within PT.

Expert interviews

Socio-technical visions or imaginaries represent 'collectively held, institutionally stabilized, and publicly performed visions of desirable futures' (Jasanoff 2015). To explore the contours of visions of energy transition, we undertook 20 semi-structured expert interviews. Interview schedules reflected Bogner and Menz's (2009) concept of the theory-generating expert interview and the problem-centred interview as described by (Heaslip and Fahy 2018). These approaches detail how expert interviews can explore implicit knowledge (e.g. of logics of change or conceptions of publics) among specialists. Such approaches can be viewed as transdisciplinary, insofar as they do not assume what the definitions of key problems addressed by socio-technical change might be. Instead they set out to actively define what is at stake in socio-technical change through collaborative work between an interviewer with some knowledge of a specialist technical area and a specialist interviewee.

Our interviews explored socio-technical visions for demonstrators, including the problems which experts saw them as helping to solve, how different innovation actors might coordinate to realize them, and what wider unintended consequences could follow. Interviews were then transcribed and analysed using a qualitative thematic approach informed by grounded theory (Henwood and Pidgeon 2003), reflecting multi-level perspectives on socio-technical systems (Geels 2005; Schot and Geels 2008). From this analysis, several distinctive potential trajectories for the energy system in PT were mapped out.

Energy transition scenarios and community workshops

Our interpretivist and constructivist approach to designing engagement activities was reflected in three stages of development and implementation.

First, based on analysis of expert interviews, we constructed socio-technical scenarios for the future of the energy system in PT. PT hosts the largest steel plant in the UK and other industry which represent particular challenges for decarbonization (Davis et al. 2018), as well as featuring popular recreational and tourist sites (Aberavon Beach and Margam Country Park). Scenarios were informed by National Grid's Future Energy Scenarios (National Grid, 2017) and drew on expert interview data, distilling four distinctive socio-technical configurations. Carefully constructed socio-technical scenarios can, 'by painting portraits of future worlds' invite scenario users 'to systemically consider values, societal regimes, governance patterns and culture' (Withycombe Keeler et al. 2019, 262). Scenarios can therefore, by painting such portraits, help mobilize reflection by participants on past experiences in order to inform reflection on possible futures.

Scenario development mirrored Schwartz's (2012) 8-step development model. We used interview data to identify drivers and scenario logics (or plots), enabling us to construct timelines for the scenarios out to 2040. To develop plots, we identified loci of dissensus (Groves et al., 2021) within expert interview data. These represented the ways in which interviewees described divergent constellations of power and heating infrastructure. Particular technologies were identified from interviews as linked to such constellations, and regulatory, social and economic aspects of the scenarios added in, with news reports and social media snippets being added to timelines to dramatize key developments.

Having four scenarios was considered optimal, to avoid potential biases associated with using fewer or more than this number (Groves 2013). Sense-checking of expert interview analysis was undertaken with interviewees and other FLEXIS engineering colleagues at a reflective workshop convened for the purpose, and specific engineering colleagues involved in relevant demonstrator projects conducted additional reviews of their content and gave feedback, which enabled us to fine tune the scenarios.

The second step was to develop workshop activities, treating the scenarios as 'skeletal' maps of future possibilities, which would be explored, fleshed out and questioned through these activities. We aimed to develop activities based on participatory mapping and imaginative world-building approaches for these purposes (Vervoort et al. 2015). We sampled participants on the basis of their substantive connections to the town, aiming with the aid of a locally-based recruiter to create several individually homogeneous (Pidgeon 2021) workshop groups, each with specific 'proximal interests' in the community and thus with different experiences of life in the town (Macnaghten 2017). For example, to work with experiences of societal change in the town across several decades, we asked the recruiter to provide a sample of residents with several generations of family in the town (see Table 1 for a list of workshop groups).

Following this purposive sampling, we conducted interviews with each invited participant, investigating experiences of everyday energy use as well as inviting them to undertake a participatory mapping task to prompt 'reflection on the ways in which scenarios for socio-technical change may relate to lived experience and linked lives' (Shirani et al. 2015). In this task, they were asked to annotate a map of PT with coloured stickers to identify locations that they felt fell into specific emotionally-resonant categories (see Figure 1). Participants were also asked to bring along printed or digital photographs of places in the town they felt to be significant which were also discussed in relation to the map.

Table 1. Port Talbot workshop groups.

Group and abbreviation used in text	Description
Multi-generational residents (MG)	People from families that have lived in PT for at least three generations
Steelworkers (SW)	People now/formerly employed on the Tata Steel site, either employees or contractors.
River users (RU)	People who use the River Afan and the pathways along it for leisure activities (e.g. angling, boating, walking).
Young professionals (YP)	People under thirty years old in employment or training, particularly in IT-related roles.
Green-fingered residents (GF)	People involved with horticulture, either in private gardens or in allotments or community gardens

The third step was to hold the workshops themselves. The team convened a series of five, seven hour long workshops, each with 6–8 community participants, at a community centre in central PT from May – September 2019. Each event comprised a morning and an afternoon session, divided into a total of five activities. Before each workshop, positions of stickers and annotations on each map completed by a participant from that group were aggregated on a master map, together with photographs that participants had provided. Open discussion of the maps broke the ice, but also allowed the group to create an initial frame of reference for the day based on their own experiences of living in the town, which manifested commonalities and differences in how people defined significant places as well as the main issues they saw as salient within the town. The exercise aimed to construct a shared 'world' comprising recognizable features

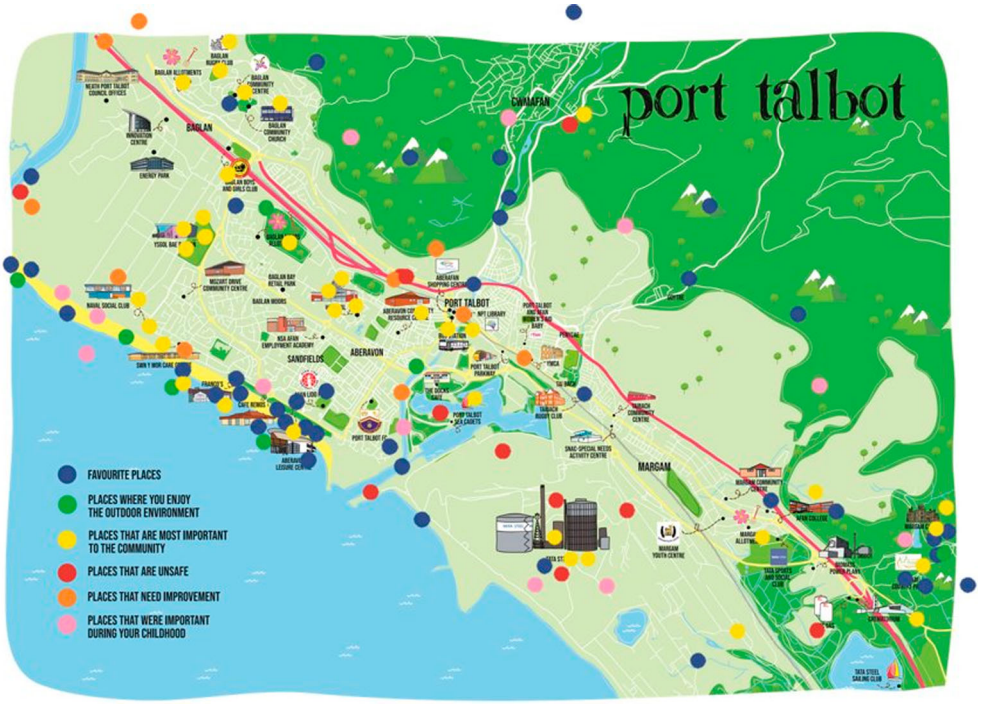

Figure 1. Example of completed map from mapping task.

of PT which would subsequently enable participants to engage with the four scenarios on terms they themselves had participated in defining (Macnaghten 2017).

Following this activity, participants were invited in a second activity to draw one or more aspects of the energy system (production, distribution, consumption for power, heat, transport) as they pictured it to themselves and discuss how these aspects related to their everyday experience of living in the town – e.g. energy production with wind turbines, such as those sited on nearby high ground at Mynydd Brombil and easily viewable from within PT.

Next, in a third activity, participants were divided into two groups and introduced to the materials, including timelines, news reports and social media extracts, for each scenario in turn, and invited to ask and respond to questions about them.

In a fourth activity, participants were invited to develop imaginary personas to represent inhabitants of PT in the years 2035-40. This activity maximized opportunities for participants to draw on their own and shared experiences of life in the town, including those recounted earlier in the day, to add content to scenarios by fleshing out accounts of everyday life and how it might differ from the present [AUTHOR PAPER]. Personas enable participants to bring personal experience to bear without necessarily requiring personal disclosures to be made, realizing a certain distance that allows playful and creative engagement with potential futures, making it possible to gradually incorporate situated experiences and relationships into reflection upon the socio-technical artefacts provided by the team. Via a prompt sheet, participants were encouraged to provide narratives about the daily activities engaged in by their characters and the challenges they might face. The value of detailed and carefully prompted narratives as a means of eliciting complex and emotionally-weighted values relating to place and everyday life has been identified by qualitative researchers, given that such values 'are inherently difficult to express as declarative statements' (Satterfield 2001, 336).

Building on the common world constructed through the mapping exercise discussion, the personas task thus represented a further extension of worldmaking. By focusing on characters with imagined lives, participants were able to reflect on how socio-technical change might reshape mundane practices and everyday beliefs, social structures and technologies, economic relationships and political institutions (Vervoort et al. 2015). By creating concrete characters within a context in which participants had already positioned themselves together earlier in the day, this presented an opportunity for participants to further develop the four scenarios by reflecting on links between local issues and challenges, and the socio-technical configurations featured in them. Finally, the day ended with a fifth activity, in the shape of a facilitated group discussion.

Overall, then, each workshop was structured to allow participants to define their engagement with the scenarios as much in their own terms as possible and to further articulate the scenarios using their own knowledge of life in PT (hermeneutic knowledge) before reflecting on the normative (ethical and political) implications of the socio-technical configurations they had participated in describing.

Audio recordings of interviews and workshops were transcribed, anonymized, and then analysed using a NVivo 12 and a qualitative thematic approach informed by grounded theory. The research team began analysis from the broad thematic concerns arising in the transcribed data, guided by themes related to the embeddedness of

energy systems in place and everyday life identified earlier. Subsequent close readings of the data identified and coded for emergent detailed themes (Henwood and Pidgeon 1992).

Findings

Expert interviews

Socio-technical visions articulated by FLEXIS experts challenged the emphasis of previous waves of UK RE development on simply stepping up energy production. By extensive deployment of onshore and offshore wind, alongside solar and other sources, the amount of renewable electricity produced in the UK, and in Wales specifically with its high levels of wind resource, was increased substantially in the first two decades of the twenty-first century. Driven by EU targets for RE production as well as UK legislation like the Climate Change Act 2008 which set out legal targets for GHG reductions, this strategy was seen as ensuring an incremental rather than disruptive energy transition: 'part of the argument in those earlier days of the establishment of the wind electricity industry was we're not going to cause problems with the system' (E[xpert] 20). Ironically, however, this strategy had indeed created disruption within the system, which had incrementally grown in scale until it represented major challenges for the transition.

Experts insisted that what had been lacking in this period had been a comprehensive high-level strategy for overhauling how energy is distributed as well as produced. Building increasing levels of DG had produced a situation where limited grid capacity – especially in rural locations in Wales where wind resource was most available – meant that expanding RE production further for power, heat and transport faced development bottlenecks, a problem encountered not only in Wales but elsewhere in the UK and indeed in Europe (O'Keeffe & Haggett, 2012).

Overcoming these capacity issues was seen as being dependent on how energy flows across transmission and distribution grids were managed. This would entail a shift in socio-technical regime, away from the kinds of grid management required within a centralized system and towards new infrastructural and regulatory configurations. As noted earlier, decentralized systems require different ways of flexibly balancing demand and supply. Experts observed that without such a regime shift the energy transition faced 'real fundamental problems' deriving from a lack of grid capacity and a lack of infrastructure to enable surplus electricity to be stored in the shorter term but also interseasonally (E10). The energy system was generally seen as requiring both reinforcement of transmission and distribution grids to provide a 'backbone' for the system, alongside greater localization of production and storage alongside demand-side measures such as widespread use of smart meters to provide constantly updated data on changing energy usage.

> I think in the future it's going to be much more on a local scale because you're going to be generating locally and then it's those neighbourhoods need to … it's a bit like back to your ant colony I guess or something like that or a beehive right? (E6)

At system level, the future trajectory of the energy transition was seen as continuing a process of electrification of power begun with the earlier waves of RE development. At the same time, the shift in sociotechnical regime from centralized to decentralized was

seen as requiring solutions to be developed for energy storage, as well as heating and transport. In all these areas, other energy sources and vectors other than electricity were seen as having a role to play.

The strategic development of 'flexible fuels' (E5) such as hydrogen and ammonia was seen by many interviewees as a key step in the longer term for interseasonal storage solutions and for decarbonizing transport. Further, production of hydrogen (e.g. via steam methane reforming together with carbon capture, utilization and storage [CCUS], and in the longer term, via electrolysis from excess renewable electricity) was viewed by some as a way of decarbonizing the heating sector without disruption to domestic and business end-users, as existing pipelines and boilers (with modifications) could be used: '[the distribution network operators/DNOs] are very interested in how they can decarbonize gas grids […] these guys are the perfect people to be running a hydrogen network' (Expert 10). Another driver identified as being behind the localization of energy systems was that, should energy production, distribution and storage increasingly become scaled to more local levels, different solutions might be required in specific locations. Battery storage in some localities may be more suitable than hydrogen or vice versa; electric heating, utilizing heat pumps, may be suited more to rural locations, and district heating networks may be suited to urban areas. In addition, the value of '[converting] from natural gas to hydrogen' (Expert 9) was associated with decarbonizing steelmaking in ways favoured by both industry and the Welsh Government (concerned about the Tata-owned steelworks at Port Talbot which is responsible for over 10% of Wales' carbon emissions).

Many interviewees were significantly concerned at how both communities and everyday life might be disrupted over the course of the energy transition. Given the number of deprived communities in rural areas and the post-industrial south Wales Valleys, the potential costs and benefits of transition and how they might be distributed equitably was a topic many mentioned, particularly in the case of communities hosting demonstrator projects. Some interviewees saw a risk that 'we're gonna be leaving them in the same position or even a worse one than they're in but having gone through a lot of disruption' (E2). Experts tended to view people's thoroughgoing dependence on the energy system as a motivation for maintaining continuity as far as possible with the current centralized regime and its governance, in order to avoid making life costlier or more difficult. At the same time, some saw positive potential in following a more disruptive trajectory towards decentralization, given the ways in which increased decentralization might support more community participation in the energy system through ownership of energy assets, as this expert suggests:

> Say for example in Wales you have 20 or 30 different communities producing their own ammonia and that again can be seen as an entire committee of 30 communities distributing or providing ammonia to these massive power plants so in that sense they become suppliers to them and then play a nice part in the production of energy (E5)

Experts therefore tended to see disruption, whether framed negatively or positively, as an important aspect of the transition between distinct socio-technical regimes. They interpreted people's experiences of disruption as central to whether or not the transition might encounter resistance. In addition, they tended to associate the transition with a growth in employment opportunities, particularly in supply chains for decentralized

energy systems, replacing established patterns of relatively low-skilled employment with new opportunities for training and work.

The four scenarios developed by the team reflected key aspects of these broad future visions articulated by experts. One of these represented greater continuity with the current socio-technical regime, featuring alongside some localization more centralized production of electricity and also of hydrogen for heating. Others featured more divergence from the current socio-technical regime reflecting key aspects of socio-technical configurations discussed by interviewees. These included localized electricity grids with peer-to-peer sharing of locally produced energy, green hydrogen for energy storage and heating, and industrial waste heat for district heating. While none of these configurations necessarily mutually exclude any others, we determined in a workshop held with interviewees that the four scenarios represented four main distinct configurations with which the FLEXIS project is concerned (Table 2 and Figure 2).

Community workshops

As discussed above in Methodology, in order to allow participants to frame their engagement with the scenarios in terms they themselves defined, each workshop began by discussing a composite affective map of PT, constructed as an aggregate of the maps created by the individual participants in each workshop (see Figure 3 below).

Table 2. Key features of the four scenarios.

Scenario	Description
Grid Town	A largely centralized energy system, where electricity is still provided through the national grid. All electricity is from low carbon sources, such as large-scale wind, tidal, solar and nuclear power plants, with warehouse-sized assemblies of batteries that are used to store this electricity for use during peak times. Hydrogen heating is now used to heat all homes and buildings, which is produced via large-scale and centralized Steam Methane Reforming (SMR) processes and related Carbon Capture and Storage (CCS). Large utility companies still dominate the energy industry and smart metres in every home allow consumers to switch companies easily. However, the best deals (known as Time of Use Tariffs) are only available to those who can adjust their energy use to times of peak wind and solar energy production.
Energy Island	A decentralized energy system, where Port Talbot is largely separate from the national grid and all electricity for the town is produced by local renewables such as solar and wind. Hydrogen heating is now used to heat homes and buildings. Excess electricity is used to make hydrogen locally from water via electrolysis, with hydrogen gas holders around the town used to store this. Electricity and gas bills are still a part of life but people in Port Talbot now buy their energy from one of several local suppliers rather than the national grid.
Industrial Hearth	A decentralized energy system, where the local council and industry have taken far more control over energy generation in the town. Waste heat from industrial sites (including Tata Steel) is now used to provide heating to homes and businesses through a district heating system. Most electricity is generated locally by solar panels and wind turbines on rooftops and in the surrounding countryside. Heat and power is supplied to consumers via one local energy company, a partnership between industry and the local council. Consumers can select from a range of energy service contracts for 'warm hours' and 'power services' that come with bundles of ultra-efficient appliance upgrades, new insulation or radiators.
Virtual Marketplace	A decentralized energy system, where all homes and businesses in Port Talbot now trade surplus electricity with each other via peer-to-peer energy trading. All homes now rely on electric heating via air source heat pumps, and many homes and buildings in the town also have their own solar panels and batteries. Homes without solar panels can still buy energy from their neighbours. Energy trading is controlled automatically by Home Energy Trading Systems in each home which can learn and adapt to the needs of the household. These AI systems will continually buy and sell energy to get the best prices for each home.

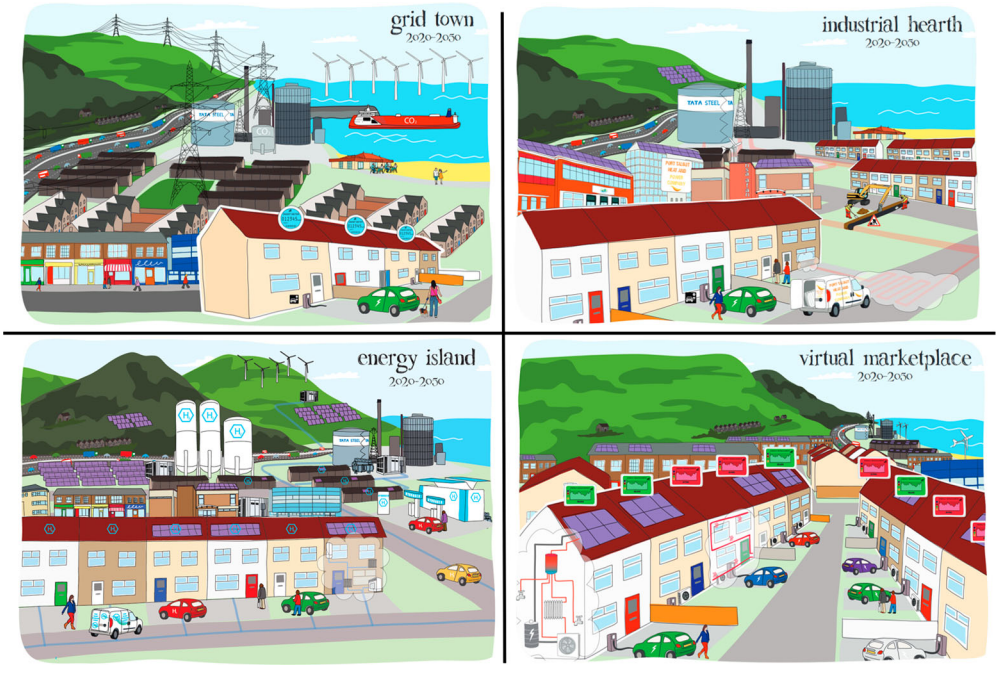

Figure 2. Pictorial representations of the four scenarios used in workshops: Grid Town (GT), Industrial Hearth (IH), Energy Island (EI), Virtual Marketplace (VM).

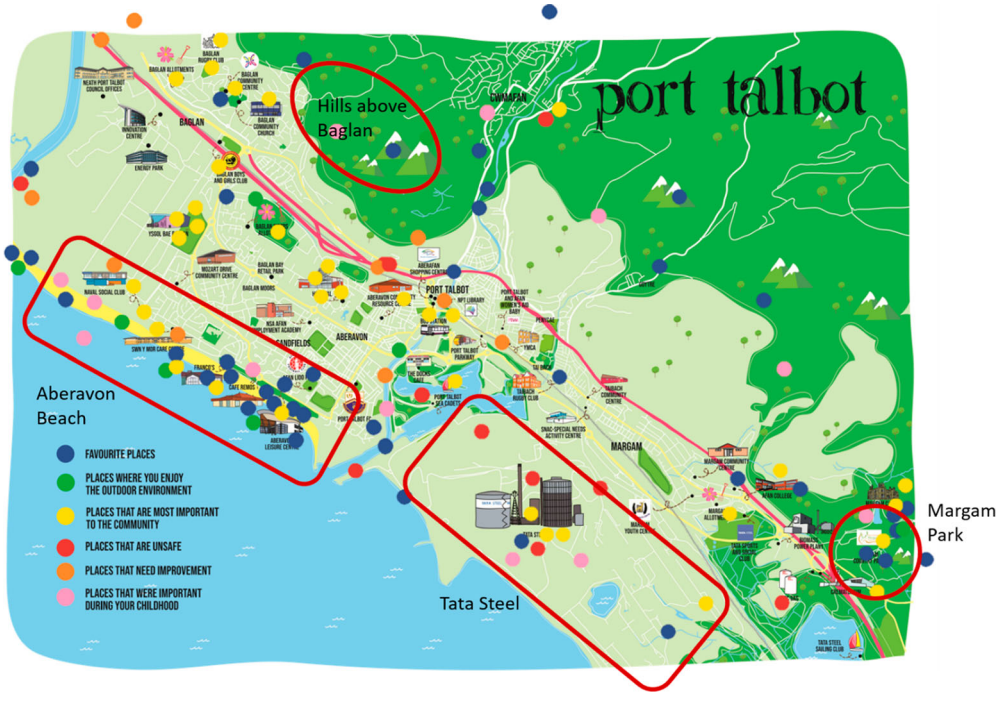

Figure 3. Example of community map which aggregates one group's individual maps, showing clustering of stickers.

Mapping task discussions

Drawing also on community participant interview data and participant photos of the town, parts of the town which were identified as particularly significant were ringed on the composite maps (Figure 3).

These clusters, as participants confirmed in initial workshop discussions, represented sites within the town that evoked strong negative, positive or markedly ambivalent emotional responses, and which were frequently depicted in the photographs participants brought with them. They included, among others, Aberavon Beach, Margam Park and the hills above Baglan, and the steelworks. The first three of these sites were seen generally as places which contributed significantly to quality of life in PT. In particular, the beach, '[t]he jewel in the crown' (Reggie, MG), which was identified as a consistent background to life in PT as well as often being foregrounded with significant emotional salience, serving as a setting for encounters with wildlife and nature, for communal leisure and family gatherings, and as the scene of important biographical moments, from teenage mischief to marriage proposals and babies' first days out.

These three sites were all seen as having been left for a long time with undeveloped potential. 'Margam Park […] is the most beautiful place in Port Talbot, we've got history as well. They [the council] just do not spend any money doing anything with it. It's such a waste' (Anne, MG). This theme often led people on to mention how other amenities within the town on which people depended for a basic standard of living had declined, alongside this unrealized potential: 'the majority of shops have gone. They're either derelict or they're charity shops … ' (Heather, YP).

Participants felt more ambivalent about the steelworks. People perceived the community as highly dependent for direct and indirect employment on 'the works' and also as having been shaped spatially and materially (and also in terms of outsiders' perceptions of the town) by the development of the works through decades of it being run by different owners: 'they built the infrastructure and tried to fit the people into [it]' (Emma, MG); 'the town is steeped in history of iron and steel and coal. And it won't change.' (Geoffrey, RU). Perceptions of the town more widely in Wales and elsewhere were felt to be negative, as a result of what people saw as stigma associated with heavy industry and attendant pollution. Many participants reported these perceptions were reflected in the epithet 'Port Toilet' (Anne, MG), which some saw as humorous and others as offensive. While the dependence of the town on the works was seen as deep and broad, it was also seen as precarious and uncertain, with many voicing doubts about the likelihood that the works would be still be a going concern in ten or even five years: 'I wish I could say that I'm 100% confident that it's going to be there, but there is a large part of me that is concerned that it won't' (Luke, SW).

Dependence on the works was therefore seen as a double-edged bargain, bundling together employment for a sizeable (yet also nonetheless shrinking) workforce with real, and not just perceived visible and invisible pollution: 'when you think about it, though, we're breathing that in' (Reggie, MG). Visible pollution was common in some areas of the town downwind of the works: 'the pink stuff that everybody's got on their windowsills and their washing' (Anne, MG). Less visible and more widespread effects of the works' emissions were also suspected, which people also tended to associate with other industrial employers like the town's former British Petroleum (BP) site: 'I

think cancer is a massive thing in Port Talbot' (Dai, GF). Such observations evoked a sense of PT as a 'faulty environment' (Irwin, Simmons, and Walker 1999), characterized by a variety of environmental problems that were also reflected in wider social and health issues.

Discussions of the aggregate maps thus highlighted a sense of interdependence between town and environment on the one hand, and town and industry on the other. While participants saw a strong and positive connection between wellbeing and valued natural spaces whose character had been preserved for decades, they saw the interdependence between town and large employers like the works more ambivalently and in some cases negatively. Indeed, for some this relationship between PT and industry was characterized by a fundamental inequality. The works' successive owners were seen as having always had a significant amount of power to shape planning and other agendas within the town for their own advantage, while also (and particularly since the site's acquisition by the multinational Tata) being committed to remaining within the town only insofar as the situation continued to offer them advantage. The sense that the company might, thanks to international economic developments, leave the town at any time led people to view the town's future as one of great uncertainty, tying the council – given the industrial heritage of PT – to offering incentives to keep the company there (cf. Marris 1996)

These initial discussions, framed through a collective and largely shared interpretation of key sites within the town via the mapping task, led in each workshop to specific ways of reading the scenarios with some key similarities across the five groups. Participants' comments tended to reflect themes of interdependence and dependence, exploring their positive, negative and ambivalent nuances, with a particular focus on how the energy transition might transform the modes of interdependence which they perceived as characterizing life in PT. The uncertainties which people felt would accompany such transformations, and how (or whether) they should be mitigated, were also a common preoccupation of all five groups.

Disruption and decentralization

In the initial phases of the scenario exercise, participants generally noted that three of the scenarios (EI, IH, WM) departed significantly from the dominant centralized, fossil-fuel based socio-energy regime. At this stage, residents tended to adopt a system-level perspective in articulating their concerns. A major focus of concern was on uncertainties interpreted as linked to the unreliability of systems that were seen as very different from participants' understanding of how a mostly centralized energy system works. Local hydrogen storage (EI), district heating (IH) and localized energy trading (VM) were all associated with greater unreliability.

By comparison, the less decentralized GT was interpreted as a system in which the key foci for innovation (such as CCUS) were located mainly elsewhere. Less extensive local change was expected, with whatever transformations did come being more incremental over coming decades, whether in relation to the electricity system (where reinforcement of the national grid to accommodate more renewables) or gas system (with largely centralized production of hydrogen replacing current supplies of natural gas). The main feature of this scenario people saw as evoking reliability was how it depicted life in the town as dependent on national energy infrastructure in a familiar way: 'there's a resilience in there' (Richard, GF).

EI and VM were especially seen as scenarios that were built around technologies that might lack resilience. With VM, the complexity of its infrastructure was seen as particularly problematic. One participant drew an analogy with vehicle maintenance: 'if it goes wrong, my old motorbike, I can take the whole lot apart and rebuild it in the shed whereas a modern car, I ain't got a starting point' (Richard, GF). Further, the need for high speed and high volume of automated home energy management system (HEMS, see Table 1) trading was seen as relying on algorithms that might lead to unforeseen and unpredictable consequences: 'they're not going to always make the right decision' (Emily, YP). With EI, concerns about resilience related mainly to balancing supply and demand, and how it could be affected by the cost of new infrastructure for producing, storing and distributing hydrogen: 'would you know how much storage of capacity of electric you would need from the winter months to the summer?' (Marcus, MG).

To some extent it can be said that participants associated more decentralized scenarios with uncertainty because of difficulties related to trying to understand scenarios that featured technological elements that were significantly different from familiar ones. At the same time, a lack of certainty cannot be attributed simply to these challenges. Residents saw the significant remodelling of relationships between energy system actors within these scenarios as a significant socio-technical source of uncertainty. In IH, for example, large scale and long term disruption was seen as an inevitable effect of building a district heating system, 'tak[ing] years to put [pipes] in, to dig up all the old gas network and everything' (Karl, RU), whereas with VM questions were asked about who would ultimately be accountable and responsible for the operational effects of the peer to peer system, and to what extent it could be meaningfully controlled. Decentralization raised the prospect for participants of PT 'going it alone' to some extent, which at this stage was seen as concerning (though many participants in the different workshops tended to change their view somewhat – see 'Interdependence and Transformation' below).

When workshops moved onto the personas task, the emphasis within discussions shifted as participants focused more on everyday life. At the household level, those with vulnerable residents (such as older people, people with mental illnesses, and people with learning disabilities) were expected be detrimentally and unequally affected by the introduction of new systems that might require users to interact with them in a more active way. 'I struggle with mental health issues. I think, my God, all this new stuff, I can't cope with … ' (Marcus, MG). In particular, HEMS were expected to place additional demands and responsibilities on end-users. Such impacts were generally expected to reduce to some extent over time as successive generations grew up with new infrastructure. But the extent to which systems requiring more active interaction might be redesigned to support more vulnerable households remained a central concern, particularly given estimates among participants of the numbers of elderly, people with mental health issues or long term limiting illnesses living in PT.

If the degree of interaction with new decentralized systems was expected to increase, how users paid for energy services was also expected to change – and also to bring challenges. In IH, a prepayment-based 'heat as a service' model (Sovacool et al. 2020) was described, in which a number of warm hours are paid for ahead of time, rather like talk minutes or data on a mobile phone contract. This was often seen as 'quite alien' (Jennifer, RU) and potentially as creating vulnerabilities. In discussion of some personas

people created, it was pointed out that household energy needs can fluctuate across the lifecourse, particularly for vulnerable individuals, making it difficult to predict what level of heating people might need. Disruption was therefore anticipated at system level, within particular places and within everyday life.

Interdependence and transformation

While participants registered concerns about disruption to system, place and everyday life in sharing reflections in small groups on each scenario, when the workshops moved on to the personas task, the focus of the future narratives people constructed increasingly fell on the character of the forms of dependence future inhabitants of PT might experience. 'Dependence' here implies more than dependence on the energy system alone. Instead the stories of personas people narrated dealt with the interdependence between economy, social relationships, environment and energy and how the four scenarios might involve interactions between these four dimensions.

For example, participants' responses to IH in the personas task saw economic and political dependencies within and beyond PT as very consequential for the district heating systems based on industrial waste heat depicted in this scenario. As discussed previously, participants often identified the town's economic dependence on the steelworks as a source of ambivalence. Despite reduced direct employment, the works still brought economic benefits to PT through its links to local businesses, yet reducing employment in the plant was counted as strong evidence of local deindustrialization and economic decline, pointing to an uncertain future: 'You shut the works, you shut Port Talbot.' (Gordon, SW).

Given this uncertainty, IH was seen by many respondents across all groups as creating a potentially harmful and destabilizing form of dependence for the community. The role of new actors, namely Tata Steel and the local council, in decarbonizing the energy system was viewed negatively due to their perceived lack of reliability and/or trustworthiness. For example, because people viewed Tata as a globalized company with interests in many countries and an interest therefore in cutting costs, they did not want PT to rely on it for provision of essential energy services such as heating. As mentioned previously, participants saw Tata as only tenuously anchored to the town. This lack of reliability was underlined for some participants by the situation of some vulnerable future personas they constructed. Commenting on a wheelchair-using character's experiences under IH in the 2030s, one participant noted that, while the IH district heating scheme might have benefits for vulnerable people (in contrast with GT or VM), it also meant the character was entirely 'reliant' on distant and untrusted globalized corporations, caught in a relationship characterized by a stark imbalance of power: 'there'd be a very large barrel they've [Tata] got the town over' (Richard, GF). Distrust of the local council was widespread and at times vociferous among the workshop groups, with much talk of 'corruption' (Harriet, RU) and 'backhanders' (Gloria, RU) in procurement and planning decisions. Consequently, IH was felt to combine a localized energy system with fragile dependence on unstable institutions.

The anticipated effects of other scenarios on interdependence were also significant. In the personas task, some participants assessed GT in terms quite different to the more positive perspectives reported above. While the socio-technical configurations central to GT were familiar and associated with reliability, the personas task saw more

ambivalent responses emerge. A number of participants pointed out it continued to base itself on forms of consumer choice (utility companies continued in the future to offer various tariffs, including cheaper time-of-use ones) that they valued: 'People want choice. I don't think people want to have no choice' (Claire, SW). At the same time, others pointed out that the existence of such a market would continue to enshrine existing power relations between consumers and distant utility companies, where 'the bigger companies have had control for so long now' (Emma, MG). A centralized system was associated both with some consumer autonomy but also with significant negative dependence.

When participants created personas for more decentralized scenarios, it was evident that, while these were often (as noted above) associated with systemic and local disruption and potential unreliability, they were often viewed more positively as a result of how they might reshape relations between the socio-economic system, everyday life, the environment and the energy system. Becoming more dependent on energy produced locally, without also being dependent on unreliable or untrusted actors, was seen as materially and symbolically significant. Participants often based such evaluations on a desire for more localized and community-based decision making, a desire which reflected their shared understandings of the past history of the interdependence of energy, community, environment and economy in Wales.

Particularly in south Wales, the history of coal extraction was seen as a symbol for how Welsh resources (including labour) had been exploited for the benefit of distant others (chiefly in England). This history was seen as having been repeated during the expansion of wind power in Wales, which increased the dependence of consumers within Wales on distant actors: '[a] lot of it goes out [of Wales] and other people benefit from it […] the control of it is from outside, so you've got less control, over where your energy's coming from' (Dai, GF). EI and to a lesser extent VM were seen as to some extent re-ordering, through decentralization, both power relationships within the energy system.

> 'I do like the fact that it [EI]'s all localised … Yeah, I prefer that if you're putting money into something, it will pay for you and be for the area rather than it be dispersed elsewhere … It's back-up isn't it, for any problems. At the same time there's more jobs if you keep them local … ' (Joey, YP)

With VM, some seized on the bottom-up, street-by-street mode of organization as promising potential for some kind of community control, in contrast with familiar individualistic visions of prosumerism as household ownership of solar panels etc.: 'something that's really powerful and you can work together' (Richard, GF). The prospect of communities entering the energy system as actors was interpreted by some as a revival of old forms of political-economic association familiar from life in the Valleys, such as cooperatives: 'cooperatives used to run a lot of the things […] now it seems to be big bodies are running us rather than us running ourselves' (Marcus, MG). Some participants questioned whether the energy trading mechanism depicted in VM, operating between individual households and businesses, could be regulated in ways that made it more solidaristic, reflecting their sense that life in Welsh communities had historically been more influenced by social-democratic norms than in England.

For example, excess energy produced by households, some suggested, could be pooled and donated to households facing a deficit, rather than just being traded in search of

profit: 'I would more than happily donate my excess energy as long as somebody will donate theirs back' (Jodie, SW). On this view, VM could potentially extend valued forms of collective agency beyond individual household autonomy, to shape what kind of energy economy (e.g. selling or sharing) households can participate in. Within the GF group, participants summed up the mode of energy production in ways which perhaps reflected their various interests in gardening and growing, as a localized and environmentally low impact 'harvesting' (Monica, GF) of energy that recognized and reshaped the interdependence between community, economy, environment and energy without rendering PT overly dependent on either unreliable industry or a mistrusted council.

Participants also saw significant drawbacks to localization of this kind, however. Transforming the energy system in ways that encouraged greater participation could exacerbate social inequalities and make them more visible in new ways. One persona was imagined as feeling 'like people are judging her' (Elaine, YP) due to her lack of solar panels. In addition, as localized energy systems were expected by participants to grow initially within and around towns like Port Talbot, rural locations (already less affluent) could suffer by comparison, with residents potentially deserting them for places with a more abundant local energy harvest: 'everybody'll wanna come down' [Sharon, RU]. The potential role for local energy companies in EI was seen as raising the problem of collusion between an untrusted council and unscrupulous operators. In one group this possibility was embodied manifest in the imagined persona of 'Dai Smart' (Gordon, SW) a disreputable tradesman selling and installing or overpriced faulty 'smart technology' to unsuspecting households. Some saw relations within particular localities in the town as potentially undermining the trust and cooperation that many felt would be needed to make scenarios like VM work: 'it'd be war, absolute war' (Elaine, YP).

An important additional perspective on decentralized scenarios which emerged in and after the personas task was how they might disrupt the tight link between Port Talbot's present and its industrial past, with broad and potentially beneficial consequences. EI, for example, opened up for some participants broader questions about the future of Port Talbot:

> […] because it's going away from how everything is now. It's moving towards something else, so in order to do that, you've got to create an infrastructure. To create an infrastructure, you've got to have plans and think about what you're doing and moving towards. (Dai, GF)

These questions touched on how decarbonization could reshape the political and economic life of the town.

> [IH is] really great but we are not Tata town, we are not the communist collective-based around a factory. We are a town in South Wales with lots of possibilities. So I think the Energy Island 'cos it takes ownership, they put the ownership on the town (Richard, GF)

EI and to a lesser extent VM were seen as offering the prospect of interrupting what many across the workshops saw as a downward spiral in the town's fortunes connected to a long process of deindustrialization. In particular, people in each workshop expressed aspirations for a new socio-economic trajectory and identity for the town, linked to the assets identified across the groups in the mapping discussions at the beginning of

each workshop, such as Aberavon beach, Margam Park and overlooked and unnoticed green spaces within the town. As a result, some participants began to sketch the outline of what might be termed a fifth scenario (Thomas et al., 2022), in which elements of the four energy scenarios were selected and presented alongside potential new uses of environmental assets to present a more rounded depiction of how interdependencies between community, economy, environment and energy might change.

> What it's suffered from is, I think, a lot of people who can't see beyond coal mining and steelworks as being proper jobs for proper people. Tourism and the like might not pay as well but the quality of life is so much better, and the length of life is usually so much better as well. (Richard, GF)

Participants thus came to question assumptions regarding the historical and potential continuing importance of industry to PT (as reflected in the socio-technical configurations depicted in GT and IH, for example). From discussions of concerns, they moved onto discussion of aspirations, and the ways in which localizing clean energy systems might help support a different socio-economic trajectory for the town.

Discussion

We have argued that developing an upstream RRI approach to energy system decarbonization represents a valuable way of eliciting social values in order to assess the broader social implications of visions of systemic socio-technical change and to reflect on the biases within such visions. For such an approach, it is important to provide participants with opportunities to bring their own diverse experiences to bear in understanding the contexts in which sociotechnical change will play out. As we have shown, this is particularly important in relation to energy system decarbonization, due to its place-dependence, the way it may transform everyday practices, and its potential implications for societal inequalities, which tend to be concentrated in specific communities (such as PT) with histories of environmental, economic and health problems.

Value elicitation, we have also argued, does not simply 'reveal' values. It is an interpretative and also constructive process, insofar as it combines presentations of future visions with explorations of context to provide opportunities for participants to actively translate these visions into matters of concern. Explorations of context (in this case study, mapping-based interviews about experiences of place and energy use together with group discussions based on outputs from these interviews) enabled participants to bring to bear experiences of place, practice and social relationships in producing structured reflections on the ways in which energy system visions might unfold in Port Talbot. We have thus shown how values can be elicited in a way that enriches the context of reflection on the priorities and purposes which shape innovation as well as upon its potential consequences.

As we have seen, using an approach of this kind to explore the interdependencies between place, everyday life and socio-technical change opened up reflection not only on potential outcomes but also on key assumptions that shaped the visions the team presented to participants. Among these were how experts assumed continuity and disruption would influence public perspectives on whether a particular socio-technical configuration would be socially desirable or not. We found in the workshops that

participants did not simply view continuity as a positive element of scenarios, in contrast with what expert interviewees had expected. Undoubtedly people had strong reservations about the implications of more decentralized configurations for energy security across the system, on the basis of their unfamiliarity, and wanted more evidence to show that such issues could be overcome. Additionally, they often associated such scenarios with difficulties for vulnerable energy consumers. Yet the results of the personas task tended to show that people saw positive aspects to the potential disruption that might accompany a transition to a more decentralized energy system. In particular, the interdependence of energy and history of place played a role here.

Participants interpreted the kinds of disruption associated with decentralized scenarios as potentially heralding a move away from a socio-economic and socio-cultural trajectory (industrialization and deindustrialization) that was seen as having significant health and environmental downsides. This was most firmly (although vaguely) expressed in the emergence of a fifth scenario in some groups (especially GF) in which elements of different scenarios were combined with a broader emphasis on tourism and environmental amenity as sources of positive potential for the community. Support for particular renewables-based scenarios was conditional in every case, but the most intense expressions of support were elicited by those scenarios which were seen as having potential for moving PT away from dependence on what were seen as increasingly precarious sources of economic activity, and about which many participants were highly ambivalent.

Whichever socio-technical pathway was under discussion, participant responses showed that another form of continuity between present and future might be highly significant. Participants tended to see distrust in institutions, including private industry but more often and more intensely the local council, as an enduring feature no matter how the future unfolded. Further, reasons for distrust (from unreliability to corruption) were seen as issues which would affect how energy system transition would happen. Questions were raised about the desirability of the involvement of these actors in the coming energy transition, indicating that support for such involvement would be highly conditional at best. Indeed, alongside more positive engagements with the scenarios, there was an undercurrent of cynicism and detachment among some participants arising from their distrust in many of the actors who might be involved in the transition (Thomas et al., 2022).

These findings thus confirm the value for RRI of modes of values-elicitation that go beyond investigating high-level public values relating to patterns of socio-technical change in general. We have shown how relating socio-technical visions to the specific histories of places where they will unfold, and to everyday life (including the practices and relationships on which it rests) can provide a richer understanding of the implications of such visions. Approaches sensitized to place and everyday life can build on insights derived from studies in interpretative risk research, place attachment and everyday energy use to provide substantive social intelligence that facilitates a richer appreciation of the assumptions on which proposals are based, of their potential consequences, and (as in the case of the fifth scenario participants began to articulate) what alternative trajectories might be followed. As noted, this scenario emerged particular emphatically, though only in a very roughly sketched-out form, in the GF workshop. Participants in this session possessed relatively weak emotional or social connections to the steelworks, but drew on their accounts of life in PT from the beginning of the workshop, which

focused upon emotional relationships to local landscapes and environmental amenities. The emergence of this fifth scenario, with variations, in more than one workshop demonstrates how an upstream values-elicitation methodology focused on place and everyday life can help provide social intelligence on how a problem that socio-technical visions try to solve may be reframed. The approach we took can therefore be judged to have successfully opened up upstream discussion around energy system decarbonization to different values and visions.

Some limitations of the approach we have taken should be noted, however. First, the scenarios we developed reflected interviews with experts already involved in research and development tied to specific socio-technical configurations. While workshops were carefully developed in a way attentive to the framing effects which may accompany using technical information or expert presentations to orient such activities, our use of scenarios still emphasized a central role for technological innovation in orienting decarbonization. Greater attention in the presentation of scenarios to the upsides and downsides of different options in terms of resilience is arguably necessary, give that participants tended to associate GT with stability, which may have been a consequence of making representations of familiar, incumbent technologies and governance arrangements central to this scenario.

Whether the descriptive focus on technologies necessarily obscures alternative pathways towards decarbonization (such as degrowth-oriented trajectories involving demand reduction and how they might interact with growth in distributed renewable energy) is open to debate. A still broader framing of the 'problem space' for the workshops would certainly be possible, perhaps developing scenarios to explore links between 'energy system decarbonization and wellbeing'. However, as discussion of the fifth scenario showed, participants in some sessions developed such a broader framing, which reflected a collective sense of 'what mattered' in PT not restricted to energy or economic prosperity alone.

Alongside questions about the breadth of reflexivity enabled by our approach, there are also limitations to its depth. While the workshops undoubtedly broadened and deepened reflection on the significance of place and everyday life for energy system decarbonization, they did not enable participants to compare and assess proposals more systematically. For example, a multi-criteria based deliberative approach could offer one way of extending our approach. Further research in this direction could then move beyond eliciting values to developing participatory methods for comparing potential impacts on values of different scenarios, and ranking or prioritizing values on this basis.

Conclusion

This paper has set out an approach to value-elicitation for RRI which may contribute to developing societal technology assessment for energy system decarbonization. This long-term transition trajectory involves societal experimentation with complex socio-technical configurations which are shaped by place. Value-elicitation therefore has to be sensitive to the characteristics of place and the ways in which citizens increasingly depend on energy systems to support a range of vital capabilities. Eliciting perspectives on what values matter has to address all these dimensions of transition together. Further, as

any such approach undertaken will generally operate in upstream mode, ahead of strategic proposals for place-based projects, lessons from STS on how value elicitation should be seen as helping to create a 'public' (even if only a temporary one) through the presentation of possible futures should be heeded.

This approach, we have argued, has significant benefits by bringing effects on place and everyday life into the ambit of RRI. We have pointed also to some limitations of the methods we developed. Nonetheless, our analysis of findings suggests that upstream explorations of the place and societal contexts in which e.g. demonstrator projects might be hosted offers clear benefits both for strategic decision making and also for potentially affected communities. Visions for such projects often seek to gain traction on the basis of the wider socio-economic and environmental benefits they may be expected to bring (Groves et al. 2021). In addition, and as expert interviewees in our study suggested, disruption is expected to undermine social acceptance (Lowes and Woodman 2020). We have shown that the disruptiveness associated with visions of sociotechnical transformation may indeed be viewed negatively. At the same time, when set in a broader context that draws on people's experiences of place and of the role of energy in everyday life, perspectives on disruption may be articulated in more nuanced and complex ways. Visions and, more importantly, evaluable goals for projects need to be framed in more inclusive ways that take account of the patterns of socio-economic and socio-cultural dependence that historically characterize particular places and communities, together with the importance of trust or distrust in those incumbent institutions that may play significant roles in transition.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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