SHAPE ENERGY Reflexive Review of Interdisciplinary Working

SHAPE ENERGY

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Executive Summary

The main foci of SHAPE ENERGY are sustainable energy transitions. Energy transitions are challenging and multi-faceted phenomena as they entail not only technological but also social, political, ecological and related challenges. The complexities of such 'socio-technical' energy transitions require interdisciplinary working across a diverse range of disciplines; a grand challenge here is to bring together Science, Technology, Engineering and Mathematics (STEM) disciplines/sectors with energy-related Social Sciences and Humanities (energy-SSH) dimensions. This also includes consideration of projects and partners beyond academia. Within energy-SSH research and practice, interdisciplinary methodologies have often been left implicit, even though their general usefulness is acknowledged. More and more, however, there is awareness of the need for explicit evaluation of the opportunities for – and challenges of – interdisciplinary collaboration in energy research. SHAPE ENERGY has made it one of its priorities to include activities focussed on fostering interdisciplinarity and to facilitate reflection on the outcomes of this.

This report presents these outcomes with regard to three overarching methodologies applied in SHAPE ENERGY: (i) an academic literature review; (ii) a set of ethnographic observations of interdisciplinary interactions, and (iii) the method of 'reference problems' which brings together scholars around commonly shared scientific problems. With the help of these methods, in this report we show that:

1. Literature around collaborative research strategies in energy- and sustainability-related SSH (section 2) relates primarily to four types: (a) *Multidisciplinarity research* is characterised by gathering knowledge from various disciplines; (b) *Interdisciplinarity research* contains a certain level of disciplinary integration which requires more extensive cooperation; (c) *Transdisciplinary research* seeks to abandon disciplinary thinking and create boundary-crossing theories; (d) *Transformative science* takes an active role in initiating scientific change processes, focusing on joint learning of scientists and laypersons. What is missing is literature on how to translate these research varieties into academic practice, and the relevance of collaboration practices in relation to expected outcomes. We recommend careful consideration of the specific research question(s) being considered to assess which integrative measure(s) may be appropriate.

2. Ethnographic observation of participant interaction (section 3) took place during the SHAPE ENERGY summer school, and 17 multi-stakeholder workshops. Analysis of this data leads us to several conclusions regarding interdisciplinary working: (a) Working across disciplines requires clear objectives on all sides, which also includes allowing sufficient time for each discipline to produce a 'rigorous' and meaningful output; (b) Interdisciplinarity is paradoxical: it requires working to achieve an efficient integration of knowledge across disciplinary boundaries, yet also maintaining disciplinary depth of each individual contributor; (c) Inclusivity in interdisciplinary activities can be achieved through careful facilitation and design; (d) Interdisciplinary encounters in SHAPE ENERGY revealed that cultural assumptions underpinning interdisciplinary exercises often remain unconsidered. Instead, these should be explicated.

3. One way of pursuing interdisciplinary research is the application of 'reference problems' (section 4), such as in the SHAPE ENERGY Research Design Challenge (RDC) and the Think Piece Collection (TPC), which invited European scholars to work together on interdisciplinary essays. Reference problems allowed authors writing on numerous energy SSH themes to come together around three scientific problems, which we explicitly link to *control, change and capacity-building* in energy systems. Authors across the TPC and RDC addressed similar energy-related topics, although they partially related to different reference problems. Topics included: *renewable energy development in local communities and society*, *reducing the social costs of the energy transition*, and *energy behaviour and decision-making*. Researchers developed their collaborative designs through focusing on the underlying reference problem, and not their personal academic background. Based on these experiences, we recommend the systematic use of this approach in the European SSH and STEM communities, as our evaluation shows it to promote *problem-driven* interdisciplinary research, prioritising the scientific problems behind the energy transition instead of disciplinary preoccupations.

Contents

1. Introduction

The main focus of the SHAPE ENERGY Platform[1] is the transition towards a sustainable system of energy provision and consumption. This transition is a challenging and complex issue as it entails not only techno-economic but also social, political, ecological and other challenges. Therefore, it is widely discussed that innovative research is needed to address the varied dimensions and to some extent that this research needs to inform and be informed by societal dynamics. It is often argued that research needs to bring together a diverse range of disciplines, whereby a grand challenge is to bring together Science, Technology, Engineering and Mathematics (STEM) disciplines and sectors with energy-related Social Sciences and Humanities (energy-SSH). SHAPE ENERGY was designed in part to highlight the value of energy-SSH to potential users such as scientists and policymakers, but also to bring together the individual SSH disciplines in collaborative research for impactful outputs and greater visibility. The latter is increasingly acknowledged as essential (e.g. by the European Commission, 2018) to enhance our understanding of 'human factors' in energy transitions.

The challenge of such interdisciplinary[2] collaboration between STEM and SSH, or within SSH disciplines, has been a preoccupation of recent academic work and a driver of new research alliances within and across universities who are reacting to the changing demands of meeting cross-cutting societal challenges (cf. Büscher, Schippl and Sumpf, 2018, p. 4). There is a growing literature on interdisciplinary SSH research from, e.g. economists, historians, political scientists, and sociologists (cf. Sovacool and Hess, 2017). Typically, SSH approaches discuss the relationship between social and technical realities as well as the dynamics and political dimensions of innovation, e.g. with reference to institutions (Fuenfschilling and Truffer, 2014; Smith, Stirling, and Berkhout, 2005; Carlsson and Stankiewicz, 1991, 109) and systemic change (Geels, 2004).

Interdisciplinary methodologies are however often left implicit in energy-related SSH contributions in that collaboration between different sectors (e.g. multiple institutions) or disciplines (e.g. technology, economics, sociology) is assumed but not necessarily examined in-depth. More and more, however, there is awareness of the need for explicit evaluation of the opportunities for and challenges of interdisciplinary collaboration (e.g. Geels, Berkhout, and van Vuuren 2016). SHAPE ENERGY has made it one of its priorities to include activities focussed on fostering interdisciplinarity and to facilitate reflection on the outcomes of this. The following sections 2-5 of this report therefore offer analytical and practical discussions of interdisciplinarity as applied to SHAPE ENERGY which lead to wider lessons for readers to take away. As implied earlier, we use the term 'interdisciplinary' to encompass both engagement between different academic disciplines and knowledge bases and also 'intersectoral' collaboration. In many of our activities, as indicated in the respective sections below, participants represented different societal sectors (such as politics, business, NGOs) rather than disciplines in the academic sense.

This SHAPE ENERGY review of interdisciplinary working therefore reports on our qualitative evaluation of SHAPE ENERGY activities, which have been designed to facilitate and enhance interdisciplinary working. These activities included an exploration of relevant literature, an early stage researcher (ESR) summer school and internship placements, multi-stakeholder workshops across 17 European cities, a 'Research Design Challenge' and collection of 'Think Pieces' collaboratively written by energy-SSH authors. Our intention in this report is not to outline the detailed outcomes of each of these activities but specifically to explain and evaluate the processes of interdisciplinarity involved.[3] The title refers to a 'reflexive' review; by

1 A €2m EU Horizon 2020 funded Platform (2017-2019) *Social sciences and Humanities for Advancing Policy in European ENERGY*, see www.shapeenergy.eu.

2 The term 'interdisciplinary' is used in this report, where not otherwise specified, as an umbrella term for cooperation of different academic disciplines and/or working sectors. There are academic distinctions between this term and 'multi-' or 'transdisciplinary' which are discussed in detail in section 2. This strict usage is most relevant in concrete research undertakings, which we indicate in the overall conclusions.

3 Most of these SHAPE ENERGY activities feature their own deliverable reports, which can be accessed through our website www.shapeenergy.eu. Thus, not every detail with respect to the individual activities is repeated in this report.

this we mean that we will, through systematic and dialogic reflection on our experiences of delivering the project, draw out lessons that can be taken forward into future work on energy.

A feature of the SHAPE ENERGY project was not only the number but also the variety of activities it supported. It was appropriate therefore to apply a mixture of evaluation methods. Specifically then, we undertook:

1. A *literature review of collaborative research strategies in energy and sustainability related SSH* including multidisciplinary, interdisciplinary, transdisciplinary and transformative research. We present an overview of such collaborative research strategies, which is a summary from a larger report being published separately by SHAPE ENERGY. This section provides a helpful introductory overview of conceptual understandings and the practical challenges involved, helping to situate our subsequent analyses of participant observation of interdisciplinary engagements (section 3) and evaluation of interdisciplinary production (section 4).

2. *Participant observation of SHAPE ENERGY face-to-face activities.* One aim of the SHAPE ENERGY project was to develop methods for, and implement, a reflexive review of interdisciplinary working during key face-to-face project activities. This will potentially be of use to other projects and initiatives wishing to undertake qualitative evaluations. The central approach used to do this was through participant observation of certain face-to-face and diary-based platform activities, drawing on ethnography. The usefulness of these methodologies in identifying issues pertaining to interdisciplinary working is also reflexively reviewed, leading to lessons for future evaluations.

3. *Cognitive integration of interdisciplinary production – The SHAPE ENERGY Think Pieces and Research Design Challenge.* SHAPE ENERGY also commissioned a number of interdisciplinary SSH outputs. This section of the report evaluates two of these products in comparison: a collaborative multi-author Think Piece Collection (TPC) and a Research Design Challenge (RDC). The TPC is in the foreground in this report, since the RDC has also been evaluated separately (cf. Sumpf and Büscher, 2018). The TPC embodies an attempt to advance energy policy through integrating social sciences and humanities, as a method of interdisciplinary cooperation.[4] In total, 10 pieces (involving 50 researchers) were commissioned following a call for papers[5] investigating three major domains: 'Energy as a Social Issue', 'Social Sciences and Humanities in Interdisciplinary Endeavours', and 'Interplay with Energy Policymaking Environments'. The RDC involved 31 researchers based in numerous different European countries and representing 16 SSH disciplines collaborating through use of SHAPE ENERGY funding to develop 13 research designs according to the pre-set energy challenges. The TPC is here evaluated using the conceptual approach of 'reference problems', which has previously been applied to the Research Design Challenge (RDC). Reference problems concern the cognitive (as opposed to normative or organisational) integration of diversified research settings through connecting research to commonly shared scientific problems, while partner autonomy is preserved. This section features both an individual TPC analysis and a comparison between TPC and RDC contributions across the reference problems of control, change and capacity-building.

In the various conclusions subsections (2.5, 3.6, and 4.3) and then in section 5, we address energy researchers, policymakers and practitioners with a professional need and/or interest in interdisciplinarity. We offer practical applications of concrete methods, lessons learned, and advice on the pitfalls readers might encounter when engaging in interdisciplinary research and/or intersectoral collaboration. Our results may also be useful for future design of EU research policy and/or funding calls associated with the design of interdisciplinary working.

Section 2 of this report was authored by Ruth M. Mourik and Yvette Jeuken; section 3 by Nathalie Ortar, Pauline Claudot, Rosie Robison, and Ruth M. Mourik; section 4 by Patrick Sumpf, Carina Mnich, and Christian Büscher. Patrick Sumpf coordinated the overall report.

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4 Full title: "Advancing Energy Policy – Lessons on the Integration of Social Sciences and Humanities". See: https://link.springer.com/book/10.1007/978-3-319-99097-2#toc [Accessed 20 November 2018].

5 https://shapeenergy.eu/index.php/activities/think-pieces/

2. An SSH literature review of collaborative research strategies within energy and sustainability

2.1. Introductory remarks

One ambition of SHAPE ENERGY is to bring together the energy-SSH knowledge available, and create opportunities for energy-SSH researchers and 'users' of research (e.g. practitioners, policymakers) to reflect on the co-production of knowledge in different settings. SHAPE ENERGY also aims at getting to know what is needed to make different forms of collaborative research successful (i.e. multidisciplinary, interdisciplinary/cross-sectoral and transdisciplinary or even transformative ways of working), and what their potential contribution and needs with respect to shaping the European energy agenda could be. The aim of this section is to briefly review existing academic literature around the need for and contribution of a better integration of SSH in the energy field, including collaboration with other types of knowledge, to discuss what type of integration might be needed in different settings, how to best organise these processes and how to measure the impact and quality of these types of collaborative research. See the full background report for a more extensive discussion[6].

To answer the above questions, we first aim to gain conceptual clarity, i.e. briefly identify various key concepts of collaborative research: multidisciplinarity, interdisciplinarity, transdisciplinarity and transformative science. Building on these various concepts and their strengths and weaknesses, we then discuss factors that have been found to have an influence on the feasibility and desirability of working collaboratively. We also discuss the gap that often exists between the ideal type (or archetype) of collaborative research, and actual practice. We then focus on the challenge of measuring (monitoring and evaluating) and learning about the impact of collaborative research, before giving our conclusions and recommendations.

2.2. Concepts and context

This subsection discusses various concepts of collaborative research, aiming to exemplify that each of these models can be appropriate depending on the circumstance. This discussion is not aimed at providing a ranking of approaches, e.g. with transformative science as the gold standard. Instead it invites for a reflexive discussion on the usefulness and necessary preconditions for each individual concept. We map the different concepts by discussing issues around inclusion, integration, research outputs and usability, strengths and weaknesses.

2.2.1. Multidisciplinary research

Multidisciplinary research is the most common work-mode in academia, especially in temporary work-settings such as project funded research. In theory and in practice: *"Multidisciplinary research arises when multiple researchers investigate a single problem, but do so as if each were working within their own disciplinary setting"* (Miller et al., 2008, p. 5). Multidisciplinary research is thus characterised by gathering knowledge from various disciplines, enriching the knowledge about that problem by adding multiple views, but without crossing disciplinary boundaries (Klein, 1990; Stock and Burton, 2011). The organisation of multidisciplinary research (projects) is usually built around an overarching theme and allows for the co-existence of multiple goals relevant to different disciplines within one project. Research output can be characterised as a bundling of expert opinions offering a kaleidoscopic perspective on a specific topic, which is a clear improvement compared to single discipline research. However, research outputs in multidisciplinary projects, often mainly accessible to academics, do not provide a coherent picture of how societal challenges can be dealt with. By its nature, the collaborative effort is not focussed on confronting differing expert opinions, nor on creating a shared language or a common problem definition (Miller et al., 2008). A process of inclusion and exclusion is

6 Jeuken, Y.R.H., and Mourik, R.M., forthcoming. *Collaborative research strategies in energy and sustainability related Social Sciences and Humanities: A literature review and practical guide.* This report also includes a detailed and graphical representation of the four different collaborative research forms discussed here, and their distinctive elements.

present to some degree, in the selection of disciplines and perspectives that are invited to multidisciplinary projects, consortia and research groups, but in general such negotiations take place beforehand and not during the course of the research process, and reflexive discussions on the value of different disciplines thus do not occur during the research. Multidisciplinary research is probably the most common collaborative approach because it requires less organisational effort compared to approaches that aim for integration of disciplines, such as interdisciplinary, transdisciplinary and transformative research. Multidisciplinary research still fits well with the organisational rationality of academia (which is biased towards disciplinary research, e.g. opportunities for funding, publications, tenure tracks), which is a conducive factor in facilitating the popularity of multidisciplinary working (Winksel, 2014; Winksel, 2018).

2.2.2. Interdisciplinary research

Interdisciplinary research is distinctively different from multidisciplinary research, in the sense that there is a certain level of disciplinary integration which requires more extensive academic cooperation than is common to multidisciplinary research (Stock and Burton, 2011). Interdisciplinary research is, according to the widely supported definition of interdisciplinarity by Klein and Newell (1996, p. 395): *"a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline or profession. Interdisciplinarity studies and draws on disciplinary perspectives and integrates their insights through construction of a more comprehensive perspective"*. Cooperation between neighbouring and subdisciplines is often easier than transcending 'distant' disciplines because discussions on methodology, relevant knowledge, data, research procedures and terminology are often less conflicting. One of the biggest challenges in interdisciplinary research is achieving effective communication between experts from different disciplines. Misunderstanding and misconception can endanger the quality of research output. Common understanding derived from a shared language furthermore plays a vital role in enhancing the relations of trust that are necessary for effective interdisciplinary working (Bracken and Oughton, 2006). A project coordinator must therefore be capable of coordinating the necessary internal discussions and create a level playing field amongst (project) participants and be able to let them confront, debate, and negotiate ideas and perspectives in order to facilitate sufficient integration of knowledge. Interdisciplinarity ideally is open to the inclusion of different theories and methods. Contrary to multidisciplinary research, negotiations concerning the inclusion or exclusion of diverse disciplines and perspectives not only take place before the formation of a consortium or research group, but are at the core of an iterative and ongoing process. This negotiation between disciplines is central to the development of more integrated research perspectives, thus providing a more comprehensive perspective on the societal challenge to be solved. The output of multidisciplinary research and interdisciplinary research is often knowledge, targeted at academic audiences, and measured along academic evaluation standards (e.g. articles in peer-reviewed journals).

If the negotiation process is not well-coordinated, then research outcomes may not be sufficiently comprehensive and may not provide new knowledge. Interdisciplinarians believe that research should be evaluated solely in terms of whether it contributes to our collective understanding (Szostak, 2007a; Szostak, 2007b), or comprehensive problem solving, and as such the receiving audiences are still often to be found in academia, but also policy and society. Despite the omnipresent use of the concept, Stock and Burton (2011) argue that researchers often claim or aim to work interdisciplinary, while in reality work with projects that are multidisciplinary with little integration of disciplines and cooperation, for example limited to providing different disciplinary perspectives on the same problem.

2.2.3. Transdisciplinary research

At first sight it is difficult to mark a clear boundary between interdisciplinary and transdisciplinary research with *"the boundaries between interdisciplinary and transdisciplinary projects [being ...] diffuse and dependent more on a subjective judgment on the level of holism applied than on the presence of clear boundary markers"* (Stock and Burton, 2011 p. 1102). However, there are a number of characteristics that make transdisciplinary research distinctively different from interdisciplinary research. Similarly to interdisciplinary research, transdisciplinary research tries to avoid one discipline or sector taking precedence over another. Transdisciplinary research

however, seeks to abandon disciplinary theories altogether and instead create boundary-crossing theories and models, thus developing permanent new collaboration spaces (Luederitz et al., 2016; Stock and Burton, 2011; Thompson et al., 2017). In addition, contrary to interdisciplinary working, transdisciplinarians require collaboration beyond academia by including a diverse range of actors from different sectors (e.g. policymakers, end users, practitioners, citizens) to be able to adopt a holistic approach. Moreover, the research design of transdisciplinary research, and the definition of relevant knowledge and problem definition, involves a participatory process in which non-academic actors are invited to co-create and co-produce knowledge (De Boer et al., 2006) such as through real-world laboratories (field labs, social labs, living labs) in which experiments take place. The output of transdisciplinary research is usually more diverse than interdisciplinary output, for the exchange of knowledge not only feeds into research papers and scientific reports but also seeks to influence the decision-making capacity (when policymakers are included) or the actions of other stakeholders (Stock and Burton, 2011; Walter et al., 2007). Although common, there is however no explicit requirement for transdisciplinary research to produce results that can be implemented (Höchtl, Lehringer and Konold, 2006; Jackson, 2006). Reflexivity concerning the processes of research and knowledge production is however deemed a key mechanism for levering a transformation in sustainability (Daedlow et al., 2016). According to some, *"transdisciplinary models of research are increasingly upheld as the gold standard of collaborative science to solve complex social and environmental problems, promising to 'close the gap' between knowledge and action, inject science with greater accountability, democratic participation, and include stakeholders as practitioners of research"* (Klenk and Meehan, 2017, p. 27). Stock and Burton however, having analysed these collaborative forms in practice, caution that *"transdisciplinary [...] research is an exception, even interdisciplinarity is seldom reached"* (Stock and Burton, 2011, p. 1098).

2.2.4. Transformative science

Transformative science is a concept that delineates a new role of science and the scientific system, which goes beyond observing and analysing, and co-creating, but rather takes an active role in initiating and catalysing change processes with the explicit aim of achieving a deeper understanding of ongoing transformations – in the sense of including all relevant forms of knowledge, not only academic, but also sectoral and lay – as well as increasing societal capacity for reflexivity with regard to these fundamental change processes (Schneidewind et al., 2016). Simultaneously, transformative science reflects on the fundamental role and function of science within society and the need for change of the scientific practice itself, not only in delivering new disciplines (such as ideally occurs in transdisciplinary collaboration). The development towards transformative science has been catalysed by the felt (negative) societal impact of technical innovations and scientific knowledge-production. Especially critical are those types of technological innovations that deeply interfere with natural and human systems and produce unintended and often irreversible ecological and social side effects (Beck, 1986). From a methodological point of view, transformative research builds on and makes use of a broad repertoire of research approaches and disciplines, which focus on joint social learning of scientists and laypersons, such as transdisciplinary case studies, participative action research, intervention research and transition research (Schneidewind et al., 2016). The most distinctive aspects of transformative science is its normative agenda. Similar to transdisciplinary research, transformative science takes place in real-world laboratories (Schneidewind et al., 2018). Research is then conducted through, alongside and guided by, the implementation of innovative interventions. The output of transdisciplinary and transformative research is usually more diverse than multi- and interdisciplinary research in terms of contributors, audiences and format.

2.3. Making collaborative research concepts work in practice

This section briefly addresses the (pre-)conditions the various different concepts of collaborative described above need in order to be translated into successful modes of working in practice, with output that meets the needs of the users. Some of these (pre-)conditions are relatively easy to put in place, whilst others require long-term investments in terms of time, coordination efforts, negotiations, or even changing funding, academic reward and/or publishing systems. For example, with respect to interdisciplinary, transdisciplinary, and in particular transformative science, short and long-term changes and investments are necessary because for these types of research to succeed it is not simply a matter of *"assembling the 'right' object, method or team"* (Klenk

and Meehan, 2015, p. 162). Below, based on a literature review, we identify a selection of (pre-)conditions that affect the different elements of the collaborative research forms elaborated here, such as integration of knowledge, methodologies, creating more holistic output etc.

First, there are **philosophical conditions** such as epistemology and methodology which often determine how a problem is framed or how the collaboration is structured. Another philosophical condition relates to the roles and responsibilities of science in and for society. Depending on what this role and responsibility is considered to be, the set-up of the collaboration may differ. In general philosophical conditions can directly result in tension or confrontation between different disciplines and stakeholders. In such confrontations, basic assumptions about what counts as knowledge, appropriate theory, methodology, norms and values are challenged, and this tension consequently requires researchers and other stakeholders to be able to (collectively) reflect on a meta-level on their research (position). One particularly important philosophical issue mentioned in the literature is how the integration between disciplines may suffer from *"disciplinary chauvinism"* where another discipline is being treated as *"secondary and peripheral"*, often negatively affecting the social sciences (Sovacool et al., 2015, p. 96). Other philosophical conditions influencing the set-up of collaborative research are for example the preference amongst funders and policymakers for (perceived) 'solid data' based on representative samples, and replicable research designs (Rau, Goggins and Fahy, 2018), or that the open and deliberate discussions needed to allow for a negotiation of researchers' values stand in stark contrast to the traditional approaches in which researchers endorse and value disciplinary assumptions (Miller et al., 2008).

An important issue to mention is that the need to integrate research is sometimes overemphasised and has become a goal in itself, assuming that confrontation and challenging of norms and values is necessary for the critical reflection needed when dealing with wicked problem (Schuitema and Sintov, 2017; Stock and Burton, 2011). Energy and sustainability transition challenges in the broader sense are often characterised as 'wicked problems' because a complete understanding of the problem(s) is lacking, and consensus regarding the potential solutions is very challenging. It is a contested field in which (social-cultural) norms and values play a role as well as a wide range of diverse stakeholders, political-institutional arrangements and other factors. The, necessarily experimental, nature of collaborative research requires a reflexive and continuous iterative learning process as a transversal aspect at the core of research projects (Luederitz et al., 2016; Popa, Guillermin and Dedeurwaerdere, 2015). The need for this reflexivity thus holds especially for complex and controversial socio-ecological issues such as many of the energy problems SSH is researching (Shove, 2004; Stock and Burton, 2011).

Then there are **organisational conditions** that affect the set-up of in particular inter- and transdisciplinary and transformative collaborative research. These are structural and operational elements of both the organisation of the academic communities as well as the organisation of funded research e.g. job requirements, status, nudges and rewards, financial opportunities. These elements are important for the ability to engage in collaborative research. One important condition is the reward system. Because of a bias towards conventional performance standards used by many universities, researchers often prefer to produce research outputs as close as possible to the disciplinary focus of their department. Otherwise it might affect their career prospects, which is especially the case for early-career academics. Requirements for tenure track are for example biased towards disciplinary research (Schuitema and Sintov, 2017). But the system of publishing in peer-reviewed journals (Klenk and Meehan, 2015; Rau, Goggins and Fahy, 2018; Stock and Burton, 2011) and the fact that qualitative and less tangible results are often excluded from evaluations and rankings, also creates a bias towards disciplinary approaches, especially impeding the collaboration between very distant disciplines (Schuitema and Sintov, 2017). Other issues include the fact that funding opportunities and criteria are still pre-dominantly disciplinary (Rau, Goggins and Fahy, 2018), although some movement towards more interdisciplinary types of funding is certainly being witnessed, or that reviewers for funding bodies often have disciplinary expertise and are therefore not fit to review proposal on all aspects (Schuitema and Sintov, 2017). Overall, the lack of a framework defining how to assess quality standards and to monitor and evaluate collaborative research processes and their outputs is potentially one of the biggest impeding organisational conditions.

Social and relational conditions are the next set of influential (pre-)conditions that affect the set-up of more integrated types of collaborative research. These include the norms and values within academic communities and how these affect social relations and work processes such as inclusion and exclusion mechanisms. This

includes processes concerning: Who is invited to join, and who is not? Is a diversity of perspectives represented in the research collaboration and common output? How are ideas, interests and perspectives negotiated? A lack of diversity of (research) perspectives can be a particular problem in cross-cutting areas such as the energy transition (Rau, Goggins and Fahy, 2018). Current participation procedures – including participation in academia – can be discriminatory towards less visible groups, in part since invitations often happen through personal networks and befriended colleagues (Popa, Guillermin, and Dedeurwaerdere, 2015). An important requirement for collaborative research aimed at integration of disciplines is the need for building trust and shared understanding between the participating researchers and other stakeholders. Trust requires a level playing field with regard to knowledge forms, perspectives etc., and a shared understanding about the relevance of each involved discipline and type of knowledge (Stock and Burton, 2011; Klenk and Meehan, 2015). These requirements are generally more challenging in heterogeneous research settings. Another issue is that non-academic knowledge contributors (i.e. practitioners) are generally less used to working with and applying academic knowledge, so that it may not be clear how they can target academic audiences (e.g. which communication channels, how to tailor information). Moreover, non-academic audiences are generally less valued by academics (Rau, Goggins and Fahy, 2018). Hence, academics may lack motivation to engage in collaborative research efforts especially when it does not directly contribute to their academic career (Klenk and Meehan, 2015).

A last category is that of conditions related to **skills and competencies,** which refer to the qualities and capacity of individual researchers to engage in collaborative research. Besides the qualities one needs to be a good researcher, collaborative engagements require social competencies with respect to functioning in or coordinating and moderating group dynamics (which may be conflict-laden because of the different disciplinary and sectoral knowledge), as well as competencies related to communication and outreach skills. Having the right skills (individual, or collectively in a project) influences the willingness of others to engage in collaborative research. What can be concluded here is that in academia there are limited training opportunities with respect to acquiring the above-mentioned relevant skills to participate in collaborative research (Rau, Goggins and Fahy, 2018).

2.4. Frameworks to design, monitor and evaluate collaborative research

Given the increasing interest in collaborative working mechanisms, there is an increasing amount of academic literature that seeks to offer quality assessment frameworks to monitor and evaluate collaborative research, and transdisciplinary and transformative science in particular, however these are not standardised and a widely agreed upon comprehensive framework for quality assessment is currently lacking (Bark, Kragt, and Robson, 2016; Miller et al., 2008; Miller, Muñoz-Erickson and Redman, 2011; Luederitz et al., 2016; Popa, Guillermin, and Dedeurwaerdere, 2015; Rau, Goggins and Fahy, 2018; Schneidewind et al., 2018). This hampers, firstly, the ability of researchers to design an approach for collaborative research that fits the problem or challenge and the necessary outputs. But further, it hampers the ability to monitor the collaboration process, and evaluate the quality of the outputs or outcomes. The fact that collaborative processes are also often reflexive learning processes, about for example the validity of knowledge or perspectives, increases the complexity of monitoring and evaluation.

The potential first step towards a framework is to reflect on a set of guiding questions (which we have derived from literature) that may help to decide what type of research format is most suitable in light of both the problem and the required output. These can be summarised as shown in the following Box 1. Answering these questions may help to identify what type of collaborative research is most suitable.

Box 1. Guiding questions for collaborative interaction design

1. What are the research goals and ambitions?
2. What type of research output and outcomes are needed and/or required?
3. What kinds of audiences are targeted?
4. Is the inclusion of other disciplines and/or sectors necessary? Which ones and why?
5. Is experimentation necessary to achieve better research outcomes?

In addition, a framework might focus on the set of four (pre-)conditions highlighted earlier affecting the set-up and output of collaborative research. These were: (1) philosophical, (2) organisational, (3) social and relational, and (4) skills and competencies. A framework could be used to determine what aspects of these conditions are needed and if they are sufficiently present. In the full background report[6], we discuss for each of these conditions the elements of a quality assessment framework to aid with the monitoring and evaluation of the collaborative process.

An additional difficulty with setting up a quality assessment framework is that multidisciplinary and interdisciplinary forms of research are more likely to be concerned with a particular problem that can be understood and solved through setting up a pre-defined methodological procedure (which is seen to be reliable and can be validated), and for which in one sense an unambiguous quality assessment framework is possible. Unfortunately, the quality of transdisciplinary and transformative research cannot be as easily determined by defining pre-set robust procedures, solid methodologies and predictions based on a quality assessment framework. This is because transdisciplinary and transformative research processes are more diverse (and open-ended) in terms of theory and method.

The main challenge is therefore, to create a framework for reflective, iterative and open questioning of the quality of the research and the work process (Lemos and Morehouse, 2005). Iteration is key to sustain the research quality, accountability and relevance of collaborative research.

2.5. Conclusions and recommendations

In this last section we briefly discuss conclusions that can be drawn from our reviews, and provide some recommendations for European policymaking in particular.

SSH-energy research is concerned with both researching and intervening in a multitude of relevant energy issues, often with respect to addressing climate change challenges. Thus collaboration between the relevant institutions, technologies and infrastructure that shape the energy system is a necessary condition for effective interventions in practice (Schuitema and Sintov, 2017). The validity of energy-SSH research furthermore increases through collaborations with other disciplines, experts, stakeholders, and end-users, because these engagements help to expose 'errors and irregularities' in commonly shared assumptions, norms and values (Schuitema and Sintov, 2017). We can also conclude that there is not yet a broad base of literature available reflecting on how to translate this need into practice in the field of energy-SSH research (e.g. proposed frameworks, quality standards).

Integration has become a 'gold standard' in research and policy. However, especially given the difficulty in setting up functioning collaborative processes aimed at integration, we have to remain critical regarding the usefulness, need and relevance of any form of integration and or collaboration in relation to the quality of the outcome sought. We also have to remain aware of the political process of inclusion and exclusion of disciplines and types of knowledge that will influence outputs/results. What can be concluded is that knowing what type of integration or collaboration is needed, how many stakeholders need to be involved, and if and how iteration may be necessary, are all closely connected to the question of why one collaborative research format may be

more appropriate than another one. These questions and their answers are so context specific that we cannot provide an a priori answer. Asking what type of integration or collaboration is needed (e.g. methodology, epistemology, and procedures) to tackle the energy challenges we are facing, is thus not fruitful. Although, an archetype matrix connecting each type of collaborative research with certain energy challenges is a valuable addition (to be found in the full background document[6]), due to the fact that both the circumstances in which the research is conducted (context, time, funding, organisational level, etc.) as well as what is required from investigating a specific research question influences the usability of different collaborative forms. This is a question that can only be answered in situ.

Project proposals should therefore be explicitly invited to discuss exactly what type of collaborative working they seek, and why and how they are going to set this up, and also why they exclude other types of collaborative working, so that they really demonstrate reflexive thinking about the collaborative research processes they set up. This includes explicit statements on process requirements with respect to the inclusion or exclusion of diverse perspectives at the beginning of the process as well as during the process, and how a level playing field will be guaranteed as to ensure a safe space in which relationships of trust can be built to negotiate and deliberate ideas and perspectives. This should be part of the concept, impact and implementation sections of 'interdisciplinary' European proposals.

What we have seen in the literature is that the terms multidisciplinary and interdisciplinary are often used almost interchangeably, although there is great difference. In practice, interdisciplinarity is rather challenging because many conditions need to be in place to allow for a good collaborative process. We recommend that more attention is paid to these necessary conditions in the design of the management of projects, in particular those related to creating a safe learning environment necessary to create relations of trust. This means for example that the project coordinator and Work Package leaders need to demonstrate expertise and skills of working with conflict-laden and reflexive processes and internal evaluation structures should be in place (e.g. supervision). Time and resources should be available to create positive learning experiences in a safe setting.

As discussed, the necessarily experimental nature of integration focussed collaborative research requires a reflexive and continuous iterative learning process. This means that the management of projects should be reflective, iterative and open for change and failing should be allowed, as long as learning from failures is facilitated. This is however not the usual approach in H2020 and similar types of funded research programmes in which payment depends on concrete results and not lessons learned. This paradigm of efficiency and effectiveness hampers real learning curves and underscores the uncertainty and contingency of (innovative) experimentation. The review processes could allow for more experimentation with the use and usefulness of SSH in projects by valuing 'successful failures', as long as reflexive learning documents based on internal process evaluations are produced. This is also important to guarantee a self-critical, reflexive and independent attitude of researchers in light of their dependence on subsidies/funding that should lead to usable and practical results.

Another issue is that it is relatively difficult to measure some impacts, e.g. capacity-building and learning among the public, private and civil society actors who may participate in research. Measuring the impact of deliberation, change in people's perspectives, ideas and convictions and the creation of shared goals and meaning is equally challenging, and efforts should be directed in creating effective monitoring and evaluation of these intangibles. This difficulty in measuring impact also applies to impacts such as a sense of shared ownership, the creation of more egalitarian work methods, feeling of having a shared goal and real meaning, institutional investment and personal commitment (Thompson et al., 2017). Many of the impacts of collaborative research only become apparent after a certain time frame, such as the formation of new consortia (Schneidewind et al., 2016) and cannot be monitored directly. This challenge of measuring impacts is indeed witnessed in the review of interdisciplinary working in SHAPE ENERGY in subsequent sections, including at face-to-face meetings.

The uptake and usage of the outputs of collaborative research, especially in policymaking, is another important issue that needs further discussion. Often responsibility for the uptake of this knowledge and output is placed on the researchers. However, Rau, Goggins and Fahy (2018) ask the legitimate question if instead *"[...] should more time and resources be allocated to policymakers for integral evidence-based policies"* (Rau, Goggins and Fahy, 2018, p. 268). Hence, more research is needed to map the social, cultural and political barriers for access and usage of scientific knowledge by policymakers, practitioners and other diverse publics.

3. Using participant observation in SHAPE ENERGY activities to evaluate interdisciplinarity

3.1. SHAPE ENERGY's three participant observation approaches

A central approach SHAPE ENERGY used to implement its reflexive review of interdisciplinary working was through *participant observation*, undertaken at several of our face-to-face platform activities, which are a set of methods informed by ethnographic research. Thus tailored materials (including diaries and observation sheets with written prompts) for recording observations were developed, to be completed by partners and SHAPE ENERGY associates as part of our Early-Stage Researcher Programme (summer school and internships) and multi-stakeholder workshops. Each of these activities (which are the subject of individual detailed reports[7]) deliberately brought together individuals and organisations representing different disciplines or sectors, and thus enabled gathering of insights into how interdisciplinary working (aimed at integrating perspectives, methods etc.) contributes to the impact of energy research.

Ethnography is an immersive methodology to collect data through observations, interviews, and textual analysis. Given the rich data it generates, analysis tends to be rich, qualitative and descriptive (Alpert, 2016), which brings with it accompanying challenges in reviewing or measuring impact as discussed in the previous subsection 2.5. Participant observation (Agar, 1996), one area of ethnographic field research found mostly within Anthropological and Sociological research, involves methods through which an investigator ('participant observer') studies the interaction of a group whilst also participating in its activities. It can provide insights into contexts, relationships and behaviours which would not be possible either through interviews/data collection at a time removed from the activity of interest, or by those who have not been part of interactions. Participant observation can be very valuable to observe processes of cooperation and domination – whether gendered, geographical, or disciplinary, for example. The position of the observer is not neutral, and requires a reflexive position that takes into account the observer's own cultural conditioning, and their epistemological and political forces. In short, the observer always observes from a situated point of view that influences the nature of their observations and their own role impacts the observation results.

Three specific methods were designed, appropriate for each of the three observed activities, as described in the upcoming sections: (i) embedded ethnographers, (ii) autoethnographic diaries, and (3) structured participant observation templates. These methods specifically focussed on issues of power and inclusion (or *dominations*), i.e. how do differences in gender, institutional and disciplinary affiliation, and seniority, influence the dynamics of collaboration. As discussed in the previous subsection 2.3, social and relational conditions are influential (pre-)conditions that affect the set-up of more integrated types of collaborative research. Exclusion mechanisms (Who is invited to join and who is not? Representation of perspectives in collaboration and outputs) have been found to affect the impact of collaboration (Rau, Goggins and Fahy, 2018) and the need to assess inclusion and/or domination may also assist in avoiding discriminatory outcomes with regards to less visible groups, organisations and researchers (Popa, Guillermin, and Dedeurwaerdere, 2015).

Importantly, the roll-out of participant observation in SHAPE ENERGY was much broader in scope than may be traditionally the case for these in-depth methodologies. In particular the workshop methods needed to be applied across a variety of cultural contexts, and in many cases carried out by those who may not have utilised (or even come across) these methods before, or indeed may not be very familiar with energy-SSH more broadly. Finally, the analysis was not carried out by those undertaking the data collection, in contrast to common practice. This was therefore to some degree experimental and therefore the effectiveness of our innovative participant observation methods employed was also evaluated (see subsection 3.5).

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7 See (1) Ortar, N., Burguet, D., Claudot, P. and Foulds, C. 2017. *The SHAPE ENERGY Summer School - interdisciplinary debates with PhD researchers.* Cambridge: SHAPE ENERGY. (2) Ortar, N., Burguet, D., and Robison, R., 2018. *Bringing Social Sciences & Humanities into H2020 energy projects: Early-Stage Researcher internship diaries.* Cambridge: SHAPE ENERGY. (3) Robison, R., Dupas, S., Mourik, R., Torres, M., and Milroy, E., 2018. *Europe's local energy challenges: stories and research priorities from 17 multi-stakeholder city workshops.* Cambridge: SHAPE ENERGY

3.2. ESR summer school

The SHAPE ENERGY H2020 platform encompassed two activities as part of a dedicated Early-Stage Researcher (ESR) programme. We first describe the ESR summer school activity, and in doing so implicitly respond to the five 'guiding questions for collaborative interaction design' as described in subsection 2.4 (p. 11) regarding the activity's: goals, planned outputs, audiences, inclusion necessary, and experimentation dimensions. (In subsections 3.3 and 3.4, we do this similarly for the other activities described).

The 5-day Summer School (June 2017; Lyon, France) gathered people from across and beyond the European Union (including Iran, USA and China) and focussed on how energy-SSH research can contribute to tackling the many energy-related challenges in Europe. The summer school programme was designed to address three objectives. These were for its participants:

1. to become familiar with key issues for future EU energy research and, in particular, how they are addressed by various disciplines;
2. to learn more about the working and possibilities of *interdisciplinary* investigation;
3. to develop an understanding of how various stakeholders address the question of energy; and
4. to get an understanding of what *transformative science* can be.

There was thus an explicit emphasis on reflecting on *interdisciplinarity* (e.g. through practical group exercises) and on the translation of academic research into policy and practice. Overall the programme was designed as an opportunity for participants to reflect on how to frame questions that help SSH become embedded into existing energy initiatives, encouraging interdisciplinary depth around problem-centred working (Sovacool et al., 2015). The summer school also facilitated networking amongst the ESRs who came from a large range of geographical and disciplinary backgrounds. Therefore the actual experience was primarily a *multidisciplinary* one, enabled by exposing the students to a wide range of disciplines including: Human Geography, Economics (issued from several different theoretical backgrounds), Social Psychology, Political Sciences, Sociology, Anthropology, Communication Sciences, Management Sciences and Engineering Sciences. An understanding of how to put *transformative science* into action was also included by way of during workshops fostering joint learning of scientists and laypersons. *Transdisciplinarity* was however not a specific focus of the event.

The event consisted of a mix of lectures, organised group activities and informal evening gatherings. Elements we sought to observe included the "unique norms, values and performance etiquette" (Jaimangal-Jones, 2014, p. 39) of the summer school event, as well as reflections on the expectations or 'symbolic interactions' (Blumer, 1969) of participants and their prevailing discourses, and how these impacted on the construction and consumption of the participants' experiences. As such this observation focussed explicitly on the social and organisational preconditions for collaborative working discussed throughout section 2.

PhD researcher Pauline Claudot, participating in the summer school and trained in anthropology, undertook the initial participant observation supported by the two organisers, Dr Delphine Burguet and Dr Nathalie Ortar, also both trained anthropologists. Materials generated included field notes taken during the observation of the various formal and informal activities (although there is a focus in this report on group activities and plenary, whole group discussions). These field notes were also informed by one-to-one discussions with some of the ESRs and academics training the ESRs. Therefore, the observations occurred in a clearly controlled setting, with a set timeframe and population.

3.2.1. Observing interdisciplinarity (and multidisciplinarity) at work

Although interdisciplinarity was only one of the core issues explored during the summer school, **disciplinary difference** was seen to play a key role in the way the problems were tackled. One issue was vocabulary usage. As the ESRs came from very different academic horizons and worked on a wide variety of topics, they were not necessarily familiar with each others' terminology. Neologisms ('prosumers'), key political concepts

('empowerment', 'resilience'), or sociological concepts born in certain contexts ('vulnerability') were often taken-for-granted and used without being investigated, although this happened to some extent when various dedicated speakers came and gave definitions. In addition, notions such as 'public' (to distinguish from 'people', for example) or others that have a different meaning across disciplines were not collectively discussed and defined, and so at times circulated among participants without being questioned, so that an unconscious but operational, functional misunderstanding could occur. On the one hand, this enabled participants to talk together and to push discussions forward without getting 'stuck' over language. On the other hand, in doing so, discussions sometimes neglected various thorny topics and burning issues related to energy or avoided connecting energy challenges to other debates (e.g. 'resilience' is a psychological concept originating as an ability to go beyond a trauma and even to make the better out of it; 'vulnerability' is a key concept from sociologycal born at the end of the Cold War that links to the double-edged nature of technology[8]). It is worth noting that presentations which placed a greater emphasis on vocabulary and language9 were both welcomed and vividly discussed by the ESRs.

The differences between disciplines also expressed themselves around the framing of problems. For example, during a plenary session which took place at the end of an interactive group 'Energy Challenge', there was a clear gap between: (1) a mainly pragmatic approach presented by one group mostly composed of economics students, and (2) the other groups which tended towards more socio-political thinking. The latter focussed on both individual and collective interests as well as the role of non-economic rationality, in contrast to rational choice argumentation. This gap does not mean that the economics-focussed group had not thought about social and political issues or that the other group had produced idealistic views putting aside economic facts, rules and constraints. It only means that at some point, each group had collectively decided to focus on certain problems and prioritised certain goals, and that these differed in each case. This type of prioritisation process is often implicit or hidden in research since methodology and disciplinary paradigms are deeply interiorised and can be part of unconscious disciplinary discrimination. By bringing it out in the open, and facilitating a reflexive discussion on inclusion and exclusion of disciplinary perspectives, a first step towards interdisciplinarity was arguably undertaken in this activity. Those processes were rendered visible because implicit disciplinary assumptions had to be revealed in order to be discussed. As discussed in subsection 2.2, multidisciplinary collaborations – in contrast – are less focussed on bringing differing expert opinions into confrontation with each other in this kind of way.

A central focus of the observations, some processes of **disciplinary inclusion and exclusion** (domination) existed between the ESRs that affected collaborations. These became especially visible during a group activity aimed at creating consistent socio-technological energy scenarios and to show participants a method to systematically interlink societal and technical aspects for scenario creation. Depending on the group composition (disciplinary, age and gender ratio as well as the balance between result-oriented personalities and understanding-driven ones), the groups either tended to reach a collective consensus or were ultimately led by one or two ESRs steering the others – whether convinced, a little tired, or a combination – to converge towards their own views. Three factors seemed to influence this process of inclusion and exclusion: (1) the personality and professional experience of each ESR, (2) their disciplinary background and (3) language skills10. This finding echoes the need for building trust and shared understanding about the relevance of each discipline (Stock and Burton, 2011; Klenk and Meehan, 2015) to enable interdisciplinary working, as discussed in section 2. Creating such an environment of trust and a level playing field is very challenging, especially in heterogeneous settings such as this one, and indeed the disciplinary background also deeply influenced the outcome of the group works. During the workshop activity referred to earlier, aiming at creating consistent socio-technological energy scenarios, the disciplinary groupings emerged as been driven by two major sets of paradigms that appeared antagonistic. On one side – broadly speaking – were ESRs whose training emphasised the questioning of premises, and suspending judgement, whilst on the other side stood ESRs used to produce more decontextualised and 'objective' statements, with visible

8 The idea that technology is similar to a pharmakon: healing and helping when correctly dosed, toxic if not.

9 E.g. Aurèlia Mañé-Estrada distinguishing between 'citizen' and 'customer', or Ute Dubois analysing the concept of energy precariousness and poverty.

10 For more details see Ortar, N., Burguet, D., Claudot, P. and Foulds, C. 2017. *The SHAPE ENERGY Summer School - interdisciplinary debates with PhD researchers.* Cambridge: SHAPE ENERGY.

or quantifiable indicators. The ESRs used to this latter kind of factual, objectifying literacy understood the cross-impact matrix workshop better than those rather more interested in interpreting and understanding subjective realities, social determinants or multiple ontologies.

Another issue highlighted through this observation related to the **collaborative skills and competencies** of researchers necessary to engage in interdisciplinary research. As discussed in subsection 2.3., collaborative engagements require individuals (and groups) to possess social competencies with respect to functioning in or moderating group dynamics, dynamics which are potentially conflict-laden due to different disciplinary knowledge and methodologies. Thus the importance of developing communication skills aimed at inclusion are clearly demonstrated. For example, in the case of the summer school, not all ESRs were fluent in English and they came from very different cultural backgrounds with not all being used to participating in public dialogue. It can be concluded that intercultural sensitivity and awareness of how the 'rules' of activity design may implicitly suit some cultures over others are important skills. In academia there are arguably limited training opportunities with respect to acquiring the above-mentioned relevant skills to participate in collaborative research (Rau, Goggins and Fahy, 2018) including communication outside of academia and openness to developing general knowledge across a variety of topics. This is something which initiatives promoting better interdisciplinary training are starting to address (European Universities Association, 2017).

Finally, a **gendered analysis** of the observation data suggests:

A degree of gender divide in disciplines, Economics and Political Sciences being the disciplines where the male ESRs were predominant.

A gendered choice of PhD topics: for example while 'policymaking' was mostly represented by male ESRs, the topics of 'new technologies' and 'renewable and conflicting energy sources' were exclusively female.

In general, female ESRs spoke less than their male counterparts during the plenaries (whole group sessions). The women who did not remain silent asked mostly focussed questions and were more likely to be interrupted, whereas men tended to make critical remarks or asked questions directly relating to the main topic of the plenary aiming at specifying an issue, nuancing a statement or detailing an example. The mastering of English and a cultural background was a further factor in contribution levels.

Gender dimensions are known to play a role in collaborative processes, and these observations support this.

3.2.2. Reflections on interdisciplinary working from the summer school

Analysing the outputs of the summer school leads us to make three recommendations regarding the design of activities, when aiming specifically at advancing interdisciplinary understandings:

1. It is important to use such activities to make explicit or visible the 'implicits' of the various disciplines, and the negotiation taking place with respect to inclusion and exclusion of perspectives, disciplines, methods etc. When collaborating in a workshop-type setting, take into consideration the time needed by each discipline to produce a 'rigorous' outcome/output as a basis for this negotiation process. A systematic explanation of the vocabulary used by each discipline[11] may also be effective in setting the base for interdisciplinary working.
2. Some framings can find themselves at odds with taking into account other perspectives. In the case of the summer school, mainstream economic thinking was sometimes in direct tension with other ESRs' perceptions of what was needed to achieve clean energy transitions. The affordances and limitations of any 'shared views' such as these need to be openly discussed as they influence the way the future is envisioned, and may close alternative paths that could have been taken.

11 Even perhaps by a sociolinguist.

3. Creating conducive preconditions, such as a level playing field and trust, is imperative. This includes creating an atmosphere that takes the cultural background, gender, age and experiences of participants into account when asking them to work together. This may involve making more explicit not only the rules of any exercises but also considering the cultural assumptions underpinning them (such as familiarity with certain debating styles etc).

3.3. ESR internship programme

The second stage of the ESR programme involved 17 SSH internships within existing Horizon 2020 energy projects over October 2017-January 2018. These internships, which lasted 2-4 weeks each, had several objectives:

- to enable ESRs to develop their skills and knowledge in the field of SSH;
- to make methodological tools from SSH available to professionals, stakeholders and researchers in other energy-related technical and scientific fields, thus fostering potentially more collaborative working processes;
- to provide solutions to H2020 energy/transport project teams on SSH-related issues; and
- to propose SSH based case studies, analyses, models and tools to better understand society's energy-related problems.

The SHAPE ENERGY ESR internship programme involved connecting ESRs working within SSH to energy project partners, with a particular emphasis on host projects in the technical fields of energy (STEM) since one aim of the internships was to at the least generate *multidisciplinary* contexts/working teams. Hosts framed interns experiences (i.e. set the general tasks they would work on) however there was a degree of flexibility, and in many cases the precise format of outputs evolved during the internships, partly since the hosts were not specialists of the ESRs academic fields and thus themselves were also learning what SSH could offer. As the team of ENTPE ethnographers could not follow each ESR during their internship, the observation of this activity was undertaken through completion of a diary that each intern wrote reflecting on their collaborative working experiences (see Appendix 2 in Ortar, Burguet and Robison, 2018). The ESRs were not however involved in the analysis of this data, which again was undertaken by the ENTPE team. These diaries included asking about ESRs' backgrounds in terms of disciplines and social influences they had been exposed to, their own relation to STEM, as well as their experience of achieving *interdisciplinarity* during the internship. Again, *transdisciplinarity* and *transformative science* were not specific foci of the internship experiences, however ESRs were asked to define the term 'transdisciplinary' (and how this approach may affect working contexts) in the diaries.

Thus, what was asked of the ESRs was to develop a reflexive ethnography or 'autoethnography' (study of themselves). This methodology is a form of qualitative research in which an author uses self-reflection and writing to explore anecdotal and personal experience. It allows connection of this autobiographical story to wider cultural, political, and social meanings and understandings (Ellis et al., 2010). Although only a few of the ESRs had already undertaken participant observation, and even fewer had undertaken autoethnography, most were familiar with qualitative research. The action took place in a limited time frame, in a delimited space, with certain actors in learning positions (the ESRs conducting their internship) and the other main observed actors being the colleagues with whom they were interacting (Goffman, 1990).

3.3.1. Main research findings

ESR understandings of and experiences of multi-, inter-, and transdisciplinarity in the internships

A key intention of the SHAPE ENERGY internship programme was to enable and observe the practical, day-to-day work involved in bringing together different disciplines. Overall, one common element of ESR responses to this programme was that work in an inter-, multi-, or transdisciplinary context is certainly challenging and obliges us to go beyond our *"comfort zone"* which helps *"to come back to [one's] own research with new*

perspectives"[12]. What this highlights is that indeed, as discussed in section 2, the learning experienced in collaborative processes continues after the actual collaboration and feeds into developing new skills and competencies, also impacting future collaborations. Definitions of multi-, inter- and transdisciplinarity from the literature were given in section 2 of this report, however this short subsection aims to reflect on how the ESRs, working 'on-the-ground', saw these concepts themselves, as well as how this played out working in such contexts (this is in part taken from a fuller discussion in Ortar, Burguet and Robison, 2018. p. 17-18).

For the ESRs, the term multidisciplinary refers to a "*juxtaposition*" rather than a combination of several disciplines. Multidisciplinary research entails "*staying within the boundaries of each discipline*" while trying to solve a common problem approached separately, which is very much in line with the definition given in section 2. Interdisciplinarity, in contrast, goes a step further than multidisciplinarity as it involves going beyond disciplinary limits and perhaps answering questions that one discipline alone cannot tackle. This combination of approaches, tools, and methods involves creativity but also a great deal of tension and potential for clashes. Doing so requires innovation and a critical vision of one's own discipline, including its limits, as well as the willingness to expand efforts in learning new approaches. All of this can take a great deal of groundwork, for example to build common languages in order to be able to work together, and even new methodologies. Finally, the notion of transdisciplinarity seemed to be less clear to the ESRs than interdisciplinary, and few ESRs ventured to define it. For those who did, the main idea expressed was that 'trans' implies the total integration and/or transcending of disciplines. This is a different definition than the one given in section 2, where transdisciplinary refers to the crossing of knowledge form boundaries to not only include academia but also other stakeholders in the process of collaboration. One ESR did however highlight this multi-sector aspect when emphasising (as several did) that interdisciplinary working is challenging for the entire team involved, as it requires them to:

> *"constantly reanalyze and reassess the research problem from multiple viewpoints. This can be challenging and necessarily involves wide stakeholder engagement, and pushing beyond one's comfort zone or area of expertise."*

As highlighted in our full report on the internships, the ESRs emphasised that interdisciplinary working is even somehow paradoxical in that it can be strengthened by solid, grounded disciplinary voices and knowledge, and thus individual researchers' need to be sure to maintain their disciplinary expertise. Working between SSH and STEM implies a need for clear objectives, and shared understanding, on both parts. For example, ESRs referred to developing a mutually defined 'code', rather than one researcher simply accepting another's definition:

> *"we constantly paid attention to explain what we meant exactly and we had to agree on a 'code' in order to really understand each other and avoid falling into the trap of a 'functional misunderstanding'"*

Lack of clarity can lead to confusion quickly, when the researcher undertaking the work lacks the background to take particular key decisions on which direction to take, or indeed may feel an entirely different direction would be most fruitful. One ESR felt hesitant over their role in the project due to such competing interests:

> *".. while some thought that the economic feasibility of biofuels should have been at the centre of my analysis, others wanted me to look into the more problematic aspects of social acceptance and public biases ... I became sceptical regarding the usefulness of my position in the project."*

During their internships, a strong message was that the ESRs felt interdisciplinarity to often be centrally about translation; this often takes place in a very tailored way specific to each project and combination of researchers. As also confirmed in section 2, building blocks were needed to facilitate such a context sensitive translation and reflexive process. Interesting, this feeds forward to discussion in section 4 which highlights how an emphasis on shared language is a characteristic of more normative integration approaches.

12 The following italicised phrases in this section are anonymised ESR quotes from the diaries for illustrative purposes.

Choice of disciplines and impact on interdisciplinary experience

The ESRs were asked in the diaries to describe their history related to their choice of discipline and choices of study, as well as their relations to other disciplines in general and STEM in particular. Finally, they had to focus on their experience of multidisciplinarity and/or interdisciplinarity based on their experience during the internship. The descriptions of both disciplinary history and choice of discipline were a way to understand the level of exposure to different disciplinary backgrounds which could later possibly influence the willingness to perform interdisciplinary work, one of the preconditions discussed in section 2.

The stories written by the ESRs give some insights about how they built their choice of study and in particular how the ESRs themselves analyse their own choices. The narratives highlight the temporality of disciplinary trajectories which begins well before graduate studies. Their stories highlight a predisposition to practice SSH rather than STEM. The choice of their schooling is to some degree built on family heritage, that of their parents or their grandparents, and connected with the parents' professions, revealing the power of social reproduction. However, the findings also show that the disciplinary interest regularly evoked by doctoral students to explain their choice of orientation cannot be reduced to external constraints any more than it can be considered the result of chance. It brings into play how the relation between a subject (the ESR) to certain types of knowledge seems to be inseparable from the functions that such particularised and practiced knowledge fulfils. It is also noteworthy that the ESRs mobilise their relationship to knowledge from a subjective position that is shaped through a socio-family history.

Thus, disciplinary choices are not due solely to the perceived prestige of a discipline, nor its profitability on the labour market. The ESRs put these characteristics at the service of the individualisation of their professional itinerary which confirms the findings of previous work (Hermet et al., 2004):

> *"When I was a child, I lived with my grandparents. They influenced me a lot. My grandfather is a professor of hydropower engineering, and my grandmother is a senior architectural engineer. [...] I cannot clearly describe all factors affecting each of my choices. Nevertheless, the combination and interaction of various influences make several 'good-fits' for me. And, as I change, learning and experiencing new things, I will continue to revise and fine-tune my career choices."*

This diversity in experience may highlight yet another important condition impacting the potential willingness to participate in collaborative working, and to 'let go' of one's disciplinary commitment, both conditions not found in the literature reviewed in section 2.

University studies are also partly influenced by early exposure to political issues such as sustainable development, energy and social justice as well as social environment including classes taken, circle of friends, or wider social network. The diaries showed that the learning of STEM was seen to some degree as opposed to that of SSH, as well as STEM being seen to be more valued in energy research than SSH (although within SSH certain social disciplines were felt to 'dominate others', such as Economics or Urban Studies). Thus, whilst the ESRs had undertaken studies in multiple disciplines, they generally presented their trajectories as anchored in SSH. Indeed, the ESRs differentiated science according to fundamental categories and expressed disciplinary preferences since they were teenagers. These preferences and interests determined the disciplinary choices for their PhDs. The very few ESRs with a combined background in STEM and SSH felt that STEM may also benefit from the critical and distanced approach specific to SSH.

More specifically for the practice of interdisciplinarity etc., the stories of disciplinary trajectories of the ESRs highlighted perceptions of a *need* to cross disciplines when conducting research in the field of energy. General familiarity with multidisciplinary working contexts in some cases had resulted from wanting to better understand their current research object. Some extracts highlighted the fact that energy-related research requires a multidisciplinary background to understand its very nature:

> *"Solving problems based on physics and mathematics are so interesting for me, because of this engineering is so interesting for me. However, when I understand the importance of other aspects in technology deployment (especially socio-governance aspects), I have become interested in the subject. During my bachelor studies, I have worked on different aspects related to energy subject,*

> *including feasibility study and policy analysis of energy systems. I believe one of the turning points was when I read a very interesting article form a professor from UCL which was discussing about importance of social-governance aspects of technology over only technical aspects. It was truly fascinating. I decided to work more on multidisciplinary and interdisciplinary topics related to energy systems which I believe are most interesting."*

There was also a willingness apparent to experiment with and question other secondary disciplines outside of their primary academic training. The very fact of choosing to work within the field of energy seemed to lead to more complex disciplinary paths in order to better understand both social and political influence, but also energy's technical dimensions[13]. Multidisciplinarity or interdisciplinarity were hence already relatively familiar positions for these young researchers. Some written testimonies provided analysis of how the ESRs understood disciplinary dominance, or how they saw (inter)disciplinary balance in projects. One explained that, in Germany, they benefited from a programme which favoured an interdisciplinary approach:

> *"I took one-month interdisciplinary courses ... The main goal of these courses is to supplement disciplinary learning so we can learn how to respond to challenges that transcend disciplines, work in the confluence of multiple disciplines, and develop research trajectories that do not conform to standard disciplinary paths. The interdisciplinary courses include special lectures on the socio-economic, historical, environmental and ecological issues of development and writing a term paper with researchers from different discipline."*

Through taking these courses, this ESR was taught how to understand, navigate and employ multiple and often contrary ways of knowing, and how to purposefully and reflectively integrate and synthesise different perspectives in order to advance understanding and solve problems. She took from these courses that an interdisciplinary research is more complete than a disciplinary research, as it can go deeply into a specific issue from different angles and provide considerable insights to help address current problems.

3.3.2. Reflections on interdisciplinary working from the ESR internships

These internship experiences within interdisciplinary and multidisciplinary H2020 projects in the field of energy lead us to a number of lessons specifically from the ESRs interdisciplinary experiences through their academic training and internship experiences. These understandably echo to some degree the overall lessons from the internships (as given in Ortar, Burguet, and Robison, 2018).

As discussed extensively in section 2, one key reflection is about the fundamental necessity of interdisciplinary working in the field of energy. The ESRs stressed that although interdisciplinarity is hard, they saw it as inevitable in energy, since this is a complex technical and social issue. Indeed, the diaries also raised an interesting point about academic and personal identity, with arguably some of the ESRs identifying to a greater extent with the issue of energy than just one disciplinary 'home'.

Thus these energy-SSH ESRs saw interdisciplinarity as challenging but rewarding, and felt it had changed the way they understand and frame research questions. However they cautioned that interdisciplinarity may be undone if, by working to cross disciplinary boundaries, the depth of each individual's knowledge is decreased. Individual researchers must, they felt, maintain sufficiently deep expertise within their own domain, and as those setting out on their careers this felt important to them. Finally, reflecting findings from the summer school, working across disciplines requires clear objectives on all sides, and sufficient time to develop mutual understanding.

3.4. Multi-stakeholder workshops

The third SHAPE ENERGY activity evaluated via participant observation were its major series of 17 multi-stakeholder workshops which took place in cities across Europe between November 2017 and June 2018,

13 A pathway that seems rather common in the field of energy, see for example Campbell. B., Cloke, J. & Brown, E. 2016 and Byrne, R. *et al.* 2011.

often in partnership with the local administration or an organising NGO. Attendees (around 20-30 per workshop) were local actors involved in energy policies as well as interest groups, businesses, and local authority representatives, all connected to a pre-defined local energy challenge. The workshops, each between half a day to a full day in length, involved a large community in the SHAPE ENERGY project to help the Platform identify needs that local stakeholders might have which could be met through energy-related SSH perspectives. As such the workshops were explicitly aimed at being transdisciplinary, or even a transformative science type of activity. It is important to note that in this context most attendees were non-academics, and thus would not necessarily identify with a 'discipline' as such, but rather with a sector. The analysis of the experiences of participants and the results of the discussions enabled a very full examination of energy-SSH issues of relevance at the local level thanks to these inputs of practitioners on the ground (Robison et al., 2018).

Unusually in the energy field, the SHAPE ENERGY workshops used storytelling methodologies (see Mourik, Robison and Breukers, 2017) designed very much to overcome some of the barriers to collaboration outlined in section 2. Thus, storytelling aims to not only allow collaboration between people of different backgrounds (such as engineers, social scientists and policymakers) on the same problem, but also create a level playing field and equal representation of all perspectives and forms of knowledge present in the final outputs. The organising institution, in liaison with the respective SHAPE ENERGY partner, were involved in discussions before each event about the major challenges relating to energy within their city. Out of those discussions a problem was defined and a story spine created and later used during the meeting to create a common starting point, and an atmosphere of collaboration between the attendees, as well as meaningful outputs.

In order to evaluate the transdisciplinary, or multi-stakeholder/multi-sectoral, interactions during the workshops, participant observation was conducted by a member of the local SHAPE ENERGY organising team during selected sessions. In an attempt to counter the lack of experience of many of these observers, most attended a short training session during the full two-day storytelling training in September 2017, as well as receiving a written manual on the general 'know-how' of participant observation. In addition, a pre-set diary template and separate observation table were designed in order to help the observers get meaningful information (see Appendix). We knew in advance that it was impossible to implement a 'full' ethnographic participant observation for each event following only one short training, but at the same time wished to experiment with scaling up these in-depth qualitative methodologies to see what was possible. Thus we designed research instruments to allow structured observation of these events by non-specialists. The diary requested some general information about the entire workshop (aims, physical set-up etc) but detailed observation was required to be carried out during only one session at each a city workshop during which the observer was acting as an observing participant (Moeran, 2017). In this session the observer noted in the pre-set table who was speaking and the type of contributions made to a group discussion (e.g. approval/disapproval/decisions), as well as giving more qualitative observations in the diary template. To some extent, this pre-set materials also helped to homogenise the collected information and allow for the general possibility of comparison across contexts.

Where possible additional, optional, information was requested related to:

- The participant observer's own hopes/fears for the meeting (to be completed prior to the day) and experiences (to be completed after the meeting),
- A history of the existing networks present during the meeting,
- The topics of discussion during the informal time, who spoke with whom,
- The persons present, and the implications of e.g. gender, disciplines, sectors, expertise, professional status, age, etc. on the dynamics, delivery, and general running of the event,
- Ultimately, any other points of reflection that the participant observers felt significant enough to be noted.

3.4.1. Main observation results from the workshops

In what ways was 'interdisciplinary working' integrated into the workshops?

We first reflect on how workshop organisers (as reported by the participant observers) were either aiming to achieve some degree of interdisciplinary discussion, or felt this topic arose. In at least a dozen cases there was specific reference to the necessity of interdisciplinary/multi-stakeholder working, and this is not surprising given the premise of the workshop series to bring different local groups together. However, it did arise in two distinct ways. In certain cases, interdisciplinary working was a very explicit aim of the event, for specific and tangible purposes, for example:

> *"Our intention is to formulate an interdisciplinary communication platform"*
>
> *"The main objective of* [the workshop] *was to establish both technical and social problems related to existing system from point of view of all interested stakeholders"*
>
> *"The objectives of the meeting are to start a conversation between crucial stakeholders ... and to make some concrete plans for further collaboration."*
>
> *"The workshop aimed to develop a common vision."*

In contrast, in other events, interdisciplinary collaboration arose during the live event as a *solution* to some of the energy challenges being discussed:

> *"The integration of multidisciplinary fields* [was seen as] *very important by the majority of the participants."*
>
> "[Participants felt] *only interdisciplinary research could bring interesting results."*

Relatedly, in some observations, this 'solutions' aspect was seen in a more implicit way, in the manner in which participants gave their input:

> *"Participants seemed to find it important to demonstrate the capacity to move between discussion of technical, policy, and end-user/social/cultural issues."*

In short, interdisciplinary working was both a starting aim and a topic of discussion across the workshops, and its necessity (in addressing local energy challenges) was even to some degree assumed as a baseline for discussion.

Storytelling as a method to combat domination

The diaries and observation were geared towards identifying domination of gender, disciplines, seniority, sectors etc. Interestingly however this domination was often not witnessed very strongly. This may be in part since this can be a subtle thing to observe, which requires some experience (and as mentioned, many of our observers had not done this before), however primarily, the lack of domination could also be attributed to the setting of the workshop itself, and the setting of a level playing field (as deliberately designed) by the storytelling methodology. The following quotes give a flavour of the atmosphere at most workshops:

> *"The tone was convivial throughout. Any tensions seemed to centre on differences between the agendas of professionals and community groups."*
>
> *"It went very well. The atmosphere was relaxed and the attitude was professional. All participants were aware that both deep listening and ability to discuss were required."*
>
> *"Very eloquent group of people, experienced in their own field, but humble enough to let others exchange freely and listen to what other people had to say. No one seemed to dominate the debate or have the upper hand."*

During the workshops, the timetables often alternated between plenary sessions, individual times of writing, and round-table sessions during which the speech was distributed alternately among all participants as each one had to share their story either individually or as a contribution to the main narrative. Across the 17 workshops, five organising teams chose to observe an individual storytelling session, three a collective

storytelling session, six a session which involved discussion based on presented stories (for example identifying 'challenges' from these), and two chose a plenary whole group discussion (in one case involving a presentation and Q&A). From the observation tables completed by observers, it is possible to see that in some cases the speech was therefore fairly evenly distributed with few comments or interruptions. The general framing of the discussions and the tacit agreement made by participating in a meeting using storytelling as a methodology advocated participants listening to each other without judging. In addition, the table moderators were explicitly trained to allot similar time to each person sitting around the table, and intervene in case of unwanted interruptions.

Such a setting does not mean that the process of domination, may they be of status, gender or discipline/sector, disappears completely, but that this to some degree temporarily suspended or is less explicit. This was a fact that we perhaps underestimated in designing the pre-set observation tables. Thus, although certainly a positive evaluation in one sense, and validation of our approach to workshop design, it perhaps limited some of the critical insights possible with regards the observation. Having said that, most of the sessions observed had at least one interaction which was classed as a 'disapproval' (that is a disagreement with a previous speaker). Indeed, many commented on how the respectful atmosphere did not mean there were not alternative views expressed, however the set-up of the workshop moderated this to be done constructively:

> *"when people disagreed, they were focusing more on explaining why they think an alternative explanation is possible rather than criticizing other views harshly."*

Further, observers were asked specifically if there were any 'hot' topics, and although this was not observed in all cases, several did indeed identify topics which stimulated slightly more combative debate, for example:

> "[there were] *disagreements when someone referred that there are no cold weather related deaths in* [country]*; when the banking sector criticised the heaviness of procedures by the municipality and the representative from the municipality defended the institution"*

In addition, in some cases domination was observed related to groups not present. As reported by one facilitator:

> *"It may be of interest to note that the groups singled out above for 'blame' were not centrally represented at the workshop."*

Observers were also asked specifically whether any participants dominated discussion. In some cases observers felt this was not the case, but others identified one or a handful of more dominant participants (and where gender was indicated, these were almost all identified as male). For example:

> [Who was dominant?:] *"Some men with a professional background. For example, because of the knowledge they have of regulations and other cases"*

However usually observers felt the facilitators handled this smoothly and enabled others to contribute. This was a specific topic of the training received in the storytelling methodology.

Multi-sited observation findings

The repeated character of the meetings, and the fact that they had been framed more or less in the same way, following the storytelling narrative, was meant to enable a useful body of material to be analysed as 'multi-sited ethnography' (Marcus, 1995; Marcus and Fischer, 1999). Indeed, analysing the results of these 17 workshops organised across Europe cannot be done without taking into account their cultural diversity, something that should also feature more strongly in policymaking. One of the most remarkable results coming out of the multi-stakeholder meetings is the local choice of topic, which frequently relate to socio-political systems and their legacy - see Robison et al (2018). Cultural diversity consideration is critical as the choice of the stakeholders or the venue of the meetings – very different from one city to another – are manifestations of the economic, social and political situations in each country. They also embody the moral and symbolic value given to those meetings for the local organiser and hosting city, and give insights of

their relationship with the EU. Indeed, each chosen topic and choice of audience were linked to the local geography, history, economy, etc. that cannot be overruled to understand what actually took place during the meeting.

Emerging from the 'Writing Culture' (Clifford and Marcus, 1986), the paradigm of multi-sited ethnography has been developed and elaborated by the anthropologist George E. Marcus since the mid-1990s. This method of ethnography moves from the localised situations of conventional ethnographic research to examine *"the circulation of cultural meanings, objects, and identities"* (Marcus, 1995, p. 96), and provides for a means to study social phenomena that cannot be accounted for by focusing on a single site. The method therefore re-orientates the idea of the social in ethnography, allowing studies to undertake cultural analysis on phenomena such as social relations, institutions, systems, processes and structures (Marcus and Fischer, 1999). Marcus and Fischer (1999) emphasise that multi-sited ethnography is more a matter of contextualising multi-sited social phenomena rather than an ethnography that covers many sites. For example, the research domains that have been studied using the method have included a focus on global organisations, bureaucracies, markets, technologies, and on policy processes and their impact on communities. Here we start from a discussion of individual cultural context before moving to what this means for insights across contexts.

Depending on the location, the SHAPE ENERGY workshops involved people with very different statuses and those variations were not homogeneous across the different meetings – two meetings, for instance, were held in the presence of a state minister in Central Europe while in other meetings, high status personality was not always present. The impact of gender, age, race, sector and seniority distribution – particularly on ability to join the discussion – was commented on by many observers (and indeed taken into account in planning in many instances), although this played out differently in different cultural contexts:

> *"All participants were very active, including women."* [This event only had 2 women attendees]
>
> *"In previous workshops we have observed that participants may hesitate to state their opinions when the elderly are of high number, possibly out of respect. Therefore,* [we planned] *a gathering of almost exclusively middle aged people."*
>
> *"Younger people were shier, especially at the beginning of the session."*
>
> *"In 'my' group, I did not notice any link between gender or age and the ability to speak up or to answer a question"*
>
> *"This was a gathering of white and almost exclusively middle aged or older middle class people."*
>
> *"While community representatives could be vocal in discussions, the agenda was set primarily by the local government officers (from a number of different agencies)."*
>
> *"The above distributions [very low female representation, higher ages] are typical for energy-related events for high-level experts. Unfortunately the high age of participants affected negatively the success of the storytelling method."*

Further, the common methodology used to facilitate the meetings (storytelling) arguably induces a certain narrative implying less apparent power relations (e.g. letting all participants speak) which is more commonly used in Northern Europe, compared to other European cultural schemes as is showed in the narratives of the setting by the unwillingness to take part to the process. Some cultures were certainly much less used to the style of workshop we were using, although in most cases were convinced by the end of the event that it could yield useful results:

> *"We were positively surprised that there was nobody left who did not say a thing at all in both the small group session and later on in the large, collaborative session."*
>
> *"To be honest, interactive workshops are very rare* [here] *and I had doubts about the readiness of participants to take more active roles. Fortunately, I was wrong."*
>
> *"Storytelling method was something new for participants but finally they understood how it works and well accepted. This technique was well received by the participants."*

Although all workshops were 'successful' and achieved useful outputs for the organisers, the message was not universally positive regarding the quality of the materials generated:

> *"There was a starting hesitation about the storytelling process from the attendees, but they welcomed the idea because they had a chance to tell their opinion about the matter. However, after checking all of the written stories by the participants, my opinion is that more involvement .was expected."*
>
> *"Storytelling was very untypical for this audience. Participants were reluctant about audio recording, video recording, and submitting their stories on paper to the organizers."*

Moving back then to ideas of multi-sited ethnography, what can we learn? What might these cultural variations mean for international endeavours looking to build networks between stakeholders, which may of course be on the local level? Although cultural difference must be considered sensitively when looking to involved a diversity of parties, these results also show there can be a willingness to step beyond the 'norm' when this is done for a clear purpose, and designed in a rigorous manner.

The role of the facilitator in enabling interdisciplinary discussion

Finally, we rather briefly highlight the role of the facilitator in all of this, as this was often reported as key for the success, or even possibility, of interdisciplinary discussion, even if it was not always a straightforward role to play:

> *"The moderator of workshop at very beginning established rules – that each voice is important. During all discussions participants were calm enough speaking with moderate voice. Many of participants knew each other and this was additional point to have friendly discussions."*
>
> *"The main organizer used some ice-breaking exercises at the very beginning of the workshop, it probably softened the atmosphere and helped people to interact and discuss with each other."*
>
> *".. the most part of the discussion was understandable by everyone. Please note that it doesn't mean that everyone could jump in the conversation. Our team tried, in a few occasions and with not so much success, to stimulate interventions by the silent people."*

Interestingly, one observer noted that the facilitators' demeanour directly 'rubbed off' on participants. Even though the earlier storytelling sessions had been very successful, their final session fell a bit more flat:

> *"I think the atmosphere was a bit colder than desired because participants realised we were disappointed by the fact that we were not reaching all the results we had expected."*

Our key conclusion here is simply not to underestimate the importance of expert facilitation skills, which can must be learnt developed, and the detailed planning work which goes into facilitation prior to events.

3.5. Lessons for future qualitative evaluation of interdisciplinary working

Our experimental use of participant observation in several different contexts gave the opportunity to reflect on our design of tools and methods, and give recommendations for those interested in employing similar techniques in future.

3.5.1. Embedded ethnographer (summer school)

With reference to the methodology used at the summer school, the greatest potential for participant observation in event settings lies in examining the social dynamics of audiences and the reasons for their behaviour (Mackellar, 2013). In the case of the summer school, the use of trained ethnographers allowed us to observe meaningful interfaces between gender, multidisciplinary interaction and systems of dominations. Being able to realise a second observation in a comparable setting could have improved the value of the observations. In addition we would recommend careful design of application criteria and selection processes, to avoid individual disciplines being placed in too dominant a position.

3.5.2. Autoethnography: Reflexive diaries (internships)

The use of a pre-set diary divided in categories mobilised two different types of reflexivity, one related to the ESRs biography, and the other to their working experience during their internship that has allowed to introduce a narrative mind-set and to induce an autoethnography in relation to the observations made during the internship. This has shown its value and the results either confirm or complete previous research on the choice of discipline in particular. The production of those diary reports has also allowed to set a manual on working in a multidisciplinary context and of pursuing an internship in such a context.

More generally, the results show that the methodology used helped the ESRs to reflect actively on the influence of family history and social environment on their stance towards mixed work settings. Another positive factor was the length of the internship as well as ESRs previous awareness of the implications of doing research in a multidisciplinary context, and of multidisciplinary work implied by any research done in the field of energy. Those elements also highlight the fact that in one way or another the ESRs had already started to conduct a reflexive analysis on their research object most likely due to an awareness learned through their social sciences background. The length of the internship and the setting of the report helped them to step back and reflect on the interactions they had experienced which is a first step into participant observation. What could have been improved was the way the diaries asked for description of the interdisciplinary process itself. Asking a few more questions in the diary, and more detailed description, could have helped get even farther in the description of the setting of interdisciplinary work and *transformative science*.

3.5.3. Structured participant observation (workshops)

As highlighted earlier, SHAPE ENERGY undertook a novel experiment in scaling up and applying participant observation over shorter time periods and with those less familiar with these techniques than might normally apply. Its novelty means the lessons learnt deserve a slightly longer reflection, which we give here. To account for the unfamiliarity of some observers with the methods to be used, measures we took included a (short) training of the future participant observers and provision of extensive template material. Even so, this approach of course brings trade-offs as compared to smaller scale studies with perhaps one dedicated observer performing longitudinal observations (more similar to that carried out during the summer school). To observe (in this present, evaluative, context) does not only mean to look with attention, but also to examine in order to draw scientific conclusions. Therefore, observing means to pay attention to gathering information and knowledge in quite a particular way. To do this, trained anthropologists will change the way they look at themselves, including considering the way others look at them.

The reading of the diaries shows that the observers (understandably) may have remained unaware of some ethnographic filters related to their socialisation and personal interests which may have been more apparent to trained observers. This included, for example, being less likely to include information about what might be being overlooked or unsaid, or reflexive accounts of the events, and instead concentrating on descriptive accounts of topics covered in discussion. This was also apparent in the stated aims of observers, with a trained ethonographer including: "*To observe how participants dealt with the transition from written language to oral expression*", obviously a fairly academic angle. The trained researchers also tended to make longer 'field notes' from which they completed the required forms, or obtained detailed feedback from individual activity facilitators (most workshops had several facilitators) which fed in. They also sometimes included an 'extra' level of interpretation of what those they observed expressed, rather than just what they are saying, e.g. fear, suspicion, feeling daunted.

The following excerpts are answers to the question of who was dominant during the discussion. The first is from someone trained in social sciences which is not the case for the second:

> *"All workshop facilitators reported that the discussions were quite balanced: while occasionally some people might have participated more with more examples and arguments, there was never a dominance of one or few people. We were positively surprised that there was nobody left who did not say a thing at all in both the small group session and later on in the large, collaborative session. The*

atmosphere was quite friendly, and when people disagreed, they were focusing more on explaining why they think an alternative explanation is possible rather than criticizing other views harshly. We believe because the topic was related to not just policy makers, participants found it easy to reflect on their own experiences. We never felt short of topics/arguments to discuss and nobody left the discussions due to boredom, etc. Example from one facilitator: "Three or four people were very enthusiastic and eager to participate, while two others were less talkative. I tried to engage them by asking direct questions to them. I knew one's background so my question was directly related to her work. Although the initial response was short, she participated more later. The question I asked the other person was more general which was also met with a short response. Then the other participants jumped in and the discussion continued on. But no one dominated these discussions. There were a few arguments that were met with counter arguments, but I did not detect any tension. There were also a few questions directed by the participants to each other. Communications and exchanges were very respectful."

"The representative from Municipality of xx and representative from the Ministry of Environment."

It is important to note however, that the actual format of the templates was critical in this and we make some recommendations below about how future designs could be improved.

Notwithstanding the above, all workshop organisers were able to complete the information requested, in most cases including the 'optional' section on reflections from the whole event. The completed observation forms varied in length from 4 to 22 pages. In some cases observers who were less familiar with the method actually provided more nuanced or detailed comments (regarding for example emotional aspects of contributions) than trained researchers. In one example there were highly insightful commentary alongside the recording of contributions, e.g.: *"informal leader", "Kept a low profile, seemed to be concerned about privacy", "Slight tendency of discussing beyond the subject, always had an opinion on everything", "Very combative", "passionate".*

Whilst there is no silver bullet solution to create an easy and quick technique yielding highly in-depth contributions in all cases, future initiatives wishing to use similar techniques might consider:

- *The broader use of the diaries:* a short form of the diaries could have been filled in as an evaluation form by the attendees, of course with a different set of questions, but to triangulate observations.
- *Documenting the cultural background of attendees* was not specifically asked for in the diaries (although was hinted at in places as described earlier) and had not been taken into consideration as something that might interfere with the very possibility of analysing the diaries. The inclusion of this would be a key recommendation for future initiatives implementing something similar.
- *Asking observers to record non-verbal language*, as one way of identifying less explicit domination in the workshop setting.
- *The implication of the design of event structure* (in our case, the central use of storytelling which aimed at creating a level playing field) for the likely data gathered (in our case, focussing on domination processes) should also receive attention as it influences the meanings of the gathered information.
- *Certain, crucial, template questions needed more explanation.* In particular one question asked: were there cross domain/disciplinary discussions? This was found to invite a yes/no or short answer, or one which often focussed on discussion topics rather than the quality of discussion. The phrasing (cross domain/disciplinary) was also interpreted very differently by different observers (and therefore whether they answered in the positive or negative). Thus important terminology such as this would benefit from a short explanation.

3.5.4. Separation of observer and analyser

Observers should take their own point of view into account in their analysis in order to understand the observed results. However our analyses for the internships and workshops were, by necessity, carried

out by those at some distance from the observer and of course the event in question. This also limited to some extent the possible analysis of the effects of the diverse multicultural contexts of the 17 workshops. Future use of scaled-up observation methods might also benefit from 'de-brief' interviews between those analysing the material, and the observers. This happened in an informal way in our case, through general contact between SHAPE ENERGY partners involved in the workshops (and in particular between all partners and the coordinator) however this could have been formalised.

3.6. Concluding thoughts

The collaboration of STEM and SSH is essential to tackle the energy issue across the micro-, meso-, and macro level and to understand the social, political, economic and technical dimensions of energy. Analysing the outputs of the summer school, the internships, and the workshops, has led us to several key observations regarding interdisciplinarity:

1. Interdisciplinarity is paradoxical: it requires working to achieve an efficient combination and integration of knowledge across disciplinary boundaries, yet team members must have sufficiently deep expertise within their own knowledge domains.
2. Working across disciplines requires clear objectives on all sides which also implies making more explicit/visible the 'implicits' of the various disciplines. In a workshop-type setting this also requires taking into consideration the time needed by each discipline to produce a 'rigorous' outcome/output.
3. Domination can be addressed through deliberate design of inclusive activities, where each participant's voice must be heard (in our case, storytelling) but this does not mean domination disappears completely. It may indeed be pushed towards groups not present. Nevertheless, this set-up (involving multiple stakeholders) strongly encourages recognition of the importance of interdisciplinary working.
4. Consideration of the cultural background of the participants when designing interdisciplinary activities is vital, however this is not to say new experiences or shared programmes across cultures cannot be tried and successful. These must be carefully designed for each context, preferably with organisers from the local context.

4. Cognitive integration of interdisciplinary production: the SHAPE ENERGY Think Piece Collection and Research Design Challenge

4.1. Reference problems

This section evaluates the SHAPE ENERGY Think Piece Collection (TPC; Foulds and Robison, 2018) with the help of the Research Design Challenge (RDC) results and experiences (Sumpf and Büscher, 2018). The goal is to find common 'reference problems' among the contributions to both activities, and formulate them as more abstract research strands for future Social Sciences and Humanities (SSH) endeavours with both academic and more practical ambitions. With the formulation of reference problems, i.e. commonly shared scientific problems, we aim at a cognitive integration of collaborative research, as opposed to normative or organisational integration (see below for further explication). Whilst the RDC was originally and explicitly built on the three reference problems of control (relating to complexity), change (relating to stability and change), and capacity-building (relating to action capacity) in energy systems, the TPC implicitly relates to these as well, which will be illustrated and compared below. In applying and evaluating the reference problem methodology, we also refer back to the different types of collaborative working introduced in subsection 2.2. (p. 29). In particular, we refer to differences in *multi- and interdisciplinarity*. *Transdisciplinarity* and *transformative science* were however not specific foci in evaluating either RDC or TPC.

As originally mentioned in the RDC collection (Sumpf and Büscher, 2018, p. 3), the RDC[14] set out to showcase how different SSH disciplines approach three scientific problems, namely control, change, and capacity-building in energy systems, which we called 'challenges' therein. These challenges served as a framework to order the contributions along three *reference problems*:

1. The first challenge concerned the reference problem of **control** with increasing system complexity, because more heterogeneous elements and varying interrelations between these elements can lead to emergent behaviour of energy systems. This relates to aspects of social control such as governance, political autonomy or complex system intervention.

2. The second challenge described the reference problem of **change** despite the need for stability because in the destabilisation of institutions, an overall loss of orientation should not occur. Simultaneously, unlearning knowledge and deviating from routines is mandatory, e.g. relating to energy pioneers, lived experience of energy systems, electric mobility, values or building energy use.

3. In the third challenge, we encountered the reference problem of **capacity-building** due to the increasing discrepancy between 'simple' interfaces and complicated technological realities in the background. This pertains to social mechanisms and innovations that mobilise human behaviour and allow to absorb uncertainty in order to remain actionable, e.g. on markets, in local communities or as building occupants.

These reference problems provide integration potential by channelling researchers' attention towards the problem at hand, going beyond their disciplinary academic definitions and comprehensions (Sumpf and Büscher, 2018; Büscher, Schippl and Sumpf, 2018). This could also be described as a shift from multi- toward interdisciplinary working. In this way, reference problems offer a practical way of 'cognitive integration' of research teams and alliances, as opposed to normative or mere organisational integration, described next.

Whilst organisational integration relates to a loose collection of projects, e.g. autonomous research of individual partners in a research alliance, normative integration indicates a value-based framework (such as sustainability or Responsible Research and Innovation) as an overarching condition for collaborative research endeavours. In organisationally integrated collaborative research, autonomy of partners/

14 This design challenge attempted to foster interdisciplinary collaboration in the energy-SSH community throughout Europe. 31 researchers based in 14 different European countries and representing 16 SSH disciplines came together through SHAPE ENERGY funding and developed 13 research designs according to the challenges defined.

disciplines is typically high, while the integration regarding common approaches/theories or methods tends to be low – the overall output of the combined research effort may not be substantially different from each partner providing it individually. In the contrary scenario of normative integration, one research paradigm (or theory, or method) may be mandatory for all researchers to adopt, usually leading to a high integration as to scientific content, but a low autonomy of participants when it comes to unfolding their own disciplines and ideas. Typical for normatively unified settings like this are promotions of common definitions between disciplines and attempts to homogenise dissimilar understandings through normative, theoretical, or methodical integration. Outcomes of such an approach can be a misrepresentation of certain partners/disciplines and involve long processes of reaching consensus on definitions in contested fields of academia, where single disciplines often do not even provide a shared state of the art research consensus. Accordingly, personal disappointment, academic setbacks, and compromises that do not necessarily reflect the potential of the involved disciplines may be outcomes of such endeavours.

The possible negative effect of organisational integration is a separation of labour: engineers take care of this (e.g. modelling, calculations), economists check profitability, and sociologists research into acceptance potentials of technology – similar to how typical multidisciplinary research was described above (subsection 2.2.). The common point of reference, or the autonomy of individual partners, can get diffuse in these ideal typical examples (cf. Büscher, Schippl and Sumpf, 2018). By *cognitively integrating* collaborative research, we try to find middle ground: having a shared basis partners relate to (reference problems), yet with their own approaches (i.e. theories and methods), and in this way upholding partners and disciplines autonomy, which is what helps unfold their full potential. Consequently, this approach (for further insight see: Büscher, Schippl and Sumpf, 2018) tries to bridge the gap between multi- and interdisciplinary approaches by preserving a certain degree of disciplinary autonomy and yet integrating on a research problem level, which embodies problem-oriented research more generally, such as technology assessment (cf. Grunwald 2018).

The idea of cognitive integration is the conceptual foundation of the emergence of control, change and capacity-building as major reference problems in the energy field. Researchers (explicitly and implicitly) relate to these and gear their work toward it, as the RDC has initially demonstrated. The following sections reveal how authors of the SHAPE ENERGY TPC (Foulds and Robison, 2018) relate to these reference problems, and how these research topics interrelate with RDC contributions, which will be highlighted in the subsection 4.3.

4.2. TPC evaluation based on control, change and capacity-building

4.2.1. Control

The three papers we aligned with this category refer to the control challenges due to increasing system complexity, as sketched out above. This applies to both the control of technical and social processes. The contributions in this category address policymakers and researchers at the same time, calling for interdisciplinary collaboration in data collection and sharing, to provide evidence-based concepts, frameworks and research outcomes that those 'in control' can rely on. Simultaneously, policymakers are also responsible for drawing critically on the concepts provided by researchers and to deal with contradictory research outcomes.

The first paper identified in this category, "Achieving Data Synergy: The Socio-Technical Process of Handling Data" by Sarah Higginson, Marina Topouzi, Carlos Andrade-Cabrera, Ciara O'Dwyer, Sarah Darby and Donal Finn (Higginson et al., 2018) sets the control focus on interdisciplinary energy research. As good quality data provides the foundation for evidence-based policymaking, research can impact those who are in control of energy policies and the energy system. Therefore, the authors focus on challenges in the socio-technical process of qualitative and quantitative data collection and sharing within interdisciplinary projects to obtain good quality data. They illustrate two specific examples of the Horizon 2020 project RealValue, that tries *"to validate bottom-up models of energy demand using trial data collected during the project"* (p. 65) and to *"triangulate the qualitative data collected on customers, using monitoring data from the*

heating and hot water appliances fitted in their homes" (p. 66). Challenges that came up were categorised into four interlinked dimensions: time, people, technology and quality. From the emerging problems, the authors derived recommendations for each category to achieve data synergy. Critical dependencies in research synchronisation, in their opinion, should be encountered with backup plans to ensure good quality data. For coordination of a multidisciplinary group including social scientists, energy modellers, software designers, the electricity supply industry and more, the authors recommend four set roles – *"a project manager, a project delivery coordinator, a data analyst and a research coordinator"* (p. 77). Technologically speaking, interface problems should be taken into consideration. In terms of good quality data, the authors regard the use of the consistent metrics and the use of data protocols *"to establish conventions for collecting and sharing data, both quantitative (...) and qualitative (...)"* (p. 78) as crucial. In the end, the authors call on both researchers and funders to implement these guidelines to obtain more reliable data and policy-relevant outcomes.

Antti Silvast, Ronan Bolton, Vincent Lagendijk and Kacper Szulecki also focus on the role of researchers in their paper "Crossing Borders: Social Sciences and Humanities Perspectives on European Energy Systems Integration" (Silvast et al., 2018). The authors criticise the negligence of SSH related issues in European Energy System Integration (ESI), a concept that has emerged in research projects, conferences and associations, and develop a socio-technical perspective on ESI which they refer to as *"the process of coordinating the operation and planning of energy systems across multiple pathways and/or geographical scales to deliver reliable, cost effective energy services with minimal impact on the environment"* (p. 98). ESI implies a socio-technical energy *system "that cuts across technological, political, social, disciplinary, jurisdictional, and organisational boundaries"* (p. 99), i.e. where boundaries between different disciplines do not exist anymore. To overcome these boundaries, the authors consider the *"seamless web"* (p. 101) approach as helpful. It integrates visions of different disciplines together in a holistic view and thereby overcomes dichotomies that create boundaries which is necessary for an energy system that sees technical, social and economic aspects connected. As social and political aspects are entangled with the technical realm, changing one component of the system impacts other system components so that interdisciplinary research is necessary. To develop and implement ESI in research and in politics, and to overcome current challenges, the authors call on SSH researchers to develop a socio-technical perspective on ESI that *"is more embedded within and engaged with the technical aspects of ESI research and practice"* to obtain benefits and prevent mismatches between techno-economic and socio-political processes. This also entails *"developing a better understanding of energy consumption practices in integrated energy systems"* (both p. 107). The call for more SSH research on ESI is seen as especially important considering the "*interpretative flexibility*" (p. 104) which means that the ESI concept and design depends on the background of the researcher. In the end, ESI will be implemented by policymakers, thereby exerting energy control across a large geographic region which emphasises the need for comprehensive and interdisciplinary research once again.

The last paper identified in the control dimension, "A Complementary Understanding of Residential Energy Demand, Consumption and Services" written by Ralitsa Hiteva, Matthew Ives, Margot Weijnen and Igor Nikolic (Hiteva et al., 2018) shifts the control focus from the researchers to those who establish policies. It draws on the author's experiences *"in designing and applying different types of models for understanding energy systems, as an input in the policymaking process in EU member states"* (p. 114). Considering that models are a *"simplifying lens"* (p. 116) that determine the perspective on the energy system, the authors criticise the models used by policymakers for establishing energy policies as they often overestimate the predictive and explanatory value of one individual model. Therefore, they present techno-economic modelling, agent-based modelling and ethnographic research as complementary models and possibly enabling a combined approach to inform energy policy. They outline the basic assumptions, benefits and restrictions of each approach and apply these to the concepts of energy demand, consumption and services. After illustrating each approach, they show their complementary value: while technic-economic modelling can be used as statistical representation of user behaviour, ABM expands that model through considering individual user behaviour, and ethnographic research provides important information about the context of user behaviour and collects data that cannot be quantified through technical appliances. Based on their illustration, the authors give three recommendations for energy policymakers. Limitations of models should be appreciated both in terms of the modelling process and the output, different modelling outputs should be appreciated and confronted to realise the complexity in the policymaking process and finally, policymakers should

be enabled to work interdisciplinarily in context and with research teams to develop a complementary understanding of the illustrated models. These recommendations are especially important for policymakers, considering that they establish policies based on models and thereby exert control over complex socio-technical processes.

4.2.2. Change

The TPC change papers refer to the challenge of institutional stability and change. During the intended phase of major transition in an energy system, the system must remain stable to ensure functions that are necessary for society. While one paper refers to the governance and social consequences of the energy transition, the two other papers ask for a paradigm change in energy research and policy related to SSH that will also impact policies established for the energy transition.

The first paper in the change category points out the lack of concepts and frameworks that can account for consequences of the energy system transition from fossil fuels to renewable energy technologies. "Challenges Ahead: Understanding, Assessing, Anticipating and Governing Foreseeable Societal Tensions to Support Accelerated Low-Carbon Transitions in Europe", written by Bruno Turnheim, Joeri Wesseling, Bernhard Truffer, Harald Rohracher, Luis Carvalho and Claudia Binder (Turnheim et al., 2018), deals with the unprecedented and accelerated diffusion of renewable energy technologies (RETs) and *"their integration into larger technical, societal and environmental systems"* (p. 153), entailing multiple environmental and socio-economic consequences. The authors emphasise the importance of the acceleration phase, a stage that refers to the *"rapid and large-scale development of [RETs]"* (p. 147). The authors consider this to be a *"decisive moment in which the overall direction of change is likely to be settled, with implications on how the transition will unfold and what kind of system we will end up with"* (p. 153). They point to the lack of research in this area and argue for the development of frameworks that can *"account for the inherent uncertainty, turbulence, conflicts [and] struggles"* (p. 154). For a start, the authors illustrate approaches within the available techno-economic, socio-technical and socio-ecological system literature. Based on their analysis, they call for interdisciplinary research to encounter four upcoming challenges for the existing system approaches: understanding system dynamics, assessing signs of systemic stress, anticipating future social and ecological impact as well as transforming systems and their governance.

While the preceding paper makes the energy system transition the subject of change, the paper "Imaginaries and Practices: Learning from 'ENERGISE' About the Integration of Social Sciences with the EU Energy Union" calls for a paradigm change in energy policy and research. The authors Audley Genus, Frances Fahy, Gary Goggins, Marfuga Iskandarova and Senja Laakso (Genus et al., 2018) set the focus on SSH imaginaries. They criticise the narrowed understanding and integration of SSH in European energy policy, research and funding and the underestimated variety of SSH disciplines due to prevailing socio-technical imaginaries. These are defined as *"collectively held, institutionally stabilised, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology"* (p. 133) and impact the way of energy policymaking. The authors point out the potential of new socio-technical imaginaries by comparing and analysing selected EU Horizon 2020 work programmes and the related ENERGISE project proposal. In the authors' opinion, Horizon 2020 offers a narrowed imaginary, based on technical challenges, focusing on energy efficiency and increasing renewable energy technologies while considering SSH mainly for social acceptability and enabling consumers to make better energy choices. They illustrate that ENERGISE offers a more comprehensive imaginary, based on the assumption of technical failure and a deeper understanding of energy-related behaviour and decision-making through comprehending and sharing energy practice and culture on the individual and collective level. Therefore, the authors argue for a paradigm change in EU energy policy, research and funding that *"integrates qualitative SSH which recognises the collective nature of social practice and its implication for establishing energy policies and governance on a renewed understanding of energy demand and how it may be reduced"* (p. 135).

Like the previous paper, Gavin Bridge, Stefania Barca, Begüm Özkaynak, Ethemcan Turhan and Ryan Wyeth (Bridge et al., 2018) ask for a perspective change and expansion in European energy policymaking

which encompasses objectives, concepts and frameworks that have already come into effect. "Towards a Political Ecology of EU Energy Policy" refers to the problem that *"existing mainstream scientific and managerial approaches to the environment fail to adequately question existing socio-economic arrangements"* and therefore *"overlook the root causes of apparently 'environmental' problems which [...] are to be found in the unequal distribution of power within society"* (both p. 165). Political ecology is an interdisciplinary approach that concentrates on the context of environmental problems by focussing *"on how economic and political power shape social and environmental outcomes"* (p. 164), based on experiences of social movements and critical social theory. Applying this approach to energy policy, the authors offer a different perspective that reveals underlying assumptions in the current energy policy, how these affect groups as well as limit possible actions, and illustrate alternative approaches that promote social equality. They argue for degrowth and eco-sufficiency as alternatives for secure, competitive and sustainable energy, energy democracy for energy citizens instead of a top-down structure from policy to energy-consumers, as well as for new (social, geographical) scales of energy production, consumption and governance driven by social movements, as an alternative for fixed scales set through public administrations, including the option to move outside entrenched social hierarchies. In the end, the authors recommend to employ the political ecology perspective on several levels in EU energy policy, including *"research with affected communities [...]; deconstructing energy policy's objectives, discourses and guiding concepts; or working creatively with frictions and alternative agendas already present in policy"* (p. 172).

4.2.3. Capacity-building

Capacity-building refers to the challenge of creating 'prosumers' and 'energy citizens' that are an active part of the energy grid and contribute to the grid's stability instead of being passive consumers that only receive energy services. The four papers identified here focus on capacity-building and empowerment of individuals and communities. The first two papers of the TPC that we aligned with this dimension refer to the impact of energy transitions, access and availability on the action capacity of individuals and communities in related areas. The other two papers illustrate the role of the community in marine renewable energy development and discuss the role of multiple-owned property residents as energy citizens.

The first paper "Plugging the Gap Between Energy Policy and the Lived Experience of Energy Poverty: Five Principles for a Multidisciplinary Approach" by Lucie Middlemiss, Ross Gillard, Victoria Pellicer and Koen Straver (Middlemiss et al., 2018) illustrates multiple vulnerabilities that are connected to energy poverty, using the insights of three lived experiences. These insights reveal how energy policies affect energy poor households in different areas like health, social inclusion and market access. Therefore, the authors suggest a multidisciplinary approach to addressing energy poverty in a holistic way as different research disciplines focus on and reveal various consequences in different areas. To consider energy poor households in the energy transition, insights from the lived experience, according to the authors, should be translated into policies on different levels. In the end, the authors offer five guiding principles to design policies based on the lived experiences. These guiding principles include taking opportunities for policymaking across domains, working with partnerships and in networks, flexible governance, a holistic progress measurement and finally, starting on energy poverty policies without being aware of all aspects in the wider context but reflecting on the implemented policies. Therefore, this paper expands the understanding of capacity-building in the energy context. Energy policies do not only impact the energy action capacity but also influence capacities and empowerment in areas that are connected to energy access and availability. Therefore, the authors ask to consider energy poor people in the energy transition to avoid unintended consequences and reduce the social costs of energy transitions.

The paper "Looking for Perspectives! EU Energy Policy in Context" by Anna Åberg, Johanna Höffken and Susanna Lidström (Åberg, Höffken and Lidström, 2018) sheds light on socio-cultural and historical conflicts that emerge in the energy transition as outlined in the EU Energy Roadmap 2050 for individuals and communities. The authors criticise the *"focus on technological aspects of possible energy futures while paying less attention to the social embeddedness of energy production and consumption"* (p. 48). They set up a fictional citizen platform in the nearby future where three women from inside and outside Europe give their opinion on three main points of the EU Energy Roadmap 2050: energy transition with benefits for all,

sustaining Europe's competitiveness as well as empowerment of consumers with predictable and lower energy bills. The fictional stories told by the women exceed the energy topic and encompass energy-related social, political, cultural and historical aspects that should be considered in the energy transition. The stories raise socio-cultural and historical key issues that are relevant for energy policy frameworks like the EU Energy Roadmap, amongst others energy poverty, colonialization, path dependencies, historical responsibilities and current possibilities for climate action and development and financial responsibility. Similar to the previous paper, the authors expand the understanding of capacity-building by pointing out that energy policies influence capacities and empowerment in several areas. While the previous paper was focussed on the consequences of energy poverty on the individual level, this paper concentrates on the wider context of the energy transition, drawing on socio-political and cultural aspects on the local, national and global level. Therefore, the authors argue for a broader perspective through SSH on the energy problem that comprises *"all the different social, political and cultural concerns that are often at the core of seemingly technical energy issues"* (p. 57).

The paper "Shaping Blue Growth: Social Sciences at the Nexus Between Marine Renewables and Energy Policy" by Sandy Kerr, Laura Watts, Ruth Brennan, Rhys Howell, Marcello Graziano, Anne Marie O'Hagan, Dan van der Horst, Stephanie Weir, Glen Wright and Brian Wynne (Kerr et al., 2018) analyses social-cultural challenges that are related to the development of Marine Renewable Energies (MRE) in communities with a *"deep physical, psychological and spiritual connection to the sea"* (p. 33). A discussion summary between researchers of the International Network for Social Studies of Marine Energy (ISSMER) and four expert guests revealed five areas that illustrate various SSH aspects relevant for MRE development. In terms of the marine space, tensions arise between legal rights and ownership and the (informal) understanding of rights and ownership perceived by the community. Community mythologies have a powerful influence on the perception of MRE, entailing that MRE development must incorporate MRE mythologies in the socio-cultural context of the community. MRE device design and implementation should also consider the socio-cultural context of the community and beyond, including the local population. Having many different actors involved in MRE development, disparities arise between and within stakeholder groups. Therefore, the final topic *"ecology of approaches"* (p. 40) argues to create an *"MRE 'development community' that includes developers, researchers, policymakers, and the local community"* (p. 41) to act in concert instead of against one another. That constitutes a challenge for SSH researchers as they have the task of translating the narratives, evidence and language of the different stakeholders, in this way making them comprehensible for all groups involved. Therefore, this paper contributes to capacity-building in MRE communities as the authors argue for a participatory approach that incorporates the local people both in terms of drawing on their marine experiences but also facilitates the integration of MRE development into their socio-cultural context to achieve a sustainable transition. As sustained engagement with the local communities is a core condition for a sustainable change and successful MRE development, the authors suggest *"bridger organisations"* (p. 42) as an option to keep track of MRE development processes, engage with the local communities and being a trustworthy contact institution for MRE development.

The last paper in this category "Building Governance and Energy Efficiency: Mapping the Interdisciplinary Challenge" by Frankie McCarthy, Susan Bright and Tina Fawcett (McCarthy, Bright and Fawcett, 2018) targets capacity-building with residents of Multiple-owned Properties (MoPs) through empowering them to take responsible energy decisions and to be energy citizens showing liable energy behaviour. The authors start out with the problem of missing data of holistic building governance including different areas and missing knowledge about energy-related decision-making in MoPs. The authors draw on the discussions of an exploratory, multidisciplinary expert workshop. To tackle the described problems, the building governance model is used for a start which assumes that *"the structure within which energy decisions can be taken in MoPs is delineated by a combination of the law of property and the law of associations"* (p. 86). While property law is essential for retrofit work, the law of associations refers to energy-related decision-making and energy behaviour change of the residents. This requires interdisciplinary collaboration in SSH both in terms of data collection to understand the governance challenge and to *"develop a framework [...] to understand how complex groups may be able to take energy decisions that benefit them collectively as well as individually"* (p. 86). While the data collection challenge is covered by the GREEAN-EU group, the challenge to develop a framework for MoPs energy decision-making is still present. SSH theories offer approaches

to understand collective decision-making and behavioural change, but further research is necessary as MoP collectives constitute a unique and complex group. The authors argue for theoretical approaches that consider the heterogeneity of MoPs as well as more evidence through case studies about MoPs that have been retrofitted, in order to understand the mechanisms in collective energy-related decision making and behaviour change that considers the roles of all included levels and actors. Although the authors argue for conducting pan-European interdisciplinary research to develop the framework and build the evidence, they also point out the emerging practical challenges of language barriers, communication, management, methods, levels of interdisciplinary expertise as well as variation in disciplinary styles and show possible solutions.

4.3. Concluding remarks: TPC and RDC in comparative perspective

The ten papers of the think piece collection illustrate challenges related to the reference problems Control, Change and Capacity-building. They cover a broad spectrum of topics in energy policies and the energy transition, ranging from the impact on a system level to the individual level while pointing out future research areas and opportunities for collaboration. Having a closer look at the individual papers, similarities and recurring issues can be recognised comparing the contributions of the Think Piece Collection (TPC) to the Research Design Challenge (RDC). Although the papers cover broadly the same topics, they are partially aligned with different reference problems. This allows us to consider similar topics from a different perspective and illustrate the interrelation between the three reference problems.

The first topic covered in both publications, TPC and RDC, is renewable energy development in local communities. While Smedberg and Light (2018; RDC) refer to the independent wind energy production on a remote island in Scotland, Kerr et al. (2018; TPC) analyse emerging challenges in local communities through MRE development. Eventually, the papers view renewable energy development in two different perspectives: Smedberg and Light focus on increased control of the community in energy policy and application, whereas Kerr et al. focus on capacity-building in marine local communities as well as their involvement and participation in MRE development. Reducing the social costs of the transition was also discussed in both paper collections. Turhan, Şorman and Larsen (2018; RDC) suggest to combine quantitative and qualitative storytelling to improve decision-making by those who are in control and reduce the effects on the socially underprivileged. Middlemess et al. (2018; TPC) connect to Turhan et al., but focus on capacities and empowerment of individuals who are restricted in various areas due to energy poverty. Åberg, Höffken and Lidström (2018; TPC) concentrate on the broader social context of the energy transition, pointing out socio-political, historical and cultural aspects on the local, national and global level and the impact on communities.

Beyond the social transition costs, the socio-technical consequences of the energy transition are also covered in both collections. Lis et al. (2018; RDC) discuss unintended socio-technical consequences in the transition to electric mobility, thereby relating to the change dimension. While they cover a specific sub-topic of change in the energy transition, Turnheim et al. (2018; TPC) refer to the broader energy system transition and point out the lack of concepts and frameworks that predict socio-technical consequences. In that way, the author teams both address change, yet at various scales, from sectoral to overall. Eventually, both papers call for more research to develop frameworks and concepts that can analyse (intended and unintended) consequences of the energy transition more thoroughly.

Furthermore, energy behaviour and decision-making are discussed in several papers across the dimensions of change and capacity-building. The first three papers on this topic refer to energy behaviour and decision-making in distinct contexts. Greene and Schiffer (2018; RDC), for instance, illustrate how the context impacts energy behaviour in an industrialised and a developing nation, explaining paths of stability and change. Genus et al. (2018; TPC) discuss the behavioural dimension in EU projects and call for a paradigm change in socio-technical imaginaries to consider energy-related behaviour as the results of energy practice and culture. Della Valle and Poderi (2018; RDC) finish that trio, creating a framework that considers contextual and individual factors for energy-related decision-making, regarding potentials

of capacity-building. These papers all reveal current insights in individual energy behaviour in context, but also illustrate how change and capacity-building interrelate in formulating emerging research priorities.

Three further papers refer to energy behaviour and decision-making in buildings. McCarthy, Bright and Fawcett (2018; TPC) discuss the problem of energy behaviour and decision-making of multi-owned properties (MoPs) residents and call for more research to develop a concept to understand energy behaviour and decision-making in complex groups like MoPs residents. Oliveira and Baborska-Narozny (2018; RDC) also point out the lack of concepts and frameworks about energy use in buildings. Schweiker and Huebner (2018; RDC) complete the behavioural topic, pointing out that for individual comfort, perceptions in energy building use must be taken into account to change energy behaviour.

The last key issue refers to the challenge of interdisciplinary collaboration and research in comparison, which was explicitly mentioned by TPC and RDC authors. Higginson et al. (2018; TPC) focus on emerging challenges in the socio-technical process of an interdisciplinary research project to receive good quality data, concluding that time, people, technology and good quality data are challenging categories to be considered in future projects. McCarthy, Bright and Fawcett (2018; TPC) also present challenges and solutions in interdisciplinary research through the language barrier, communication, management, methods, levels of interdisciplinary expertise as well as variation in disciplinary styles. While the previous two papers focus on research collaboration, Wokuri and Pechancová (2018; RDC) present an analysis of two community energy projects in the EU which also include project collaboration. Based on their analysis, they show requirements for similar project implementation. Therefore, references of collaborative research across the TPC and RDC address researchers, policymakers and practitioners at the same time.

5. Overall conclusions: qualitative evaluation in SHAPE ENERGY

After reviewing a number of major qualitative activities in SHAPE ENERGY, our conclusions are multifold and concern interdisciplinary collaboration at different levels, scales and settings. We encourage researchers, policymakers and practitioners to consider the following advice in interdisciplinary endeavours, so that expectations can be realistic and synchronised, mistakes might be avoided, and convincing outputs may be generated.

First of all, the analysis of academic literature around collaborative research strategies in energy and sustainability related SSH (section 2) explored four concepts:

- *Multidisciplinarity research* gathers knowledge from various disciplines and adds multiple views, but without crossing disciplinary boundaries;
- *Interdisciplinarity research* contains a certain level of disciplinary integration which requires more extensive cooperation than is common to multidisciplinary research;
- *Transdisciplinary research* seeks to abandon disciplinary theories and create boundary crossing theories and models, including non-academia actors for a holistic approach;
- *Transformative science* takes an active role in initiating and catalysing change processes in science and the wider scientific system, building on a broad repertoire of research approaches and disciplines, which focus on joint social learning of scientists and laypersons.

What is somewhat missing in the literature is how to translate these types of research into SSH practice. We thus recommend pursuing this, considering the organisational as well as social and relational context surrounding collaborative research. Further, the skills and competencies of involved researchers and the philosophical conditions underpinning collaboration must be taken into account. Overall, even though 'integration' has become a gold standard in many academic calls and project structures, it often remains unclear (including within funding calls and proposals) what type of integration with regard to the above concepts is referred to and what type of outcome is expected from the collaboration. We therefore recommend a close look at the usefulness, the need and relevance of any form of integration in relation to the desired outcome, and to carefully consider the specific research question for appropriate application of integrative measures.

Throughout the SHAPE ENERGY summer school, ESR internships and 17 multi-stakeholder meetings, qualitative data was collected through participant observation and diaries, and analysed to learn about multi- and interdisciplinary collaborations. The design specifically focussed on issues of power and inclusion (or *dominations*), i.e. how do differences in gender, institutional and disciplinary affiliation and seniority influence the dynamics of collaboration. Observation of interactions during the ESR summer school showed that interdisciplinarity played a key role in the way the problems were tackled, i.e. economics focussed and socio-political working groups emerged who had vivid debates in attempting to bring together their approaches to energy (not always succeeding). Domination processes affected ESR's collaborations regarding disciplines and topics (e.g. policymaking being a more 'male' category, while more recent topics such as RES being more represented by female ESRs). Interaction analysis also revealed that the cultural background of ESRs in terms of discussion style, approaches to topics or emphasis of themes is not always considered sufficiently during collaboration, which is an aspect we would like to stress here as a recommendation for future endeavours.

Main research findings of the ESRs internship diaries reveal that ESRs' university programme choices - which were primarily in the SSH - had to some extent been affirmatively influenced by their social heritage and awareness raising since childhood, and their social environment, but was also the product of chance in some cases. The ESRs considered learning of STEM very valuable in addition to their SSH education, but in particular stressed that this willingness to cross disciplines for the sake of better research outcomes is crucial in the field of energy. Further, following their internship experiences, they felt that it was crucial for individual researchers to maintain their own disciplinary depth, to bring to interdisciplinary collaborations.

They also reported on their perceptions of the dominance of certain disciplines in the field of energy, and the dominance of some cultural areas in academic energy research.

Both the summer school and internships highlighted that working across disciplines requires clear objectives on all sides, i.e. explicate the 'implicits' of the various disciplines and time for each discipline to produce a 'rigorous' output.

With regard to the 17 multi-stakeholder workshops, we implemented a novel method of focussed participant observation, conducted at all events. Key findings included the appearance of interdisciplinary working as both an aim of the workshops (for tangible outcomes) and a solution proposed by participants (both explicitly and implicitly) for solving local energy challenges. The method of storytelling was found to be effective at generating an inclusive atmosphere, and thus addressing to a large degree domination issues. Having said that, domination was not entirely absent, with groups not present in some cases being the object of 'blame', as well as individual participants in some cases tending to control the conversation. In the latter case, skilled facilitation was key and we highlight the importance of expert facilitation skills in supporting interdisciplinary conversation and activity. The workshops also allowed a slightly more in-depth analysis of cultural context (than was possible through the ESR programme) although we would recommend even more emphasis on cultural diversity in future. We make several other recommendations for projects which may wish to use similar observation techniques.

Once an appropriate research question is identified, one way of pursuing fruitful collaborative (energy) research is the application of 'reference problems' (section 4), such as in the SHAPE ENERGY Research Design Challenge (RDC). This method allowed authors representing numerous energy-SSH themes to come together around three scientific problems, i.e. *control*, *change and capacity-building* in energy systems. In this review, reference problems were also used to analyse the SHAPE ENERGY Think Piece Collection (TPC), underscoring that these are repetitive problems valid in a multitude of energy-related SSH. Both TPC and RDC address comparable topics, although they partially relate to different reference problems. This provides the opportunity to consider the same topic from different perspectives, and illustrates the interrelation between the three reference problems. Key topics include:

- *Renewable energy development in local communities and society*

  Contributions refer to increased control of the community level in energy policy and application, change through local energy-startups and ecovillages, as well as capacity-building in local communities through involvement and participation in renewable energy development;

- *Reducing the social costs of the energy transition*

  Main aspects are the impact of energy transitions, regarding access and availability of individuals' and communities' capacity-building and control in related areas;

- *Socio-technical consequences of the energy transition*

  Contributions point out the lack of concepts that predict socio-technical consequences at different scales of change and call for more research to develop frameworks that analyse consequences of the energy transition more thoroughly;

- *Energy behaviour and decision-making*

  Key aspects are energy behaviour and decision-making in specific contexts and in buildings, connecting the reference problems of capacity-building and change. The papers refer to the socio-cultural context of energy behaviour as well as contextual and individual factors to be considered in energy-related decision-making. Other contributions focus on buildings, pointing out special features of energy behaviour in multi-owned properties, or the importance to consider the needs of the individuals inhabiting a building.

Based on these aggregated research themes and reference problems, we recommend to more systematically pursue this concept in the European SSH and STEM communities. The concept worked in the SHAPE ENERGY RDC because many researcher teams with different disciplinary backgrounds were able to engage in common, unified approaches without separating their parts distinctly along the involved disciplines. In

a majority of cases, researchers managed to develop their designs in focusing on the reference problem of their respective section, and not around their personal academic background. The above comparison with the SHAPE ENERGY TPC, highlighting crossover themes and problems, underscores the potential of this approach. Consequently, for the future of energy-SSH, we are confident that this evaluation builds a starting point for further *problem-driven* interdisciplinary research that prioritises the scientific problems behind the energy transition instead of disciplinary preoccupations. Another attempt with more specific conceptual preparation and pre-selected authors has been made elsewhere (Büscher, Schippl and Sumpf, 2018), so that there is a strong basis for advancements in this domain.

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7. References

Agar, 1996. *The professional stranger: An informal introduction to ethnography* (2nd ed.). San Diego, CA: Academic Press.

Alpert, B., 2016. Writing in qualitative research. In: N. Sabar-Ben Yehoshua, ed. 2016. *Traditions and genres in qualitative research: Philosophies, strategies and advanced tools*. Tel Aviv: Mofet Institute, pp. 236–262.

Åberg, A., Höffken, J. and Lidström, S., 2018. Looking for Perspectives! EU Energy Policy in Context. In: Foulds, C. and Robison, R. eds., 2018. *Advancing Energy Policy – Lessons on the Integration of Social Sciences and Humanities*. Cham: Palgrave Macmillan, pp. 47-59. [online] Available at: https://link.springer.com/book/10.1007/978-3-319-99097-2#toc [Accessed 20 November 2018].

Bark, R.H., Kragt, M.E. and Robson, B.J., 2016. Evaluating an interdisciplinary research project: Lessons learned for organisations, researchers and funders, *International Journal of Project Management*, 34, pp.1449–1459. http://dx.doi.org/10.1016/j.ijproman.2016.08.004.

Beck, U., 1986. *Risikogesellschaft. Auf dem Weg in eine andere Moderne*. Frankfurt: Suhrkamp.

Blumer, H., 1969, *Symbolic Interactionism*. Prentice-Hall, Englewood Cliffs, NJ.

Bracken, L. and Oughton, E., 2006. What do you mean? The importance of language in developing interdisciplinary research. *Transaction of the Institute of British Geographers*, 31(3), pp. 371-382.

Bridge, G., Barca, S., Özkaynak, B., Turhan, E. and Wyeth, R., 2018. Towards a Political Ecology of EU Energy Policy. In: Foulds, C. and Robison, R. eds., 2018. *Advancing Energy Policy – Lessons on the Integration of Social Sciences and Humanities*. Cham: Palgrave Macmillan pp. 163-175. [online] Available at: https://link.springer.com/book/10.1007/978-3-319-99097-2#toc [Accessed 20 November 2018].

Büscher, C., Schippl, J. and Sumpf, P. eds., 2018. *Energy as a Sociotechnical Problem. An Interdisciplinary Perspective on Control, Change, and Action in Energy Transitions*. Routledge Studies in Energy Transitions. London: Routledge.

Byrne, R., Smith, A., Watson, J. and Ockwell, D., 2011. Energy Pathways in Low-Carbon Development: From Technology Transfer to Socio-Technical Transformation. [online] *Steps Working Paper 46*, Brighton: STEPS Centre. Available at: https://steps-centre.org/wp-content/uploads/Energy_PathwaysWP1.pdf [Accessed 20 November 2018].

Campbell, B., Cloke, J. and Brown, E., 2016. Communities of Energy. *Economic Anthropology* 3(1), pp. 133-144.

Carlsson, B. and Stankiewicz, R., 1991. On the Nature, Function and Composition of Technological Systems. *Journal of Evolutionary Economics* 1(2): pp. 93–118. https://doi.org/10.1007/BF01224915.

Clifford, J., and Marcus, G. E., 1986. *Writing Culture: The Poetics and Politics of Ethnography*, Berkeley: University of California Press.

Daedlow, K., Podhora, A., Winkelmann, M., Kopfmuller J., Walz, R. and Helming, K., 2016. Socially responsible research processes for sustainable transformation: our integrated assessment framework. *Current opinion in Environmental Sustainability*, 23, pp.1-11.

De Boer, Y., De Gier, A., Verschuur, M. and De Wit, B. 2006. Bruggen Bouwen: Onderzoekers over hun ervaringen met interdisciplinair onderzoek in Nederland. [online] RMNO, KNAW, NWO, COS. Available at: https://www.rvo.nl/sites/default/files/bijlagen/Onderzoekers_over_interdisciplinair_onderzoek_Bruggen_bouwen_Ymkje_de_Boer_2006.pdf [Accessed 13 June 2018].

Della Valle, N. and Poderi, G., 2018. What works for consumer engagement in the energy transition: Experimenting with a behavioural-sociological approach. In: Sumpf, P. and Büscher, C. eds., 2018. *SHAPE ENERGY research design challenge: Control, change and capacity-building in energy systems*. Cambridge: SHAPE ENERGY 2018, pp. 104-113. [online] Available at: https://shapeenergy.eu/wp-

content/uploads/2018/04/SHAPE-ENERGY_D3.5_Research-design-challenge-collection-1.pdf [Accessed 20 November 2018].

Ellis, C., Adams, T. E., and Bochner, A. P., 2010. Autoethnography: An Overview [40 paragraphs]. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, [online] 12(1), Art. 10, Available at: http://nbn-resolving.de/urn:nbn:de:0114-fqs1101108 [Accessed 20 November 2018].

European Commission, 2018. Integration of Social Sciences and Humanities in Horizon 2020: Participants, Budget and Disciplines - 3rd Monitoring report on SSH flagged projects funded in 2016 under the Societal Challenges and Industrial Leadership priorities, [online]. Available at: https://publications.europa.eu/en/publication-detail/-/publication/4365f75a-5efe-11e8-ab9c-01aa75ed71a1/language-en [Accessed 20 November 2018].

European Universities Association, 2017. *Energy Transition and the Future of Energy Research, Innovation and Education: An Action Agenda for European Universities. Brussels: EUA*. Available at: https://energy.eua.eu/downloads/publications/energy-transition.pdf [Accessed 19 November 2018].

Foulds, C. and Robison, R. eds., 2018. *Advancing Energy Policy – Lessons on the Integration of Social Sciences and Humanities.* Cham: Palgrave Macmillan. [online] Available at: https://link.springer.com/book/10.1007/978-3-319-99097-2#toc [Accessed 20 November 2018].

Fuenfschilling, L. and Truffer, B., 2014. The Structuration of Socio-Technical Regimes -- Conceptual Foundations from Institutional Theory. *Research Policy* 43(4): pp. 772–91. https://doi.org/10.1016/j.respol.2013.10.010.

Geels, F. W., 2004. From Sectoral Systems of Innovation to Socio-Technical Systems: Insights about Dynamics and Change from Sociology and Institutional Theory. *Research Policy* 33(6–7): pp. 897–920. https://doi.org/10.1016/j.respol.2004.01.015.

Geels, F.W., Berkhout, F. and van Vuuren, D.P., 2016. Bridging Analytical Approaches for Low-Carbon Transitions. *Nature Climate Change* 6(6): pp. 576–83. https://doi.org/10.1038/nclimate2980.

Genus, A., Fahy, F., Goggins, G., Iskandarova, M. and Laakso, S., 2018. Imaginaries and Practices: Learning from 'ENERGISE' About the Integration of Social Sciences with the EU Energy Union. In: Foulds, C. and Robison, R. eds., 2018. *Advancing Energy Policy – Lessons on the Integration of Social Sciences and Humanities.* Cham: Palgrave Macmillan, pp. 131-144. [online] Available at: https://link.springer.com/book/10.1007/978-3-319-99097-2#toc [Accessed 20 November 2018].

Greene, M. and Schiffer, A., 2018. Learning from past and current energy transitions to build sustainable and resilient energy futures: Lessons from Ireland and The Gambia. In: Sumpf, P. and Büscher, C. eds., 2018. *SHAPE ENERGY research design challenge: Control, change and capacity-building in energy systems*. Cambridge: SHAPE ENERGY 2018, pp. 57-66. [online] Available at: https://shapeenergy.eu/wp-content/uploads/2018/04/SHAPE-ENERGY_D3.5_Research-design-challenge-collection-1.pdf [Accessed 20 November 2018].

Goffman E., 1990. *The Presentation of Self in Everyday Life.* New York: Penguin.

Grunwald, A., 2018. *Technology Assessment in Practice and Theory*. Oxford: Routledge.

Hermet, I., Laterrasse, C., and Capdevielle-Mougnibas, V., 2004. Rapport au savoir et importance des caractéristiques disciplinaires dans les choix d'études des doctorants en histoire et en mathématiques, *L'orientation scolaire et professionnelle*, 30/4. [online] Available at: http://journals.openedition.org/osp/4909 [Accessed 20 November 2018] DOI: 10.4000/osp.4909.

Higginson, S., Topouzi, M., Andrade-Cabrera, C., O'Dwyer, C., Darby, S. and Finn, D., 2018. Achieving Data Synergy: The Socio-Technical Process of Handling Data. In: Foulds, C. and Robison, R. eds., 2018. *Advancing Energy Policy – Lessons on the Integration of Social Sciences and Humanities.* Cham: Palgrave

Macmillan, pp. 63-81. [online] Available at: https://link.springer.com/book/10.1007/978-3-319-99097-2#toc [Accessed 20 November 2018].

Hiteva, R., Ives, M., Weijnen, M. and Nikolic, I., 2018. A Complementary Understanding of Residential Energy Demand, Consumption and Services. In: Foulds, C. and Robison, R. eds., 2018. *Advancing Energy Policy – Lessons on the Integration of Social Sciences and Humanities*. Cham: Palgrave Macmillan, pp. 111-127. [online] Available at: https://link.springer.com/book/10.1007/978-3-319-99097-2#toc [Accessed 20 November 2018].

Höchtl, F.; Lehringer, S. and Konold, W., 2006. Pure theory or useful tool? Experiences with transdisciplinarity in the Piedmont Alps. *Environmental Science Policy*, 9, pp. 322-329.

Jackson, M.C., 2006. Creative holism: A critical systems approach to complex problem situations. *Syst. Res. Behavioral Science*, 23, pp. 647-657.

Jaimangal-Jones D., 2014. Utilising ethnography and participant observation in festival and event research, *International Journal of Event and Festival Management*, 5, pp. 39-55.

Kerr, S., Watts, L., Brennan, R., Howell, R., Graziano, M., O'Hagan, A.M., van der Horst, D., Weir, S., Wright, G. and Wynne, B., 2018. Shaping Blue Growth: Social Sciences at the Nexus Between Marine Renewables and Energy Policy. In: Foulds, C. and Robison, R. eds., 2018. *Advancing Energy Policy – Lessons on the Integration of Social Sciences and Humanities*. Cham: Palgrave Macmillan, pp. 31-46. [online] Available at: https://link.springer.com/book/10.1007/978-3-319-99097-2#toc [Accessed 20 November 2018].

Klein, J.T., 1990. *Interdisciplinarity: History, Theory, and Practice*. Detroit, Michigan: Wayne State University Press.

Klein, J.T. and Newell, W.H.,1996. *Advancing interdisciplinary studies*. In J.G. Gaff and J. Ratcliff, eds. 1996. Handbook of the Undergraduate Curriculum: A Comprehensive Guide to the Purposes, Structures, Practices, and Change. San Francisco: Jossey-Bass Publishers, pp. 393-395.

Klenk, N.L. and Meehan, K., 2015. Climate change and transdisciplinary science: problematizing the integration imperative. *Environmental Science and Policy*, 54, pp. 160-167.

Klenk N.L. and Meehan, K., 2017. Transdisciplinary sustainability research beyond engagement models: Toward adventures in relevance. *Environmental Science and Policy*, 78, pp. 27-35.

Lemos, M.C. and Morehouse, B.J., 2005. The co-production of science and policy in integrated climate assessments, *Global Environmental Change*,15, pp.57–68. 10.1016/j.gloenvcha.2004.09.004.

Lis, A., Wagner, A., Ruzzenenti, F. and Walnum, H.J., 2018. Envisaging the unintended socio-technical consequences of a transition from fossil fuel-based to electric mobility. In: Sumpf, P. and Büscher, C. eds., 2018. *SHAPE ENERGY research design challenge: Control, change and capacity-building in energy systems*. Cambridge: SHAPE ENERGY 2018, pp. 67-76. [online] Available at: https://shapeenergy.eu/wp-content/uploads/2018/04/SHAPE-ENERGY_D3.5_Research-design-challenge-collection-1.pdf [Accessed 20 November 2018].

Luederitz, C., et al., 2016. Learning through evaluation - A tentative evaluative scheme for sustainability transition experiments, *Journal of Cleaner Production*, 169, pp. 61-76. http://dx.doi.org/10.1016/j.jclepro.2016.09.005.

Mackellar, J. (2013). Participant observation at events: theory, practice and potential. *International Journal of Event and Festival Management*, 4(1), pp. 56-65.

Marcus, G.E., 1995. Ethnography in/of the World System: The Emergence of Multi-Sited Ethnography, *Annual Review of Anthropology*, 24, pp. 95-117.

Marcus, G.E. and Fischer, M.M.J., 1999. *Anthropology as Cultural Critique. An Experimental Moment in the Human Sciences*. Chicago: University of Chicago Press.

McCarthy, F., Bright, S. and Fawcett, T., 2018. Building Governance and Energy Efficiency: Mapping the Interdisciplinary Challenge. In: Foulds, C. and Robison, R. eds., 2018. *Advancing Energy Policy – Lessons on the Integration of Social Sciences and Humanities.* Cham: Palgrave Macmillan, pp. 83-96. [online] Available at: https://link.springer.com/book/10.1007/978-3-319-99097-2#toc [Accessed 20 November 2018].

Middlemiss, L., Gillard, R., Pellicer, V. and Straver, K., 2018. Plugging the Gap Between Energy Policy and the Lived Experience of Energy Poverty: Five Principles for a Multidisciplinary Approach. In: Foulds, C. and Robison, R. eds., 2018. *Advancing Energy Policy – Lessons on the Integration of Social Sciences and Humanities.* Cham: Palgrave Macmillan, pp. 15-29. [online] Available at: https://link.springer.com/book/10.1007/978-3-319-99097-2#toc [Accessed 20 November 2018].

Miller, T.R., Baird, T.D., Littlefield, C.M., Kofinas, G., Chapin, F., III and Redman, C.L.,

2008. Epistemological pluralism: reorganizing interdisciplinary research, *Ecology and Society*, 13(2), 46. [online] Available at: https://www.ecologyandsociety.org/vol13/iss2/art46/ [Accessed 04 October 2018].

Miller, T.R., Muñoz-Erickson, T. and Redman, C.L., 2011. Transforming knowledge for sustainability: towards adaptive academic institutions, *International Journal of Sustainability in Higher Education*, 12(2), pp. 177-192. 10.1108/14676371111118228.

Moeran, B., 2017. From Participant Observation to Observant Participation: Anthropology, Fieldwork and Organizational Ethnography, *Creative Encounters Working Papers #2*, pp. 1-25.

Mourik, R., Robison, R., and Breukers, S., 2017. *Storytelling - SHAPE ENERGY facilitation guidelines for interdisciplinary and multi-stakeholder processes*, [online]. Cambridge: SHAPE ENERGY. Available at: https://shapeenergy.eu/wp-content/uploads/2017/08/SHAPE_ENERGY_Storytelling.pdf [Accessed 20 November 2018].

Oliveira, S. and Baborska-Narozny, M., 2018. Feeding back or feeding forward? A new lens into building energy use. In: Sumpf, P. and Büscher, C. eds., 2018. *SHAPE ENERGY research design challenge: Control, change and capacity-building in energy systems*. Cambridge: SHAPE ENERGY 2018, pp. 87-94. [online] Available at: https://shapeenergy.eu/wp-content/uploads/2018/04/SHAPE-ENERGY_D3.5_Research-design-challenge-collection-1.pdf [Accessed 20 November 2018].

Ortar, N., Burguet, D., Claudot, P., and Foulds, C., 2017. *The SHAPE ENERGY Summer School – how Social Sciences and Humanities can contribute to advancing European energy policy*, Cambridge: SHAPE ENERGY. [online] Available at: https://shapeenergy.eu/wp-content/uploads/2017/11/SHAPE_ENERGY_Summer_School.pdf [Accessed 20 November 2018].

Ortar, N., Burguet, D., and Robison, R., 2018. *Bringing Social Sciences & Humanities into H2020 energy projects: Early-Stage Researcher internship diaries*. Cambridge: SHAPE ENERGY. [online] Available at: https://shapeenergy.eu/wp-content/uploads/2018/04/SHAPE-ENERGY-D3.2_ESR-placement-feedback-review.pdf [Accessed 20 November 2018].

Popa, F., Guillermin, M. and Dedeurwaerdere, T., 2015. A pragmatist approach to transdisciplinarity in sustainability research: From complex systems theory to reflexive science, Futures, 65, pp.45–56. http://dx.doi.org/10.1016/j.futures.2014.02.002.

Rau, H., Goggins, G. and Fahy, F., 2018. From invisibility to impact: Recognising the scientific and societal relevance of interdisciplinary sustainability research. *Research Policy*, 47, pp. 266-276.

Robison, R., Dupas, S., Mourik, R., Torres, M., and Milroy, E., 2018. Europe's local energy challenges: stories and research priorities from 17 multi-stakeholder city workshops. Cambridge: SHAPE ENERGY. [online] Available at: https://shapeenergy.eu/wp-content/uploads/2018/12/Workshop-Key-Findings.pdf [Accessed 18 December 2018].

Schneidewind, U., Singer Brodowski, M., Augenstein, K., Stelzer, F., 2016. Pledge for a transformative Science, *Wuppertal Paper 191(29)*, Wuppertal: Wuppertal Institute for Climate, Environment and Energy.

Schneidewind, U., Augenstein, K., Stelzer, F., Wanner, M., 2018. Structure Matters: Real-World Laboratories as a New Type of Large-Scale Research Infrastructure. A Framework Inspired by Giddens' Structuration Theory, *GAIA 27/S1*, pp. 12–17.

Schuitema, G.D. and Sintov, N., 2017. Should we quit our jobs? Challenges, barriers and recommendations for interdisciplinary energy research. *Energy Policy*, 101, pp. 246-251.

Schweiker, M. and Huebner, G., 2018. Beyond the average consumer: Exploring the potential to increase the activity of consumers in load-shifting behaviours by means of tailor-made solutions. In: Sumpf, P. and Büscher, C. eds., 2018. *SHAPE ENERGY research design challenge: Control, change and capacity-building in energy systems.* Cambridge: SHAPE ENERGY 2018, pp. 124-134. [online] Available at: https://shapeenergy.eu/wp-content/uploads/2018/04/SHAPE-ENERGY_D3.5_Research-design-challenge-collection-1.pdf [Accessed 20 November 2018].

Shove, E., 2004. Changing human behaviour and lifestyle: a challenge for sustainable consumption. In: *The ecological economics of consumption*, Reisch, L.A. and Ropke, I., eds. 2004. Cheltenham: Edward Elgar, pp. 111-131.

Silvast, A., Bolton, R., Lagendijk, V. and Szulecki K., 2018. Crossing Borders: Social Sciences and Humanities Perspectives on European Energy Systems Integration. In: Foulds, C. and Robison, R. eds., 2018. *Advancing Energy Policy – Lessons on the Integration of Social Sciences and Humanities.* Cham: Palgrave Macmillan, pp. 97-110. [online] Available at: https://link.springer.com/book/10.1007/978-3-319-99097-2#toc [Accessed 20 November 2018].

Smedberg, A. and Light, A., 2018. Autonomy and control in Orkney: An inquiry into the social benefits of community wind energy. In: Sumpf, P. and Büscher, C. eds., 2018. *SHAPE ENERGY research design challenge: Control, change and capacity-building in energy systems.* Cambridge: SHAPE ENERGY 2018, pp. 18-26. [online] Available at: https://shapeenergy.eu/wp-content/uploads/2018/04/SHAPE-ENERGY_D3.5_Research-design-challenge-collection-1.pdf [Accessed 20 November 2018].

Smith, A., Stirling, A. and Berkhout, F., 2005. The Governance of Sustainable Socio-Technical Transitions. *Research Policy* 34(10): pp. 1491–1510. https://doi.org/10.1016/j.respol.2005.07.005.

Sovacool, B.K., Ryan, S.E., Stern, P.C., Janda, K., Rochlin, G., Spreng, D., Pasqualetti, M.J., Wilhite, H. and Lutzenhiser, L., 2015. Integrating social science in energy research. *Energy Research & Social Science*, 6, pp. 95-99, https://doi.org/10.1016/j.erss.2014.12.005.

Sovacool, B.K., and D.J. Hess, 2017. Ordering Theories: Typologies and Conceptual Frameworks for Sociotechnical Change. *Social Studies of Science* 47(5): pp. 703–750. https://doi.org/10.1177/0306312717709363.

Stock, P. and Burton, R.J.F., 2011. Defining Terms for Integrated (Multi-Inter-Trans-Disciplinary) Sustainability Research, *Sustainability*, 3, pp. 1090-1113. 10.3390/su3081090.

Strathern, M., 2004. *Partial connections*, Walnut Creek, CA: Alta Mira Press.

Sumpf, P. and Büscher, C. eds., 2018. *SHAPE ENERGY Research Design Challenge: Control, change and capacity-building in energy systems.* Cambridge: SHAPE ENERGY 2018. [online] Available at: https://shapeenergy.eu/wp-content/uploads/2018/04/SHAPE-ENERGY_D3.5_Research-design-challenge-collection-1.pdf [Accessed 20 November 2018].

Szostak, R., 2007a. Comprehensive curricular reform: Providing Students with an overview of the scholarly enterprise. *Journal of General Education*, 52(1), pp. 27-49.

Szostak, R., 2007b. How and Why to Teach Interdisciplinarity Research Practice. *Journal of Research Practice*, 3(2), pp. 1-16.

Thompson, M.A., Owen, S., Lindsay, J.M., Leonard, G.S. and Cronin, S.J., 2017. Scientist and stakeholder perspectives of transdisciplinary research: Early attitudes, expectations, and tensions. *Environmental Science and Policy*, 74, pp. 30-39.

Turhan, E., Şorman, A. H. and Larsen, K., 2018. Reconciling qualitative and quantitative storytelling in just energy decision making: A research design challenge contribution. In: Sumpf, P. and Büscher, C. eds., 2018. *SHAPE ENERGY research design challenge: Control, change and capacity-building in energy systems*. Cambridge: SHAPE ENERGY 2018, pp. 27-34. [online] Available at: https://shapeenergy.eu/wp-content/uploads/2018/04/SHAPE-ENERGY_D3.5_Research-design-challenge-collection-1.pdf [Accessed 20 November 2018].

Turnheim, B., Wesseling, J., Truffer, B., Rohracher, H., Carvalho, L. and Binder, C., 2018. Challenges Ahead: Understanding, Assessing, Anticipating and Governing Foreseeable Societal Tensions to Support Accelerated Low-Carbon Transitions in Europe. In: Foulds, C. and Robison, R. eds., 2018. *Advancing Energy Policy – Lessons on the Integration of Social Sciences and Humanities.* Cham: Palgrave Macmillan, pp. 145-161. [online] Available at: https://link.springer.com/book/10.1007/978-3-319-99097-2#toc [Accessed 20 November 2018].

Walter, A.I., Helgenberger, S., Wiek, A. and Scholz, R.W., 2007. Measuring societal effects of transdisciplinary research projects: Design and application of an evaluation method. *Evaluation Program Plan*, 30, pp. 325-338.

Winskel, M., 2014. Embedding Social Sciences in Interdisciplinary Research: Recent Experiences from Interdisciplinary Energy Research. *Science as Culture*, 23(3) pp. 413-418. 10.1080/09505431.2014.926150.

Winksel, M., 2018. The pursuit of interdisciplinary whole systems energy research: Insights from the UK Energy Research Centre. *Energy Research & Social Science*, 37, pp. 74–84. http://dx.doi.org/10.1016/j.erss.2017.09.012.

Wokuri, P. and Pechancová, V., 2018. Islands of innovation in the UK and the Czech Republic. In: Sumpf, P. and Büscher, C. eds., 2018. *SHAPE ENERGY Research Design Challenge: Control, change and capacity-building in energy systems*. Cambridge: SHAPE ENERGY 2018, pp. 35-43. [online] Available at: https://shapeenergy.eu/wp-content/uploads/2018/04/SHAPE-ENERGY_D3.5_Research-design-challenge-collection-1.pdf [Accessed 20 November 2018].

8. Appendix: Field notes diary template

This document is intended to help realize the participant observation during the multi stakeholders meetings. It must be sent to Delphine Burguet (delphine.burguet@entpe.fr) and Nathalie Ortar (nathalie.ortar@entpe.fr) within a week after the meeting has taken place. As observation can be very demanding, we will ask you to observe only one session (recommendation on which will likely be sent out nearer the time) in detail. The diary contains two parts:

1. First part describes the mandatory information about the meeting and the observed session (e.g. one-hour in duration).
2. Second part deals with further information that would help improve the analysis of the meeting.

Please anonymise the name of the participants. The full reports will be submitted confidentially to the Commission to demonstrate the depth of data.

Part 1 - mandatory for all to complete

SETTING	
WHERE	
WHEN	
DETAILS OF THE MEETING	*[Chosen topics of discussion? How have they been chosen? By who?]*
OBJECTIVES OF THE MEETING	*[What are the objectives of the meeting?]*
EXPECTED RESULTS	*[What are the expected results for SHAPE ENERGY as well as the partners co-organising the meeting?]*
PARTICIPANTS OBSERVERS	

OBSERVED SESSION	
AIM OF THE SESSION	
REASON FOR CHOOSING THIS PARTICULAR SESSION TO OBSERVE	
TOPICS OF DISCUSSION	*[Please detail each of them]*
WERE THERE CROSS DOMAIN/ DISCIPLINARY DISCUSSIONS?	*[Please detail which cross domain/disciplinary discussions took place]*
TECHNICALITY OF THE DISCUSSIONS	*[Could everybody jump in the conversation?]*
INTERACTIONS	*[Who spoke the most/the least? Who was leading the debates?]*
TONE OF THE DISCUSSIONS	*[What was the tone of the conversations? Were there some "hot" subjects? Which one? Could you tell why?]*

Observation table – social interactions

The detail of the conversation does not need to be transcribed, instead simply tick the contributions that your participants made to a group discussion or any other sort of sessions implying discussions. Tick only the box relating to the observed action, and please do so in chronological order when possible. You might also insert some comments. Some actions may take place at the same time. Try as far as possible to still keep to the chronological order.

This table needs to be anonymise but do not forget to put the gender of the participants as well as some information about her/his position.

OBSERVATIONS NAME	Introduction to the session	Comments/ Remarks made during the sessions	Questions asked during the session	Answers given	Solutions/ Actions proposed in reference to the topic of the session	Who approved	Who disapproved	Decisions taken	Who drew the general conclusions of the session	General comments (gender, sector)
1. e.g. Mrs A	x									
2. e.g. Mrs B			x							
3. e.g. M. C							x			
Total										

Part 2 – (encouraged) optional observations

FEEDBACK ABOUT THE ENTIRE MEETING	
WHAT WERE THE MAIN TOPICS COVERED?	
WERE THERE CROSS DOMAIN/ DISCIPLINARY DISCUSSIONS?	
WHICH TOPICS WERE DOMINANT?	
WHO WAS DOMINANT DURING THE DISCUSSIONS?	
DESCRIPTION OF THE PERSONS PRESENT, AND THE IMPLICATIONS OF E.G. GENDER, DISCIPLINES, SECTORS, EXPERTISE, PROFESSIONAL STATUS, AGES, ETC. ON THE DYNAMICS, DELIVERY, AND GENERAL RUNNING OF THE EVENT	
GENERAL OBSERVATIONS ABOUT STORYTELLING (HOW DID IT GO, WERE THERE ANY ISSUES?)	

EXCHANGES & SPACES	
WORKPLACES	*[Description of the settings]*
INFORMAL MEETING POINTS AND TOPICS	*[What are the informal meeting points? What are the main topics covered? What are the subjects of conversation? Who speaks? Who speaks the most/least?]*
NETWORKS	
HISTORY OF THE EXISTING NETWORKS	• How where the participants invited? • Which networked were used?

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