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Renewable energy:
A Social Sciences and Humanities annotated bibliography

Energy-SHIFTS
ENERGY SOCIAL SCIENCES & HUMANITIES INNOVATION FORUM TARGETING THE SET-PLAN

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Executive summary

Background

This annotated bibliography evolved as one outcome of the European Commission (EC) funded project *Energy Social Science and Humanities Innovation Forum Targeting the SET-Plan* (Energy-SHIFTS), which contributes to the European Energy Union by further developing Europe's leadership in applying energy-related research and knowledge from the Social Sciences and Humanities (Energy-SSH). The bibliography provides context to the findings from the extensive Horizon Scan exercise, which resulted in the '100 priority SSH research questions on Renewable Energy' reported earlier[1].

The aim

This report provides annotations to 26 key publications from SSH research on renewable energy deployment to provide a backdrop to the 100 priority SSH research questions in the Horizon Scanning report. With this annotated bibliography, we aim at informing policymakers and other non-experts on the breadth of energy-SSH knowledge that characterises the richness of the research field today.

The approach

We present a selection of peer-reviewed scientific publications that contextualises the research priority questions identified in the Horizon Scan. Expert recommendations on the key literatures and further sampling of relevant scientific publications led to a literature sample from which the final collection was then selected. The set of presented literatures follows the idea to feature the diversity of research themes and the plurality of perspectives in the energy-SSH field.

The findings

SSH research on renewable energy has seen different key themes such as social acceptance or the governance of energy transitions over the last decades. It has more recently engaged with new research strands such as energy (in)justice and power or renewable energy citizenship from diverse disciplinary perspectives. Overall, research on renewable energy emerged with a focus on techno-economic feasibility studies. The scientific literature illustrates a shift to coupled, socio-technical and socio-ecological perspectives with more academic responses evolving to questions of energy justice and power dynamics, of novel policy mixes, of cross-sector governance and to novel institutional alternatives for renewables. SSH research contributions to the study of energy system change have diversified and enriched the field, offering important theoretical and empirical work and providing the cross-disciplinary knowledge needed for transitions to renewables-based energy systems.

1 Available at: https://energy-shifts.eu/wp-content/uploads/2020/12/D2.3_WG1_renewables.pdf

Contents

1. Introduction

1.1. Background: Energy-SSH and the Energy-SHIFTS project

This annotated bibliography was compiled as one outcome of the *Energy Social Science and Humanities Innovation Forum Targeting the SET-Plan* (Energy-SHIFTS)[2]. Energy-SHIFTS has worked to support the EU Energy Union by developing Europe's leadership in energy-related Social Sciences and Humanities (energy-SSH) research. The growing field of Energy-SSH has remained marginal in terms of funding and policy impact, giving way to energy research interests dominated by the natural and technical sciences (Øverland and Sovacool, 2020; Robison and Foulds, 2019; Foulds and Christensen, 2016). However, the European Commission (EC) has expressed a commitment to mainstream SSH research and innovation activities, including supporting standalone energy-SSH projects. The Energy-SHIFTS project aims to strengthen energy-SSH for European research and innovation, as well as to strengthen its relevance to EU's energy policy.

Energy-SHIFTS has contributed cutting-edge research priorities from energy-SSH research communities, which can guide and anchor EU research and innovation funding for SSH research and bridge the current science-policy gap. Through the Horizon Scanning exercise, four Europe-wide working groups identified each a set of 100 priority SSH research questions on key topics within the EU Energy Union and EC research and innovation funding priorities: (1) Renewable energy (von Wirth et al., 2020), (2) Smart consumption (Robinson et al., 2020), (3) Energy efficiency (Foulds et al., 2020), and (4) Transport and mobility (Ryghaug et al., 2020). Four annotated bibliographies serve as companion pieces to these four Horizon Scan reports.

2 For more information, please visit the official project website: https://energy-shifts.eu/

1.2. Aims of the Annotated Bibliographies

This annotated bibliography aims to provide a contextual backdrop and a sense of the evolution and state of the academic research on SSH research on renewable energy. It is supposed to be read alongside the 100 priority SSH research questions presented in the Horizon Scanning report on renewable energy. An annotated bibliography is a compilation of references to scientific articles and book chapters followed by short descriptions of their content and key arguments. This report provides annotations to 26 key publications in SSH research on renewable energy. Similar to the four Horizon scan reports, this is one of four bibliographies, alongside smart consumption, energy efficiency, as well as transport and mobility. These are intended to give policymakers and other non-experts insight into the breadth of energy-SSH knowledge and approaches, which characterise the field today. They portray the main advances in energy-SSH fields and, as such, offer context for the forward-looking priority SSH research questions.

The annotated bibliographies offer a taste of the main SSH debates, milestones, and advances in the field through a summary of key scholarly contributions, without claiming to provide full coverage of the field. The ambition is to demonstrate the range and variation of energy-SSH research, incorporating different and sometimes contradictory disciplinary perspectives, research themes and approaches. The bibliographies can give policymakers and other non-experts insights to help navigate the SSH field of renewable energy.

1.3. The topic of this bibliography: Renewable Energy

This annotated bibliography focuses on SSH research on Renewable Energy. Decarbonizing energy systems is a key priority in EC research and innovation funding

and critical to achieving the EU's aim of carbon-neutrality by 2050. The Energy-SHIFTS Working Group on Renewables has framed the SSH research purpose as "*contributing to a better understanding of just transitions to renewables-based energy systems, by recognising the social conditions and consequences of using and further implementing renewable energy technologies*" (von Wirth et al., 2020, p.7). While research on renewable energy has been conducted in Europe for several decades, the contribution of SSH disciplines remained marginal for long. Yet, diverse research has indicated that in order to realise a future energy system that is low carbon, just, and reliable will require a more intense and meaningful collaboration between the physical sciences and the SSH (Sovacool et al., 2015).

The Horizon scan exercise to identify priority research questions for renewable energy SSH research resulted in eleven themes: (1) Transformative governance, (2) Culture, imaginaries, narratives, (3) Social acceptance, (4) Energy democracy, (5) Energy Justice, (6) Financial and organisational structures, (7) Socio-ecological effects, (8) Renewables Policies, (9) Renewables System Design and integration across sectors, (10) Geography of renewables, and (11) Power dynamics and conflicts. While the identified research questions in these themes highlight pressing topics and perspectives, we highlight that the field is much broader, encompassing topics that resist immediate categorisation. In this annotated bibliography, we therefore aim to present a broader view of what constitutes SSH scholarship on renewable energy, which does not always relate to "*energy system transitions*". Nevertheless, the presented key pieces are relevant stepping stones and serve hopefully as sources of inspiration for stimulating new research topics, interests, perspectives, and debates.

1.4. Procedure for selecting key pieces of literature

Twenty-six publications were selected based on their relevance to address the research priority questions in the Horizon Scan. This selection includes peer-reviewed scientific publications, review articles, and monographs. The selection process was guided by the principles of diversity (of research themes) and plurality (of disciplinary perspectives) in order to highlight the breadth and richness of the energy-SSH field.

Publications were collected by conducting ten expert interviews with an interdisciplinary cross-section of leading experts and frontrunners in the research field (all working group members). The interviews were conducted between January and March 2020, during the initial stages of the Horizon Scanning process. Each interviewee was asked to recommend at least five publications they considered seminal for the development and the current state of the field. From this sample, a selection of publications were included into the annotated bibliography based on criteria such as: number of citations, perceived impact within the field, and contribution to new research avenues, thematic shifts and emerging key discourses within the field. Decisions were made by members of the Steering Committee of the working group on Renewable Energy. Some publications suggested by interviewees were excluded due to their lack of focus on SSH research, or due to being situated out of scope with respect to our definition of renewable energy. The authors then identified additional gaps based on the interviewees' descriptions of the field and key research themes that emerged during the Horizon Scan. Hence, additional publications were sourced from the Horizon Scanning survey responses[3].

1.5. How to use the Annotated Bibliographies

The annotations are short summaries of the original source material and provide a taste of each scientific contribution. We hope readers become inspired to seek out the full publications on their topics of interest. This collection does not claim to be comprehensive. In addition, we acknowledge that there cannot be a single, all-encompassing set of key literatures that all SSH communities would agree upon. Given the limited selection of publications, readers may also use the list as a tool to seek out additional or more specific literature on the research field. The bibliography may, for instance, be read prior to viewing the 100 priority SSH research questions in the Horizon Scan report, or as an independent source of information.

Readers may also be interested in studying the annotated bibliographies from the *Social Sciences and Humanities for Advancing Policy in European Energy* (SHAPE-Energy) project which was the predecessor to Energy-SHIFTS and offers more systematic reviews of the given fields[4].

3 For more information on the expert interviews and annotated bibliographies, please read the methodological guidelines (Foulds et al., 2019).

4 Can be downloaded here: https://shapeenergy.eu/index.php/publications/annotated-bibliographies/

2. Key literature in the field of SSH research on renewable energy

In the following sections we present summaries for the identified key literatures illustrating relevant SSH research on renewable energy. We have structured the literature into seven themes, which reflect the evolution and current state of the SSH research field on renewables. The field has shifted from a focus on economic feasibility studies and early work on social acceptance of infrastructures to a more comprehensive and diverse understanding of energy system transitions, including aspects of energy justice and power, energy system imaginaries and visions, community energy and energy citizenship as well as aspects of policy mixes for renewables' deployment and energy citizenship.

Given the still marginalised role of SSH research on renewable energy compared to the natural and engineering sciences, complementing energy system modeling with SSH perspectives receives increasing attention and is addressed as a separate theme here as well.

2.1. Overviews of SSH energy research

There has been an increase in SSH contributions to studying renewable energy over the last years. While the starting point was a reflection on the rationale using the perspectives and analytical methods offered by SSH, the further development of energy-SSH research led to identifying the dynamics of energy transitions as a non-linear, long-term and complex socio-technical process with its inherent challenges. The energy-SSH community has started a reflection about capacities and provided already first attempts of overviewing the field and proposing future research agendas, which is reflected in the below listed review studies of energy transitions in general and renewable energy deployment in particular.

Sovacool, B.K., 2014. What Are We Doing Here? Analyzing Fifteen Years of Energy Scholarship and Proposing a Social Science Research Agenda. *Energy Research & Social Science*, 1, pp.1–29.

This is a relevant review article that offers a retrospective analysis of Social science research in energy studies in general. The author provides both quantitative and qualitative analyses of 15 years of energy scholarship including a content analysis of several thousand research articles that were published in the three leading energy journals between 1999 and 2013. The authors demonstrate that only 19.6 percent of authors reported training in a social science discipline, and less than 0.3 percent of authors had disciplinary affiliations in areas such as History, Psychology, Anthropology, or Communication studies. Hence, this article provides thorough evidence that SSH scholarship is still underrepresented and marginal in energy research over the studied period. The author concludes with presenting methodological and topical areas for future research, in order to deepen and broaden social science energy research.

Gross, M. and Mautz, R., 2015. Renewable Energies (Key Ideas). Milton Park, Routledge.

This concise book was designed to provide a better framing of contemporary theories of energy transformation, including challenges of transitioning from centralised to decentralised systems, the relationships between renewable energy technologies and the patterns of using them, as well as addressing risks and conflicts and the strategies of coping with them. It uses a sociological lens to explain different configurations of actors, technologies and cultural contexts. The authors discuss the notion of energetic foundations of sociology and then reflect on how renewables are being integrated into existing electricity systems. In conclusion, the authors underline the uniqueness of ongoing energy transition processes, which in contrast to other sectors are not just adding the new energy

sources to existing systems, but instead, have to focus more than ever on exuviating existing forms of energy production and consumption in order to amplify the transformation.

Markard, J., 2018. The next phase of the energy transition and its implications for research and policy. *Nature Energy*, 3(8), pp.628-633.

This article is relevant in providing a concise analysis of the emerging dynamics in energy transitions. In many places, the electricity sector is continuing to accelerate a transition towards larger shares of renewable energy technologies. During early phases of such transitions, a key concern for researchers and policymaker was the establishment of renewables as technically and economically feasible and reliable alternatives. The author then highlights the changing situation today: renewables are adopted rapidly in electricity grids, generating significant changes for established technologies, organisations and infrastructures in current energy systems. In this new phase of the energy transition, qualitatively new phenomena can be observed and need to be addressed by research and policy. According to the author, these are: the complex interactions of different energy technologies, the decline of established business models and technologies, intensified economic and political struggles among the key actors (e.g. utility companies, industry associations), and further challenges for the overall performance of the electricity sector (e.g. the integration capacities for renewables).

Hirsh, R. F., & Jones, C. F. (2014). History's contributions to energy research and policy. *Energy Research & Social Science*, 1, 106-111.

The authors argue for the relevance of historical research for assisting research and policy in analysing contemporary energy systems or designing energy policies. It is suggested that the value of history for energy research stems from offering insight into often-overlooked considerations among practitioners who propose and adopt energy policies. Such considerations may include social and political impediments that designers of new energy technologies often cannot imagine or may manifest in long-standing, yet difficult-to-articulate resistances among established stakeholders who oppose implementation of novel energy plans. The authors ask for caution as history does not directly repeat itself or allows for future prediction. With presenting several case studies, this article highlights historians' efforts to identify the essential role of social and cultural considerations in co-shaping the successes and failures of dominating practices in energy systems. In essence, energy researchers and policy makers can learn much from history about the links between energy, culture, and society as well as the need to reevaluate the traditional notion of energy transitions.

Jacobsson, S. and Bergek, A., 2004. Transforming the energy sector: the evolution of technological systems in renewable energy technology. *Industrial and corporate change*, 13(5), pp.815-849.

With this paper, the authors present an analysis of the development and diffusion of technologies that utilize renewable energy sources in Germany, Sweden and the Netherlands. This analysis enlarges the life cycle model of industry evolution towards a model, where the focus is on the formation and evolution of new technological systems. The particular focus in this work is on explaining success and failures in shifting from a formative phase into one characterised by positive feedbacks. A set of challenges is identified for policy makers (e.g. the challenge to implement powerful, predictable and persistent pricing policies to generate favourable conditions for investing in renewables as well as the challenge to design these pricing policies in a technology specific way), attempting to influence the process of transforming the energy sector further into renewables-based systems.

2.2. The social acceptance of renewable energy deployment

The public perception of renewable energy infrastructures and their social acceptance remains a controversial challenge for research, industry and policy (de Geus et al., 2020). Over more than 30 years, SSH studies have provided better insight into the phenomena of acceptance and acceptability of deploying diverse energy technologies in society. In consequence, a significant shift in the understanding of social acceptance of renewables can be observed: evolving from an instrumental approach considering the (lack of) social acceptance in terms of an investment risk and as a barrier to participatory approaches, towards deliberative energy governance guiding the inclusion of diverse stakeholders and communities as a key ingredient for energy transitions to move forward. The discourse around Social acceptance of renewable energy has seen a reevaluation of the 'Not-In-My-Backyard (NIMBY) phenomenon' to overcome simplistic assumptions discrediting local stakeholder positions as

being in resistance or opposition against installations of renewable energy innovations. Instead, SSH research contributed to better recognising the factors shaping local and national responses to energy infrastructures and has offered a more nuanced understanding of contextualised processes laying behind (the lack of) social acceptance of renewable energy deployment.

Wüstenhagen, R., Wolsink, M. and Bürer, M.J., 2007. Social acceptance of renewable energy innovation: An introduction to the concept. *Energy policy*, 35(5), pp.2683-2691.

This paper provides a conceptual introduction to social acceptance of renewable energy innovation. It is one of the first and seminal overview articles unpacking the dimensions and characteristics of social acceptance of renewable energy. With ambitious government targets to increase the share of renewable energy in many countries, it is increasingly recognised that social acceptance may be a constraining factor in achieving this target. This is particularly apparent in the case of wind energy, which has become a subject of contested debates in several countries largely due to its visual impact on landscapes. The paper introduces three dimensions of social acceptance, namely socio-political, community and market acceptance. The article outlined opportunities for further research on social acceptance of renewable energy.

Devine-Wright, P., 2005. Beyond NIMBYism: towards an integrated framework for understanding public perceptions of wind energy. *Wind Energy: An International Journal for Progress and Applications in Wind Power Conversion Technology*, 8(2), pp.125-139.

This paper is devoted to public perception of wind technology. This work makes a relevant contribution to the field by critically reflecting on the 'Not in my backyard' (NIMBY) phenomenon, which refers to peoples' resistance to development if it happens proximate to people's (residential) location. Devine-Wright in this work highlights the shortcomings and limitations of the concept, and instead offers a multidimensional framework that integrates previous research findings on social acceptance with theory from social and environmental psychology. Based on existing empirical research, the author discusses several factors shaping the public acceptance for wind technologies' implementation, which entails physical, contextual, political, socio-economic, social, local and personal aspects. With this integrated perspective, the article broadens the previous narrow NIMBY understanding of social acceptance. This allows for critical reflection of the complex and multidimensional dynamics shaping public perception of renewable energy implementations.

Batel, S., 2020. Research on the social acceptance of renewable energy technologies: Past, present and future. *Energy Research & Social Science*, 68,101544.

With this article, the purpose of social acceptance research on renewable energy is presented as a relevant way forward to anticipate and create more just, democratic and sustainable energy systems and societies. The paper offers an overview on the research conducted on the social acceptance of renewable energy technologies over the last 30 years. It describes how the conceptual ideas and the research have emerged and changed over time. For example, the author presents three waves of research on the social acceptance of renewable energy technologies (RET): the social side of RET with normative approaches during the 1990's; the social acceptance of RET with criticism approaches from 200 onward; and the people's responses to RET with critical approaches from 2010 onward. The author comments and differentiates the current state of research and identifies directions for future research.

Cuppen, E., 2018. The value of social conflicts. Critiquing invited participation in energy projects. *Energy Research & Social Science*, 38, pp. 28-32.

Invited participation is a popular approach in recent work on energy governance that aims to achieve more fairness in participatory planning processes and claims to help build public acceptance. This paper proposes a critical consideration of this approach taking into account the possible constructive role that social conflicts can play in energy policy and planning. It defines social conflicts as self-organised participation and rises attention to its value. The author discusses two basic characteristics of conflict and shows limitations of the invited participation approach. Among these limitations is the fact that social conflict emerges to challenge existing rules and practices in the energy system, while at the same time invited participation is often initiated by governments, companies and other actors that are entangled with incumbent institutions being challenged. Secondly, social conflict is a dynamic phenomenon which often faces the emergence of diverse values and novel actor groups over time. Tools for invited participation reveal limitations as they tend to neglect these notions of emergent values and groups. In essence, this article offers a novel perspective on conceptualising conflict and participation in the debate about social acceptance of renewable energy technologies.

2.3. Frameworks and models of energy system transformations

When addressing energy system transformations, scholars but also diverse other stakeholders from the energy sector (e.g. energy utilities, grid operators, energy cooperatives) construct and use mental tools and assumptions (i.e. models and frameworks about how energy systems function) as a prerequisite of their actions. These models and frameworks also co-determine policymaking in the energy sector and hence, are most consequential for the transformation of the sector. SSH research proves that including social, ecological and systemic elements in these models and frameworks is indispensable for successful transformations. The scientific literature included in this section provides guidance and examples of successful implementations of more comprehensive models and frameworks, especially on meso (policy) and macro (country) level.

Trutnevyte E., Hirt F.L., Bauer N., Cherp A., Hawkes A., Edelenbosch O.Y., Pedde S. and van Vuuren D. P., 2019. Societal transformations in models for energy and climate policy: The ambitious next step. *One Earth*, 1(4), pp. 423-433.

This article provides a key contribution for involving societal aspects into energy and climate policy modeling. Questions on how long-term energy and climate targets can be reached depend on diverse interlinked factors: technology, economy, environment, policy, and society at large. The article argues that integrated assessment models of climate change or energy-system models have so far limited representations of societal transformations, such as behavior of various actors, transformation dynamics in time, and heterogeneity across and within societies. After reviewing the state of the art, the authors propose a research agenda which guides experiments to integrate more insights from social sciences into models. The proposed agenda allows for interdisciplinary learning between modelers and social scientists, improved models with a more complete representation of a multifaceted reality, and identification of new and more effective solutions to energy and climate challenges.

Hodbod, J. and Adger, W.N., 2014. Integrating social-ecological dynamics and resilience into energy systems research. *Energy Research & Social Science*, 1, pp.226-231.

With this study, the authors address the often-relegated role of the ecological impacts of energy production and consumption. Social–ecological dynamics are presented as critical aspects with respect to the access to modern energy services which tend to be inadequate for significant sections of the world's population. The ecological impacts of energy use are often analysed as a set of environmental externalities, many of which are uncertain or unquantifiable (e.g. species extinction or the loss of visual landscape amenity), particularly if they stem from earth system change such as anthropogenic climate change. The authors hence suggest to analyse energy systems as social–ecological systems. The paper builds on an extensive literature review from ecology and resilience theories. It compares the analytical domains, major findings and emphasis of social–ecological systems with socio-technical transition research. The authors demonstrate that social–ecological systems research combines the analysis of interactions with ecological systems and power relations between actors in energy systems.

Geels, F.W., Kern, F., Fuchs, G., et al., and Wassermann, S., 2016. The enactment of socio-technical transition pathways: A reformulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990-2014). *Research Policy*, 45, pp.896-913.

This paper makes a relevant contribution to the field by presenting a typology of transition pathways which is illustrated by an analysis of the German and UK low-carbon electricity transitions. The authors argue that (energy) transitions may shift between pathways, depending on struggles over technology deployment and institutions. The analysis shows that Germany is on a substitution pathway, enacted by new market participants deploying small-scale renewable electricity technologies (RETs), while the UK is on a transformation pathway, enacted by the currently dominating actors deploying large-scale RETs. Further analysis shows that the German transition has recently shifted from a 'stretch-and-transform' substitution pathway to a 'fit-and-conform' pathway, because of a fightback from utilities and altered institutions. It also shows that the UK transition moved from moderate to substantial reorientation towards the established actors, as government policies became stronger. Recent policy changes, however, substantially downscaled UK renewables support, which is likely to shift the transition back to a less disruptive path.

2.4. Energy (in)justice and aspects of power

As all socio-technical systems, energy systems are subject to questions of (in)justice and power. While justice, equity and societal inclusion in deploying energy infrastructures and shaping energy systems were rarely covered until recently, more systematic frameworks and approaches to study energy justice and questions of power were developed in the last decade. Some of these literatures provide the conceptual foundations to study just energy systems from interdisciplinary SSH perspectives while others address the facets of fair transition processes to renewables-based energy systems more explicitly. Aspects such as dealing with energy poverty, socio-economic inequality, and implications of energy transitions on employment are further evolving themes. SSH research offers both a critical analysis of justice issues, as well as more normative questions about how a 'just transition' can be attained.

Sovacool, B.K., Burke, M., Baker, L., Kotikalapudi, C.K. and Wlokas, H., 2017. New frontiers and conceptual frameworks for energy justice. *Energy Policy*, 105, pp.677-691.

This article makes a relevant contribution to the field because it analyses how different concepts from justice research and ethics can help informing decision making in the energy sector. The authors emphasise the moral and equity dimensions of energy production and use and contributes a novel definition of "energy justice", when referring to "a global energy system that fairly distributes both the benefits and burdens of energy services, and one that contributes to more representative and inclusive energy decision-making" (p.677). The authors focus on a list of new research frontiers for the future of energy justice. It starts with a call for the inclusion of non-Western justice theory and argues to expand justice frameworks beyond human agency, hinting to neglected aspects for example of the rights of nature. Another avenue for future research is identified in cross-scalar issues of justice such as embodied emissions as well as is the generation of novel business models and the associated benefits expected to emerge when considering a justice perspective. Still overlooked are also research questions addressing the tradeoffs within energy justice principles and the uncovering of unjust discourses. The research agenda presented in this article is exemplified with 30 research questions and is underpinned with a conceptual framework in order to guide decision-making.

McGee, J. A. and Greiner, P.T., 2019. Renewable energy injustice: The socio-environmental implications of renewable energy consumption. *Energy Research & Social Science*, 56, pp.2-11.

This article makes an important contribution to understanding the role of income inequalities may influence the relationship between renewable energy consumption and the reduction of CO2 emissions. The authors test the hypothesis that renewable energy consumption reduces emissions more effectively when it occurs in a context of increasing inequality, while it would reduce emissions to a lesser degree when occurring in a context of decreasing inequality. This study builds upon data from a large sample of 175 nations for the period from 1990 to 2014. The authors demonstrate that when income inequality increases, renewable energy consumption is found to be associated with a much larger decrease in CO2 emissions. The authors refer to previous research conducted by energy poverty scholars; the authors conclude that national income inequality affects the way renewables are deployed. It is recommended to policy makers that efforts aimed at increasing renewable energy consumption should be combined with policies that aim for the effective displacement of fossil fuels and the reduction of inequality.

Jasanoff, S., 2018. Just transitions: A humble approach to global energy futures. *Energy Research & Social Science*, 35, pp.11-14.

This is a key article that presents persistent mismatches between current problems, policy framings, and proposed solutions in the context of energy transitions. These mismatches are pointing to unsettled ethical considerations such as that the energy system is being imagined at the centers of global power. The author argues that development is still too often considered as the means to achieve sustainable futures, even though decades of research point to complex and uncertain relationships between prosperity and sustainability. The author also addresses the neglected aspect of disparities within societies that demand differentiated socio-technical solutions rather than considering a focus on technological change as essential for energy transitions. The perspective paper then turns to principles about how to navigate and guide energy transitions with paying particular attention to social justice. Among these are: being more attentive to systematically neglected issues as for example the role of communal practices and norms in relation to energy use. Integrating more prominently the influence of history and culture, especially when these affect experiences of vulnerability and resilience. Moreover, the author strongly invites to restore

normative concerns to energy policy deliberations for example with a focus on distribution, fairness, and justice. Finally, the paper argues for the design of new participatory strategies to offer larger publics greater access to scientific resources and official political institutions at diverse levels of policy making.

Jenkins, K., McCauley, D., Heffron, R., Stephan, H. and Rehner, R., 2016. Energy justice: a conceptual review. *Energy Research & Social Science*, 11, pp.174-182.

This is a relevant article that offers a broad conceptual review of the literature to date and provides empirical examples of its applications in the contexts of energy policy, energy production and systems, energy consumption, energy activism, energy security and climate change. The authors pay particular attention to distributional, recognition and procedural justice aspects. These three aspects are key because if (energy) injustice is to be tackled, actors need to identify the concern – 'distribution', identify who it affects – 'recognition', and only then identify strategies for remediation – 'procedure'. The authors present a novel research agenda related to the notion of 'energy systems justice' and emphasise energy justice as being of a pluralist nature; that is not restricted to a particular technology, application, location or point in time. Future research should aim to further detect where injustices occur, identifying new processes for mitigating and recognising new further affected parts of society. More concretely, the authors highlight the lack of research on the energy justice movement which is seen as seemingly mute in comparison to activist origins of environmental and climate justice.

2.5. Energy system imaginaries and visions

Studying possible and plausible future states of energy systems has been on the agenda of SSH research for a while. However, the potential of future imaginaries and visions of renewables-based energy systems for policymaking seems to be still untapped. In addition, many visions for energy transitions are still focused on techno-economic factors and often overlook social conditions and social consequences. Unlike market strategies and technical forecasts, imaginaries incorporate future visions, dreams and expectations of citizens or other social actors. In recent years, policy making has started acknowledging the plurality and contestations in visions of future energy systems. Implications of this multiplicity have been addressed and communicated by SSH scholars.

Longhurst, N. and Chilvers, J. 2019. Mapping diverse visions of energy transitions: co-producing socio-technical imaginaries. *Sustainability Science*, 14(4), pp.973-990.

This is a relevant paper as it expands beyond the dominant visions of energy transitions and brings counter- hegemonic, alternative imaginaries onto the agenda. It describes how there has been growing criticism of the dominant technocentric transition visions for energy systems. The paper reveals that what is often presented as a primarily 'technical' transition is always normative in bringing forward particular forms of social and political order. It presents new insight into the diversity of visions for energy transitions within the societal context of the UK by studying twelve visions produced across different institutional settings such as the state, business, science and technology, and civil society. The authors introduce a new analytical framework grounded in relational co-productionist perspectives in science and technology studies (STS). This opens up debates for alternative models of progress, social change, and the roles of publics in imagining energy futures. The authors claim that mapping these visions will contribute to reflexive, and responsible practices of future-making of the energy system.

Delina, L. and Janetos, A., 2018. Cosmopolitan, dynamic, and contested energy futures: Navigating the pluralities and polarities in the energy systems of tomorrow. *Energy research & Social science*, 35, pp.1-10.

This paper considers energy futures as cosmopolitan, multidimensional, contradictory as well as being politically, geographically and culturally contextualised. It underlines plurality and reflexivity in understanding the multiple ways of imagining energy futures. The authors reflect on the consequence of how people imagine, navigate, and contest such futures. This article highlights that energy futures are not free of cultural, political, and economic influence, and hence can be best approached with cosmopolitan and plural lenses. Plurality is as well evidenced in terms of the disparate geographic locations, disciplinary foundations, conceptual frameworks, and methodological choices in particular for SSH research on energy system transformation. This breadth points to the many roads of imagining energy system futures and of making these expectations real and durable.

2.6. The politics and policies of renewable energy systems

At the heart of transitions from fossil fuel to renewables-based energy systems is a societal change which implies new configurations of actors, material objects, interactions, and meanings. SSH research provides in-depth insights into the complexities of these configurations paying attention to politics and policies as drivers of the anticipated changes as well as the instruments for coping with their unintended consequences. An energy transition is inherently political and requires public debate and political interventions. Regarding political interventions, the unique value offered by SSH research lies with discussing multiple scenarios and pathways which can make public debate more flexible, open and adaptive. Offering the systematic monitoring of interventions which recognise multiple societal interest, positions, and practices, SSH scholars provide the evidence that supports policymaking, while stimulating further discourse on the values and possible horizons of designed actions, which hopefully makes the transition processes more reflexive.

Munro, F. R.,and Cairney, P., 2020. A systematic review of energy systems: The role of policymaking in sustainable transitions. *Renewable and Sustainable Energy Reviews*, 119, 109598.

This article unpacks the role of policy and policy making in the context of studying the transition of energy systems. The authors indicate the interconnectedness of key actors, outcomes from a large number of interactions, and the proposed transformation towards sustainable energy systems. According to the authors, applying systems analysis and 'systems thinking' are promising lenses to capture the dynamics in energy system change, yet, remains often too vague to guide energy transitions well. The authors show how these concepts arise frequently in UK energy policy research and what their impact can be on policymaking. Clear conceptual underpinnings for policy and policymaking are identified as key in amplifying energy transition research, but a key challenge remains to identify the appropriate policy mixes as well as their likely effects. In this context, the study argues that non-governmental action is crucial, yet, the relationship and collaborations between governmental and other actors is often not clear. The authors conclude with the call to develop rules within and beyond government action to generate mechanisms to ensure high cooperation among diverse actors and to instigate societal ownership of the means to achieve energy transitions.

Meckling, J., Sterner, T. and Wagner, G., 2017. Policy sequencing toward decarbonization. *Nature Energy*, 2, pp.918-922.

With this relevant article the authors challenge the proposition held by many economists that carbon pricing—either through a carbon tax or cap-and-trade—is one of the most cost-effective ways to achieve decarbonized energy systems, preceded with subsidies for basic research and development. So far, green innovation and targeted industrial policies aiming to foster low-carbon energy technologies have proliferated. According to the authors, such initial government support for low-carbon energy technologies faces two enduring challenges: avoiding the lock-in of sub-optimal low-carbon technologies and maintaining support for government investment in low-carbon technologies. With the prominent exceptions of a few Scandinavian carbon taxes and some EU fuel taxes, most early carbon pricing systems had a limited effect in reducing emissions or inducing innovation The authors unpack the distinct sequence of policies introduced by low-carbon frontrunners such as the government of California and the European Union (EU). Their policy sequences helped to overcome some of the political challenges facing low-carbon policy by building economic interest groups in support of decarbonization and reducing the cost of technologies required for emissions reductions. The authors illustrate the three-stage policy sequence of California and the EU, which has primarily played out in the electricity sector. When aiming for deeper emissions cuts in the future, further cuts in the electricity sector and efforts to broaden policies to the transport and building sectors are crucial.

Jacobsson, S. and Lauber, V., 2006. The politics and policy of energy system transformation—explaining the German diffusion of renewable energy technology. *Energy Policy*, 34, pp.256-276.

This article presents a detailed historical analysis of the political and policy measures related to the rapid spread of wind turbines and solar cells in Germany. The authors explore the diffusion of the two renewable energy technologies with a particular focus on the employed policy instruments and to the political process which led to the adoption of these instruments. The instruments as part of the wider regulatory framework formed in an institutional battle , during which the German parliament, which was informed and supported by an advocacy coalition, backed support policies for renewable energy sourced electricity against often

reluctant governments and the opposition from interests of nuclear and coal industry. This study traces the details of a political process in Germany over decades and provides further insight into the societal costs that the political and environmental achievement brings about.

Stirling, A., 2014. Transforming power: Social science and the politics of energy choices. *Energy Research & Social Science*, 1, pp.83-95.

This paper addresses energy choices, both for the social sciences and for society at large. The author argues for opening up active political spaces for critical contention over alternative energy transition pathways. A key principle identified in this paper is that the roles of social science in interdisciplinary energy research are not just about the social complexities encountered in pursuing goals driven largely by natural sciences or engineering. Instead, social research can also assist in framing priorities, questions and options for these disciplines such as engineering. Yet, social science perspectives require acknowledging plurality. According to the author, it should not only refrain from, but rather actively critique, policy recommendations presented in singular prescriptive forms. This article suggests instead that it should convey to policy making and wider political debates an explicit and symmetrical plurality of social interpretations of energy alternatives, each valid under different reasonable perspectives with each, its associated constituting conditions. The ideas and hopes about possible pathways for energy system change can be deeply constituted by interests of established energy system actors. In conclusion, the authors emphasise that the social choice of energy transition pathways is inherently a matter for explicitly political rather than solely analytical resolution.

2.7. Community renewable energy and energy citizenship

Energy communities are manifestations of community-led approaches to energy transitions. In contrast, energy citizenship emphasises the energy consciousness and literacy as well as sustainable energy practices by citizens engaging as social and political actors. Both notions have been used frequently in scientific and media discourses. Their multidimensional character and evolution still offers further potential to SSH research regarding questions about ownership, agency and relations in energy systems. Literature on energy community and energy citizenship have addressed issues of rights, responsibilities, identities and civic relations connected to energy issues. The papers chosen for this section provide systematic overview and insights into the diverse understandings of energy communities and citizenship and discuss important implications for policymaking.

Walker, G. and Devine-Wright, P., 2008. Community renewable energy: What should it mean? *Energy policy*, 36(2), pp.497-500.

This paper is based on a UK case study and proposes two key dimensions that underlie the views on what community means to policy makers, administrators, activists, project participants and local residents. The authors then construct the analytical matrix to place the utility of wind farms in relation to the different understandings of community energy. They argue that community is an easily used word that is readily attached to projects, initiatives and policies as part of the discursive politics of modern governance. In this work, the authors consider the way in which community has become attached to renewable energy projects both in grassroot action and in mainstream energy policy. The study presents community understandings and interpretations that revolve around questions of both process and outcome. The importance of the process design for realising meaningful local participation are highlighted.

Ryghaug, M, Skjølsvold, T.M. and Heidenreich, S., 2018. Creating energy citizenship through material participation. *Social studies of science*, 48(2), pp.283-303.

This relevant paper draws on STS theories and is focused on the topic of creating energy citizenship emphasising the active role of social actors in decarbonizing energy systems. The authors use the theory of material participation and illustrate how novel energy practices emerge. Referring to artefacts such as electric vehicles, smart meter and photovoltaic panels, the study reflects on how the material participations shape energy citizenship. As connectors or bundlers of interests and practices, such artefacts show potential to co-produce energy citizenship and new modes of engagement with environmental issues. The authors argue that material objects can anchor energy and climate change-related discourses and practices in everyday life, through processes of material localisation, integration and diversification. Hence, in order to evolve from passive users or mere customers to active energy system participants, different forms of user and community with new low-carbon energy technologies should be co-created. The paper concludes with

a discussion about the role of policies for low-carbon energy transitions on the making of energy citizenship, as well as limits of introducing a materially based energy citizenship.

Kunze, C. and Becker, S., 2015. Collective ownership in renewable energy and opportunities for sustainable degrowth. *Sustainability Science*, 10(3), pp.425-437.

This paper is a relevant work because it provides empirical insides to test the hypothesis that small-scale energy technology and decentralised ownership can be regarded as precursors of a sustainable degrowth society. Based on the results of a survey conducted in European Union member states during 2013, the authors discuss small-scale ownership structures in renewable energy as an alternative to community energy approach. The survey data is paired with four case studies relating to the debates on degrowth to small-scale renewable energy schemes. The concept of collective and politically motivated renewable projects (CPE) is introduced as a heuristic notion to broaden the debate on small-scale renewable energy. CPE's combine collective forms of ownership and decision-making with explicit political aspirations, with a degrowth orientation being one of the possible aspirations. These projects can be seen as degrowth initiatives as they seek to reduce the per capita energy consumption and integrate ecological principles into their business practice.

Bauwens, T., 2016. Explaining the diversity of motivations behind community renewable energy. *Energy Policy*, 93, pp.278-290.

This is a relevant article that addresses the plurality of motivations behind engaging with community renewable energy (CRE) initiatives. The author empirically investigated the heterogeneity among members of CRE projects in terms of their motivation and levels of engagement. CRE initiatives are becoming more important actors in the transition toward decarbonizing energy systems. However, in order to further stimulate investments in CRE projects, a better understanding of investors' motives and attitudes is required. Based on quantitative data from a survey study conducted with two renewable energy cooperatives in Flanders, Belgium, the paper presents a more fine-grained analysis of how institutional factors and, in particular, social norms may interplay with spatial patterns and attitudes towards innovation diffusion that shape renewable energy investments at the community level. Activating social norms is illustrated as a promising mechanism for triggering investment decisions into CRE, although the implications of its interplay with economic incentives are still to be further explored.

3. Conclusions

This annotated bibliography has surveyed the breadth of scholarship characterising SSH research on renewable energy. The field has shifted from a focus on economic feasibility studies and early work on social acceptance of infrastructures to a more comprehensive and diverse understanding of renewables, including aspects of energy justice and power, cross-sector integration, governance of energy system transitions, policy mixes for renewables' deployment, or energy citizenship.

Our selection of scientific work also pays tribute to the agenda-setting done by the European Commission, directing the course of changes in European energy systems towards just transition pathways to renewables-based energy systems, by recognising the social conditions and consequences of using and further implementing renewable energy technologies.

In order to identify the possible and desirable pathways towards just, renewables-based energy systems, unintended consequences and appropriate incentives to overcome the inertia and path dependencies of the existing energy system structures will likely become more prominently in the scientific debate ahead. Moreover, the expected cross-sector effects of energy transitions (e.g. with the mobility, housing, agricultural sectors) and aspects of subsequent system-integrations have not been adequately covered in the literature to date.

The highlighted contributions have policy relevance and/or have influenced new research trajectories. Nevertheless, several important debates, themes, and studies could not be included here. Topics related to emerging SSH research on renewables system design and cross-sector integration, novel financial and organisational structures, or on particular social geographies of renewable energy are some examples of work that was not integrated at this stage.

We critically acknowledge a selection focus of studies primarily produced in and focusing on North-Western Europe. Although scholars from these geographical regions have dominated the field, this focus constitutes a limitation to our literature overview. Yet, we are convinced, this bibliography characterises some of the different avenues of scholarship and debates within the field, and we hope readers are inspired to seek out in-depth knowledge and further literatures on renewable energy beyond the publications presented here.

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5. References

Foulds, C. and Christensen, T.H., 2016. Funding Pathways to a Low-carbon Transition. *Nature Energy*, 1(7), pp.1–4.

de Geus, T., Bode, N., Robison, R., Rohse, M., Foulds, C., Wagner, A., Krupnik, S., Świątkiewicz-Mośny, M., Rudek, T., Kuittinen, H. Lisi, V., Søraa, R., Lunevich, I., Wittmayer, J. 2020. *Shifting perspectives: insights from the Energy Policy Fellowships.* Cambridge: Energy- SHIFTS

Foulds, C., Royston, S., Berker, T., Nakopoulou, E., Abram, S., Ančić, B., Arapostathis, E., Badescu, G., Bull, R., Cohen, J., Dunlop, T., Dunphy, N., Dupont, C., Fischer, C., Gram-Hanssen, K., Grandclément, C., Heiskanen, E., Labanca, N., Jeliazkova, M., Jörgens, H., Keller, M., Kern, F., Lombardi, P., Mourik, R., Ornetzeder, M., Pearson, P., Rohracher, H., Sahakian, M., Sari, R., Standal, K. and Živčič, L., 2020. 100 *Social Sciences and Humanities priority research questions for energy efficiency in Horizon Europe*. Cambridge: Energy-SHIFTS.

Foulds, C., Bharucha, Z.P., Krupnik, S., de Geus, T., Suboticki, I., Royston, S. and Ryghaug, M., 2019a. *An approach to identifying future Social Sciences & Humanities energy research priorities for Horizon Europe: Working Group guidelines for systematic Horizon Scanning*. Cambridge: Energy-SHIFTS.

Øverland, I. and Sovacool, B.K., 2020. The misallocation of climate research funding. *Energy Research & Social Science*, 62, p.101349.

Robison, R. and Foulds, C., 2019. 7 *principles for energy-SSH in Horizon Europe: SHAPE ENERGY Research & Innovation Agenda* 2020-2030. Cambridge: SHAPE ENERGY.

Robison, R., Skjølsvold, T.M., Lehne, J., Judson, E., Pechancová, V., Foulds, C., Bilous, L., Büscher, C., Carrus, G., Darby, S., Demirbağ-Kaplan, M., Douzou, S., Drevenšek, M., Frantál, B., Guimarães Pereira, A., Hargreaves, T., Karvonen, A., Katzeff, C., Kola-Bezka, M., Laakso, S., Lettmayer, G., March, H., Parag, Y., Renstroem, S., Sáfián, F., Swora, M., Tjørring, L., van der Werff, E., van Vliet, B., Wallenborn, G., Wolsink, M. and Wyckmans, A. 2020. 100 *Social Sciences and Humanities priority research questions for smart consumption in Horizon Europe*. Cambridge: Energy-SHIFTS.

Ryghaug, M., Suboticki, I., de Geus, T., Loorbach, D., Foulds, C. and Bharucha, Z.P., 2019. *Terms of Reference: Energy-SHIFTS Working Group 4 – Transport and Mobility.* Cambridge: Energy-SHIFTS.

Ryghaug, M., Suboticki, I., von Wirth, T., Smeds, E., Scherrer, A., Foulds, C., Bertolini, L., Beyazit, E., Brand, R., Cohen-Blankshtain, G. Dijk, M., Freudendal-Pedersen, M., Gössling, S., Guzik, R., Kivimaa, P., Klöckner, C., Nikolova, C.L., Lis, A., Marquet, O., Milakis, D., Mladenović, M.N., Mom, G., Mullen, C., Ortar, N., Paola, P., Oliveira, C.S., Schwanen, T., Seidenglanz, D., Tuvikene, T. and Wentland, A., 2020. 100 *Social Sciences and Humanities priority research questions for transport and mobility in Horizon Europe*. Cambridge: Energy- SHIFTS.

Sovacool, B. K., Ryan, S. E., Stern, P. C., Janda, K., Rochlin, G., Spreng, D., ... and Lutzenhiser, L.. 2015. Integrating social science in energy research. *Energy Research & Social Science*, 6, 95-99.

von Wirth, T., Loorbach, D., Wagner, A., Koretskaya, O., Wade, R., Krupnik, S., Rudek, T., Foulds, C., Adem, C., Akerboom, S., Batel, S., Caspar Rabitz, F., Certoma C., Cherp, A., Chodkowska-Miszczuk, J., Denac, M., Dokupilová, D., Dotterud Leiren, M., Frolova Ignatieva, M., Gabaldón-Estevan, D., Horta, A., Karnøe, P., Lilliestam, J., Markard, J., Mišik, M., Mühlemeier, S., Nemoz, S., Nilsson, M., Osička, J., Papamikrouli, L., Pellizioni, L., Sareen, S., Sarrica, M., Seyfang, G., Smith Stegen, K., Sovacool, B., Telesiene, A., and Zapletalova, V., 2020. 100 *Social Sciences and Humanities priority research questions for renewable energy in Horizon* Europe. Cambridge: Energy-SHIFTS.

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