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Beyond instrumentalism: Broadening the understanding of social innovation in socio-technical energy systems

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ABSTRACT

Social innovation is an important dimension of current transformations in energy systems. It can refer to alternative business models, novel policy instruments, financing schemes, participatory governance approaches to energy questions, or new discourses. Its significance for energy systems is often considered in narrow instrumentalist terms, reducing it to a tool serving particular policy objectives. Grounding the concept in social science and humanities insights, this review essay proposes a broadened social innovation understanding. We propose 1) to open up the normative complexity of the concept; 2) to appreciate the multi-actor nature of social innovation; 3) to understand it as an analytical entry point for socio-material intertwinement; and, 4) to understand social innovation as premised on experimentalism-based intervention logics. The proposed social innovation understandings provide a broader imagination and strategizing of structural changes in energy systems.

1. Introduction: The rise of social innovation in energy systems research

The search for decarbonised futures unites many policy bodies across governance scales – such as, cities as members of the European Covenant of Mayors, states as signatories to the Paris Agreement, and the European Commission through its vision of an Energy Union [1] and European Green Deal as presented by its President von der Leyen. Although current developments show an increasing attention for changing energy systems, such as the adoption of the Clean Energy Package by the European Parliament, policymakers, academics and civil society actors agree that these changes need to accelerate further to meet the Paris Agreement [2,3]. In many European countries, policy efforts have largely centred on pursuing pathways that rely on nationally structured technology substitutions. For instance, in Germany, policies have aimed to accelerate the development of renewable energy technologies [4], and are now supplemented with discontinuation policies for fossil-based energy provision [5]. In many countries, a combination of high-tech infrastructural developments (e.g. off-shore wind parks), high-voltage transmission lines, and smart-grid developments

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are presented as paramount to enable energy transitions.

The need for accelerating changes in energy systems has turned attention to the widely neglected social dimensions of sustainable energy transitions [6–11]. In doing so, researchers and policy workers have started to adopt the concept of social innovation (e.g. [12–15]). In this work, social innovation involves various non-technological innovations and active contributions from consumers, citizens and organisations beyond the purchase and adoption of low-carbon technologies. It is generally understood to affect both supply and demand in different sectors, such as mobility, heat, and electricity. It includes phenomena like alternative business models (e.g. community energy cooperatives, energy service companies, crowdfunding); subsidy schemes or participatory governance approaches to energy questions (e.g. cooperatively governed neighbourhood-based heat systems); innovative policy interventions (e.g. based on behavioural insight, such as nudging); new framings such as 'prosumerism', energy democracy or energy poverty; or new ways of organising such as those developed by the contemporary climate movement (e.g. school strike for climate).

In line with ideas on the social acceptance of energy technologies [12], social innovation in energy research, practice, and policy is often considered as a means for achieving specific energy-related social goals (e.g. [13]) as a counterpart to or extension of technological innovation [16,17]). As will be discussed later, this overlooks a broad and long-standing 'critical stream' of social innovation thought [18]. Criticisms on the current interpretation converge on the issue that social innovation is approached instrumentally [19], narrowly conceived [20], and framed as an extension of technological innovation to shape society in specific pre-defined directions [21–24]. These critical voices point to the 'capture' of social innovation along a neo-liberal growth paradigm, connecting the concept with market-oriented solution strategies and depoliticised problem framings [22,24,25].

It is important to critically examine this narrow and instrumentalist uptake of social innovation. Marking an increasingly influential narrative of change [26], it has performative effects on the dynamics and governance of energy transitions. Whilst mobilising understandings from the 'critical stream' of social innovation thought based on Social Sciences and Humanities (SSH), we diverge from some of the more principled critiques. Taking a re-constructive perspective that seeks to translate critical awareness into constructive proposals (cf. [27]), we acknowledge that social innovation in the energy domain calls for a certain instrumentalisation. Whilst maintaining a critical stance along social innovation understandings as developed regarding issues of social economy and territorial development, we also acknowledge that the context of pressures towards climate action, energy security, and grid stability calls for some degree of instrumentalisation. Our key consideration is therefore that the prevailing narrow and instrumentalist social innovation adoptions are unsatisfactory *even in instrumental terms.* Focusing on their limited view on the societal significance of social innovation, this article explores the following question*: What would a broadened understanding of social innovation in energy systems look like?* Our proposal for a more comprehensive understanding pertains to four dimensions: 1) the normative complexity of the concept, 2) its multi-actor nature, 3) socio-material intertwinement and 4) experimentalism-based intervention logics.

This critical review draws on three main sources. First, a review of 37 peer-reviewed articles which resulted from a Scopus search in March 2019 using the search string 'social innovation' AND 'energy' and screening the abstracts of the 67 results for relevancy. The literature review served to establish an understanding of the current use of the concept in energy research. Secondly, we draw on the insights and discussions from a transdisciplinary expert workshop that took place in April 2019 in Rotterdam [28]. The workshop was framed along this literature review and aimed at exploring the diversity, contributions as well as challenges of social innovations in energy. Insights from the workshop and subsequent discussions shaped the framing of the article along the four dimensions and provided numerous examples and references to energy policy and practice. Thirdly, we relied on the collective insights of the group of authors, based on their sustained engagement with energy, sustainability transitions, social innovation and relevant SSH literatures.

The article is structured as follows. In Section 2, we lay the groundwork by discussing the different scholarly understandings on the boundaries of the social innovation concept. Sections 3–6 each discuss one of the four dimensions of broadened social innovation understandings. Bearing in mind that this article is targeted at scholars, practitioners and policy workers alike, we conclude by a synthesis of our argument that provides foothold in the form of alternative system understandings (Section 7).

2. Social innovation: Interpretations and applications

Social innovation is gaining traction in current imaginaries of energy system transformations. Before discussing the prevailing instrumentalist understandings (Section 2.2) and the need for more critical and comprehensive understandings (Section 2.3), it is important to clarify how the social innovation concept has been translated differently across contexts (Section 2.1).

2.1. Social innovation – A mobile concept

A range of literature reviews has tracked what the notoriously ambiguous social innovation concept has been taken to refer to [23,29,30]. This work has clarified how the concept continues to be shaped by different disciplinary traditions, and thus by different ideas about its purposes, its driving actors, and its societal significance. Taking a sociology of knowledge perspective clarifies the co-production of the concept by researchers, policymakers, activists, and citizens [31]. Innovation sociologists have highlighted further that social innovation is as much a policy concept as it is a scientific descriptor of 'socially innovative' activities (e.g. [24]). Social innovation is 'realised' through mutually constituent gains in scientific and societal authority [32]. This co-production indicates that there is no singular best interpretation that holds across contexts.

Having circulated in various policy and research communities for decades or even centuries, the concept has reached the energy domain only quite recently. Outside this domain, it has gained currency especially in areas of socio-economic and territorial policy [21,29,33,34]. Scholars and policymakers have taken it to refer to many different innovations in social practices or social relations [18,35–39]. Beyond the historical key examples of cooperatives, social movements, and urban activism, more recent examples are initiatives on urban gardening, car sharing, or digital fabrication workshops. Policy uptake at the EU-level accelerated around 2010 with the advent of the Innovation Union strategy. This rise on the agenda has been attributed to governmental budget constraints, the realisation that societal problems are not cured by markets alone, the need for new strategies to address strong vested interests that inhibit necessary reforms, and the background of a fast-changing and interdependent world (e.g. ICT, migration, market fluctuations) [34]. Various overview articles have already indicated that this recent rise marks the *re*-emergence of social innovation – involving more contemporary interpretations of the concept, and new domains of application.

2.2. Instrumental uptake in energy systems

Notwithstanding the only recent uptake in energy research and policy, social innovation is on the rise within the agenda of 'mission-driven' innovation policies [14]. The EU explicitly fuels the development of social innovation to further its Energy Union goals through its 2020 work programme in energy research. Specifically, in 2018–2020, investments were dedicated to support R&D on the role of social innovation in the pursuit of the EU goal for a secure, sustainable,

affordable and competitive energy system[1]. The EU also implicitly supports social innovation as part of its instrumental roll-out of 'mainstreaming' SSH in more technological EU-funded energy research and innovation projects (e.g. overtly focusing on social acceptance of innovation [40]). Also, in EU-member states, social innovation is taken up in national innovation policies. In the German High-Tech Strategy, for example, social innovation is considered necessary to succeed with addressing societal challenges including those related to sustainability, climate protection, and energy [41]. This innovation policy context indicates how the adoption of the social innovation concept is guided by rather pragmatic interests, and considerations of effectiveness.

This instrumental uptake corresponds with the 'practical stream' in social innovation discourse as distinguished by Moulaert and MacCallum [18, p. 36]. Charting the evolution of the concept, they identify a bifurcation into a 'practical' and a 'critical stream'. Emerging largely from management studies and technical innovation literatures, the former perspective considers social innovation mainly as new social practices that complement technological innovation [42]. On this account, social innovation is an extension of the problem-solving and optimisation mode that characterises much technological, efficiency-driven innovation. It is telling in this regard how social innovations in energy systems are often appreciated as social 'niches'. This framing associates social innovation with the pursuit of radical novelty and systematic upscaling that also characterises technological niches (e.g. solar panels, electric vehicles). As such, it neglects that not all social innovations are intended to penetrate markets, and that many of them contain restorative elements [43].

In the energy domain, social innovation is quite naturally welcomed as an innovation category. It is inevitably being bound up with technological innovation (cf. Section 5), and the associated issues of efficiency, technological feasibility, grid balancing, and infrastructure planning. Moreover, the earlier mentioned demands of emission reductions indicate how the instrumental significance of social innovation is becoming only more pressing: in energy systems, social innovation develops in a societal context of pressures for socio-technical transition [12,42,44]. Involved actors, whether 'incumbents' or 'challengers', seek to seize any social and technological means available. Community energy initiatives, feed-in tariff arrangements, regional development funds, demand management initiatives, crowdfunding, and (collective) net-metering schemes all share this instrumental significance.

2.3. Beyond narrow instrumentalism

Considering the inclination towards instrumentalist interpretations of social innovation in the energy domain, insights from the 'critical stream' of social innovation thought are at risk of getting lost in translation. This stream has articulated in various ways how the instrumentalist view – even if intuitively reasonable – may compromise the social innovation concept. Whereas the 'practical stream' has been largely fed by business management and innovation theory literature, the 'critical stream' can be retraced to a range of SSH-disciplines and strands of heterodox social theory. Like arguments that have been raised against social engineering and technocratic approaches to societal planning, the 'critical stream' has raised a series of issues that challenge the idea of social innovation as a 'tool'.

First, one of the main points of the 'critical stream' is that social innovation is not simply a bolt-on module to technological innovation. As Moulaert and MacCallum [18] argue, historically, the emergence of social innovation can even be seen as a radical challenge to technological and market innovation, and as a remedy for their adverse societal consequences. Second, various scholars have pointed out how instrumentalist interpretations of social innovation reproduce preoccupations with productivity, economic growth, and entrepreneurial inventiveness [25,45]. These critiques instructively identify the instrumentalisation of social innovation as an epiphenomenon of the current 'innovation society' [24], and in particular of the attendant 'pro-innovation bias' [46]. Third, it has been pointed out that instrumentalist policy logics are appropriating and co-opting the motivations of the communities, 'grassroots' initiatives, and political movements that many social innovations spring from. Subsuming the latter motivations of reciprocity, trust and authenticity under concerns of efficiency, the former rationalities uproot social innovation from its origins in 'lifeworld' logics [42,47,48]. A fourth line of critique reminds of the processual, emancipatory dimension that is easily missed in instrumentalist interpretations of social innovation. Pioneers in social innovation research have promoted it as an emancipating concept to assert the under-exposed innovative activity of social movements, marginalised communities, and social economy initiatives [43,49–51]. The social innovation category could lead the way into 'innovation democracy' [52]. Finally, instrumentalist interpretations have been criticised for remaining limited to incremental innovation - reproducing structural imbalances in society. In line with the arguments to take social innovation beyond reformist tinkering and 'caring neoliberalism' [49], various scholars have insisted that social innovation should not be instrumental to goals defined along dominant societal structures. It should be guided by counterhegemonic political programmes instead. This argument has been elaborated under the headings of 'transformative' [35,49], 'systemic' [38], and 'maximalist' [20] social innovation.

These points about ideological uprooting, productivism, emancipation and transformative potentials indicate clear limitations to the instrumental adoption. In taking the social innovation concept to the energy domain, quite a lot tends to get lost in translation. On the other hand, some of the more principled critiques seem to neglect the particularities of the domain of application, i.e. the pressures towards instrumentalisation that come with an energy transition context (Section 2.2). There seems to be place for a social innovation understanding that takes on board insights from the SSH-based 'critical stream' whilst staying relevant for the domain of application. The key consideration is that some of the critiques point out shortcomings that are problematic *even in instrumental terms*: Instrumentalist interpretations of social innovation tend to be very narrow in scope and thus underestimate the potential societal significance of the concept. Implicit assumptions about, for example, entrepreneurial creativity obscure the broader range of dispersed socially innovative agency in society [53], and preoccupations with particular beneficiaries may similarly distract from broader transformative impacts [49].

In the following sections, we therefore explore broadened understandings of social innovation in energy systems. These pertain to the normative complexity of the concept (Section 3), its multi-actor nature (Section 4), socio-material intertwinement (Section 5) and experimentalism-based intervention logics (Section 6).

3. Normativity: Beyond improvement towards normative complexity

One intuitively reasonable interpretation of social innovation considers it as a form of 'social', collectively beneficial, desirable action – as opposed to for example 'irresponsible innovation' [45], or 'outlaw innovation' [54]. This marks the distinct normative load of the concept. Regarding this normative dimension, instrumentalist interpretations tend to assume the capacity of social innovation to improve matters and to empower people. A prominent example thereof is the definition by the Bureau of European Policy Advisers (BEPA), which has been guiding many recent research agendas. Here, social innovations are defined as "new ideas that simultaneously meet social needs and create new social relationships or collaborations. (..) [T]hey are innovations that are not only good for society but also enhance society's capacity to

[1] For example, European Commission Cordis: https://cordis.europa.eu/programme/rcn/704431/en.

act" [55, p. 9]. The emerging work on social innovation in energy is inclined towards similar understandings. For instance, Hoppe and de Vries [13, p. 13], build on the BEPA definition when describing social innovations in the energy transition as: "Innovations that are social in their means and contribute to low carbon energy transition, civic empowerment and social goals pertaining to the general well-being of communities". Hewitt et al. similarly link social innovation to the aim of improving societal well-being [12]. However intuitively acceptable, instrumentalist social innovation understandings tend to assume its inherent desirability. This slots in well with the earlier discussed 'pro-innovation' bias in the energy domain. The narrowness of instrumentalist social innovation interpretations resides partly in the teleological fallacy of restricting social innovation to particular (desirable) goals and outcomes (e.g. [30,56,57]). Going beyond such teleology, the following considerations are substantiated by insights and critiques pointing to a considerable normative complexity that lies below the surface.

Towards emancipatory structural change: First, the 'critical stream' of social innovation (cf. Section 2) argues incisively against forms of social innovation that pursue improvements or efficiency gains serving otherwise unquestioned societal systems. Insisting that social innovation should be 'counterhegemonic' [18,51], or 'institutionally imaginative' [20], various authors have pointed to the difference between alleviating needs and addressing the societal structures that keep generating those needs. In normative terms, this indicates the difference between commitments to utilitarian improvement on the one hand, or to broader emancipation and substantive freedom on the other. These political economy-oriented social innovation understandings are addressed in energy research through foci on energy justice [58] or energy democracy [59,60]. Particularly relevant are debates on energy cooperatives as prominent social innovation initiatives, and as ways to democratise energy production. Concerns have been raised on their exclusionary tendencies – serving members rather than the interests of a broader public [61,62] and being composed by relatively homogenous groups, featuring mainly highly-educated, white males of above average age [63–65]. Vulnerable people, elderly, youth or minorities tend to remain underrepresented in such community initiatives [66] – but also in participative policymaking more general [67].

Towards sustainability-oriented structural change: Second, normative complexity also resides in the dual pursuits of social empowerment and sustainable development. Reaching beyond 'incremental innovations' and marginal improvements, the work on 'systemic' [38] and 'transformative' [35,68] social innovation largely converges with earlier 'critical stream' accounts of social innovation. Importantly, it diverges however from the explicit commitments to social solidarity economy principles and substantive freedom that characterise the latter [18,25,51]. Rather, societal ambitions towards energy transitions evoke expectations of social innovation as levers for sustainable development – as expressed through various accounts of 'social niches' [16,43,69]. Grassroots innovations, for example, are considered to challenge 'regime power' [70], and contribute to achieving European energy targets [71]. Such pursuits of shifts in socio-technical 'regimes', even if referred to rather generally in terms of 'sustainable' or 'low carbon' futures, indicate various normative concerns. Often pursued through normatively rather empty innovation management categories (e.g. 'upscaling' or 'transition pathways'), these sustainability transitions perspectives comprise concerns over ecological performance, cost-efficiency, environmental lifecycle, energy security, reliability, accessibility, and resilience to disturbances.

Towards trade-offs, unintended consequences and ambiguity: Third, prevailing social innovation discourses have been criticised for their depoliticising effects, and for not reflecting the uncertainty, dilemmas and contestations of social innovation practice [25]. Whilst the two previous points help to move beyond simplistic notions of improvement, they often share some teleological elements: Activist engagement, whether to 'solidarity' or 'sustainability' or combinations thereof, brings along its own tendencies towards instrumentalism – and towards a certain suppression of normative complexity. Therefore, this third point broadens the understanding by taking a certain distance from such activism and building more on SSH-based reflexivity that the 'critical stream' also has brought forward. Key insights in this regard pertain to the fact that social innovation purposes tend to emerge from and evolve through political negotiation [18,43], that social innovation tends to revolve around societal tensions [38], and that the empowerment aspired to tends to be pervaded with paradoxes [35,72]. Social innovation comes with trade-offs, unintended consequences and ambiguity. In energy research, we see these being considered through notions such as 'social innovation failures' [73, p. 638], accounts of increased social exclusion and limited transformative power [74], and of undesirable consequences *for some* (cf. [75]). Whilst some warn against ignorance towards unintended effects [30,76], others underline that social innovation entails experimentation, uncertain outcomes, and risk [73,77,78]. Ambiguity shows in accounts of communities becoming divided over cooperatively owned wind turbines or solar PV farms [79] or is discussed in the form of trade-offs, and neglected political conflicts [76]. Prominent is the apparent trade-off between efficiency and democratisation. For example, Dutch governments historically prefer larger renewable energy projects (e.g. offshore wind parks, 'green gas' production), run by incumbent utilities and other market-oriented investors. This decreases the scope for smaller, community-based projects [80].

In resume, we propose to move beyond simplistic notions of 'improvement'. Social innovations do not inherently lead to more fair and sustainable energy systems, and they are not necessarily solutions to current problems. In line with various 'critical stream' understandings, broader social innovation understandings acknowledge the normative complexity at hand - especially when freed from all too heavy ideological and normative anchors. Such non-teleological understandings are not to be confused with claims to normative neutrality, relativism, or disengagement. Rather, they open up a more plural understanding of social innovation phenomena, taking up the SSH awareness of trade-offs, unintended consequences, and ambiguity.

4. Agency: Beyond heroic outsiders towards multi-actor involvement

In the prevailing instrumentalist and narrow understandings, social innovation is often conceived along an 'innovation hero' imaginary. It thus focuses on the agency of individuals or small collectives, which are often framed as 'outsiders' to the system. Community energy collectives can be considered such outsiders. They have arguably become the most prominent example of social innovation in energy systems in the last decade or so [12,13]. Although there are many different interpretations and definitions, community energy broadly refers to collective citizen action to achieve sustainable energy goals while striving to improve the well-being of local communities [81]. Community energy has been researched in relation to social innovation in at least three ways, as pertaining to the (1) new social configurations it provokes [12,61,82]; (2) the ways it represents civil society [60,69,83]; and (3) its impact [84–87]. Social innovation is then understood as being initiated bottom-up, by civil society or citizens, experimenting with new solutions (e.g. [37,39]) – an interpretation that reflects the aim of improving societal well-being through the engagement of civil society actors [12,88].

This narrow focus has been criticised as being a 'minimalist' interpretation [20] since it 'corners' social innovation to community and the third sector. Changes in social relations can arguably originate from multiple societal corners [89]. It is also susceptible to the 'reductionist' interpretation [53] lacking appreciation that social innovations are complex societal processes involving multiple networked actors and distributed agency [48,90,91]. More broadly, social innovations could be understood as processes reaching across sectors and institutional

logics, and involving agency from different societal corners – possibly transforming current political and economic arrangements [20,92]. Taking these critiques as a starting point, the current understanding of social innovation could be broadened along the following lines.

Towards public sector innovation: First, local governments can be considered active players in social innovation, turning attention to social innovations taking place in public sector or state spheres, or initiated by public actors. The trend towards re-municipalisation of energy utilities means that municipalities take ownership of the energy production and distribution, and establish enterprises and cooperatives to get infrastructures (back) in public hands [93,94]. Driven by their owners (e.g. left-wing progressive city governments), utility companies (e.g. in Munich, Basel, Zurich) take the financial risks to invest in large-scale pilot projects (e.g. geothermal heat, virtual power plants, district batteries, early smart meter roll-outs etc.) [95,96]. In addition, (semi-) public organisations, such as for example Dutch regional grid managers, have been actively supporting and initiating projects and experiments such as aggregators, neighbourhood batteries, household and community demand response, or electric mobility (e.g. [97,98]). Local governments also exert influence through local regulation, such as city-level transport regulation or cantonal policies for energy in buildings in Switzerland [99,100], raising funds at higher governmental levels [101,102], engaging in public-civic-private partnerships [103], creating experimentation spaces [104] or engaging in co-production with citizens [102]. An example of the latter is the initiation of new forms of collaboration and local governance around transitioning from gas-based heating to renewable heating in Dutch neighbourhoods[2]. In Poland, 'energy clusters' are proposed as legal framework for community-level production and trade. While these clusters assume active roles for local government, local companies from different sectors, incumbent energy companies, and research and development institutions including universities, they allow only a limited role for individual citizens [105].

Towards business model innovation: Second, entrepreneurs of all colours can also be considered active players in social innovation. Doing so draws attention to the social innovation taking place in the form of business model innovation [106,107]. Such business models can be driven by community, public or market values or by a combination of those [108]. As an expression of the latter, hybrid organisations combine different institutional logics and goals [82,109] as well as modes of governance [110]. Energy cooperatives are a prominent example, since they combine a community logic aiming for social or environmental impact with a market-driven for-profit orientation [111]. Besides, community initiatives receive support from intermediaries that come in different institutional forms [87] and participate in collaborative projects or experiments with other agents such as governments, municipalities, and businesses [112,113]. With his research into Transition Town initiatives, Aiken [48] illustrates that while community initiatives are celebrated as a bottom-up initiative of non-state actors, they can also be considered as an extension of governmental (energy transition) policies – thereby supporting governmental goals.

Towards distributed agency, network governance and institutional complexity: Third, moving away from a reductionist understanding that focuses on individual agency, social innovation could be understood more broadly in terms of distributed agency, network governance and institutional complexity. This would mean moving beyond an understanding of the innovative agency of civil society actors, social entrepreneurs or policy entrepreneurs in isolation. It would mean appreciating that they often act in relative institutional voids [114] and have difficulty sustaining their operation. For example, given a lack of capacities (e.g. in terms of personnel, skills, leadership, and finance) in the majority of community energy initiatives, intermediary support mechanisms have been developed across European countries [115]. The focus then comes to lie on these or similar support structures affording and co-shaping this agency – the networks [91] and ecosystems [53,116–118] that social innovation is embedded in and co-shaped by. Many community energy initiatives, for example, are dependent on traditional government bodies. Rather than acting in isolation, they co-create public policies and local actions, and are involved in public service delivery via co-production arrangements (e.g. [119]). Such a relational understanding of social innovation acknowledges its distributed, co-produced diffusion [57] while not neglecting the particular agency of those actors shaping a certain social innovation [120]. Instead, it allows zooming out to account for the broader fields that social innovations are afforded by and in which social innovation actors are embedded in, through concepts such as "action fields" [121] or "arenas of development" [122].

We thus propose to broaden the focus on agency in social innovation. This includes moving attention from outsiders of the system, such as community energy collectives, towards considering that social innovation also emerges within and from actors in different societal spheres such as public or private actors. We also proposed to broaden the narrow focus on the agency of single individuals or organisations towards embracing distributed agency in energy systems.

5. 'Objects' of innovation: Beyond 'bolt-on' activity towards socio-material intertwinement

In instrumentalist understandings, social innovation serves as a social 'bolt-on' supporting the implementation of technological advances [24]. This idea of social innovation as a complement to technological innovation reflects what Moulaert and MacCallum [18] identified as the 'practical stream' of social innovation thought. Energy scholarship often shares this social innovation understanding, when using social innovation to indicate societal relevance of technological research or innovation (e.g. [123,124], or when framing it as a secondary form of innovation that supports the implementation of technological advances. In this view, social innovation is instrumental in establishing the social acceptance of technologies diminishing implementation barriers (e.g. [125]), and enabling learning, capacity building and increasing awareness regarding new technologies [17,83,126–128]. This may reflect the more general tendency in innovation research programs to invoke SSH perspectives as somewhat secondary add-on modules – that serve to ensure smooth implementation of a technological innovation [49].

Whilst usefully challenging instrumentalist appropriations of social innovation, the 'critical stream' of social innovation thought tends to continue the division between social and technological innovation. For example, social innovation has been considered in rather antagonistic fashion as a remedy of externalities (e.g. social inequality, expertocracy, environmental degradation) brought forward through technological innovation [18]. Others have similarly accentuated the narrow economic motivations driving much technological innovation – evoking social innovation as a counter-hegemonic answer [25,46]. However, when importing social innovation into the context of energy systems, part of these suspicions towards technological innovation will have to be suspended: Whether as only incremental or more transformative innovation, it remains a principal medium of change. Moreover, as theorised and empirically demonstrated in Science and Technology Studies and in innovation sociology [129,130], innovation is always an entanglement of social and technological aspects [131–133]. Focusing on one to the detriment of the other obscures how they constitute each other in processes of sociotechnical change. We concur that antagonistic views on the social/technological distinction should be avoided. Meanwhile, the term social innovation can still serve as a meaningful analytical entry point to understand energy systems as an interplay of

[2] See for example the 'Paddepoel Energiek' initiative in the City of Groningen [151], the 'DE Ramplaan' initiative in the city of Haarlem [44], or Thermobello in Culemborg [166].

social and technological – or more broadly, *material* – elements. Such sensitivity to socio-material intertwinement also discloses how we can move beyond a narrow 'bolt-on' understanding.

Towards innovations in social-material relations: First, in technology-dominated energy systems, the term innovation generally has a technological connotation, focusing on for example smart grid or offshore wind park developments. However, energy systems also consist of a wide range of established institutions, rules, policies, regulations, power structure, norms, beliefs and practices – all of which need to change profoundly to move towards more sustainable energy systems. Adding the prefix 'social' to 'innovation' can add clarity in discussions, shift attention to interactions between social and material innovations, and highlight innovation in the very social-material relations that prevail in society. It has been pointed out for example how social innovation provides a form of 'repair' of social and technological developments that are 'out of sync' [134]. For example, social innovations such as collectively or municipally owned forms of energy production could be considered a countermovement to the centralised power and hierarchy of current incumbent energy systems. They seem to address the excessive 'delegation' of agency onto the technologies, experts, and system operators that manage energy on behalf of society [135]. Likewise, social innovation can be appreciated as a lens through which to re-interpret the apparent technological innovations of the 'EnergieWende' in socio-material terms of ownership [136].

Towards instrumentalising technological innovation: Second, the instrumentalist logic could also be inverted to consider technological innovations as potential means of empowerment and as levers for transformative change. This shift of emphasis, or re-assertion of priority, would be in line with some of the 'critical stream' in social innovation thought [18]. This view is particularly prominent in analyses of renewable energy prosumerism, community energy, energy democracy, and energy justice (e.g. [58,60,137–140]). Here, technologies and infrastructures are essentially analysed as technological 'bolt-ons' to programs of social innovation and institutional reform (e.g. [20]). In the UK, advocates have argued that smart meters engage consumers with their energy use. Through more frequent information they effectuate 'socially innovative' processes of demand reduction, faster switching between suppliers, energy cost reduction, energy literacy, and active participation in energy systems [141,142]. Such an understanding does extend the instrumentalist logic, of course, and the associated somewhat artificial separation of the social and the technological. These examples show how the distinction between technological and social innovations can support analytical precision, however. Inverting the intuitive instrumentality of the one to the other, the interaction between innovation dimensions is captured with greater depth (cf. [24]).

Towards social innovation as unintended side-effect: Third, leaving instrumentalism behind, social innovation could be considered as newly emerging social relations linked to ongoing technological changes in energy systems, and thus as a rather accidental by-product or unintended side-effect. Different from social 'scripts' [143] circumscribing the behaviours of users of PV panels, various forms of less purposive and open-ended social re-scripting is introduced through smart meters, battery technologies, blockchain applications and microgrids. The 'material participation' of citizens is changing [144] and energy systems are transforming through wider 'ecologies of participation' [145]. Such 'evolutionary drift' understandings of social-material relations stretch the social innovation concept considerably. When considering changing social relations as emergent rather than purposive, effects of empowerment and disempowerment become blurred. However, the various new social arrangements developing around 'smart energy systems' [146] can very well be compared with other social innovation - even if they emerge as by-products. Moreover, the 'critical stream' of social innovation thought underlines that social innovation indicates a recursive introduction of new means and new ends – a point fully taken up by this proposed broadening. Applied in energy systems, social innovation could be a useful concept through which to grasp newly emerging behavioural repertoires and power relations such as those associated with demand management, surveillance, cyber security and artificial intelligence.

We thus propose to move beyond considering social innovation as a bolt-on activity to technological innovation. Three ways of broadening are suggested: considering social innovation as innovation in social-material relations, inverting the instrumentalist logic, and considering social innovation as emergent by-product of technological change.

6. Intervention logics: Beyond mechanistic intervention logics towards experimentalism

In the context of major energy transition challenges, the instrumentalist understanding takes social innovation to be an instrument in the 'energy systems toolbox'. As indicated by Schubert [134, p. 62], especially EU policy documents are inclined towards this interpretation along "…the engineering image of fixing social relations by employing distinct social technologies". The idea of social innovation as a tool reflects a longstanding tradition of social engineering, and the idea that "progress can be engineered or planned" [24, p. 383].

The underlying mechanistic intervention logic has been criticized heavily. Swyngedouw [72] warned early on how claims to empowerment and self-organisation obscured the linkages of social innovation with prevailing governmentalities. Lévesque [147] clarified its affinities with the spirit of New Public Management. Others have pointed out how social innovation rather revolves around horizontal, less control-oriented modes of governing [47], and how an instrumentalist mind-set quarrels with the pursuit of social innovation as a collective activity [48]. Moulaert and MacCallum [18] also outline how squeezing social innovation into a mechanistic intervention logic guided by managerial notions of 'best practices', 'upscaling', 'impact', and 'incentives' has given rise to a social innovation 'industry'. The mechanistic intervention logics extend well beyond those circles, however. Grassroots initiatives and other subaltern actors can often be seen to reproduce visions of controlled, linear, and evidence-based transition trajectories [48,148]. This testifies to the pervasiveness of linear, reductionist representations of transition pathways [149], and of preoccupations with the 'upscaling' of social 'niches' [43]. Leaving those behind, we suggest a broadening towards social innovation premised on alternative, more experimentalist intervention logics.

Towards self-organisation and self-governance: First, there is the already ongoing shift towards 'self-organisation' and 'self-governance' of energy [150,151] rather than control-oriented governance in energy systems. This self-organisation comes in different forms and ranges from 'self-reliant citizens' and 'self-serving consumers', to 'energy autarkic communities' and 'self-employed social entrepreneurs'. Citizens buying back infrastructure such as in Hamburg [152], the move of households and collectives producing their own energy [137,153] or municipalities embarking on a 100% renewable path with locally produced energy are exemplifying this intervention logic. Self-organisation and self-governance can be viewed from many angles: from a localist-environmental perspective, which sees citizen self-governance as a way to become less dependent from centralist, incumbent-led systems that harm the environment and local interests, to a New Public Management perspective, which sees citizen self-governance as an efficient way to organise public service delivery in various domains, and avoid inefficient public sector spending. This ongoing shift in governance and intervention logic evokes the typical turbulences of institutional mismatch and change, as detailed in abundant SSH work on energy system transformation. Whilst endorsed as socially innovative and enterprising initiatives, community energy collectives have long struggled and still do, to find favourable legislation sufficiently stable and permissive for their business cases to become viable [80,106,154]. Given their dependency on traditional government bodies, many community energy initiatives co-create public policies or local actions and are involved in

Table 1
Broadened understandings of social innovation in energy along twelve considerations.

Narrow instrumentalist understanding	Broadened understanding
Normativity	
• Limits social innovation to particular (desirable) social goals and outcomes towards improving society • Blends out uncertainties, dilemmas and contestations of social innovation practice	• *Towards emancipatory structural change*: acknowledges the need for structural change for emancipation, equality and broader freedom. • *Towards sustainability-oriented structural change*: acknowledges the need to address underlying societal structures inhibiting more sustainable lifestyles. • *Towards trade-offs, unintended consequences and ambiguities*: acknowledges the negotiated nature of social innovations in practice including the societal tensions and paradoxes they address.
Agency	
• Focuses on the agency of individuals or small collectives framed as outsiders to the system; i.e. bottom-up, civil society or community-led innovative energy practices	• *Towards public sector innovation:* acknowledges social innovations as originating from and within the state and public sector. • *Towards business model innovation*: highlights social innovations as originating from and within market, business and private sector. • *Towards distributed agency, network governance and institutional complexity:* appreciates social innovations as involving multiple networked actors and as being afforded by the multi-actor contexts they are embedded in.
'Objects' of innovation	
• Values social innovation as a 'bolt-on' supporting the implementation of technological advances • Appreciates social innovation to establish the societal relevance and acceptance of technologies	• *Towards innovations in social-material relations:* highlights innovation in social-material relations sustained through informal and formal rules, norms, values, practices, narratives, scripts, etc. • *Towards instrumentalising technological innovation:* considers technological innovations as 'bolt-on' to programs of institutional reform, emancipation or transformation. • *Towards emergent social innovation:* considers social innovation as by-product or unintended side-effect of ongoing technological changes and thus as less purposive and open-ended social re-scripting.
Intervention logics	
• Appreciates social innovation as a tool in a broader energy systems toolbox supporting planned incremental change • Considers social innovation as being replicable and scalable	• *Towards self-organisation and self-governance:* directs attention to decentrally-organised interventions of a distributed nature. • *Towards experimentation in context:* appreciates social innovation as an experiment-based form of system development. • *Towards counter-hegemonic change*: acknowledges social innovation as involving activities at the interstices between institutions that form alternatives to the dominant political economy.

public-service delivery via co-production arrangements [119,155]. In the end, considerations of security of supply, perceived system efficiency but also the consistency of revenue from taxes, fees, and surcharges have been the leading considerations, at the cost of non-committal endorsements of self-organised and socially innovative energy [156].

Towards experimentation in context: Second, beyond (or next to) traditional preoccupations with upscaling, market penetration, systematic 'roll-out' and economies of scale, there is a growing openness to experimentation and contextual solutions. There is not only an increasing awareness that social innovations are developing in a context-dependent manner, but also that they cannot be simply copied from one city or nation state to another. This realisation has pervaded the continued quest for 'best practices' with an awareness of relevant differences in technology, local geographical/weather conditions, institutional conditions, ownership cultures, etc., as well as accompanying translation processes. It also creates room for intervention logics and governance approaches that are of a more experimental nature [157–161]. Witness to this move are policy experiments focusing on the use of new technology within new governance arrangements. For example, the legal experimentation by the Dutch government around smart grid technology led to an Experimentation Decree in 2015 that allowed for legal derogation of the Electricity law, to further experiment with decentralised renewable electricity generation [162]. Other examples include participatory experimental settings, such as living labs, as a move away from public deliberation and engagement towards more diverse forms of public participation in energy [163]. In this way, social innovation in energy could be approached as an experiment-based form of system development. However, such experimentation does not start from a blank slate. The transformation will also involve processes of bending or adapting inherited social relations of existing systems.

Towards counter-hegemonic change: Third, social innovation could be understood in line with various calls for empowering, transformative, and counter-hegemonic social innovation. Such a 'maximalist' view of social innovation takes it as "deliberate prefiguring of different ways of ordering society itself" [92, p. 51] and thus as involving activities at the interstices between institutions that form alternatives to the dominant political economy [20]. Social innovation in this perspective is considered to be transformative to the extent that it challenges, alters or replaces dominant formal and informal institutions [30,35,76]. Moulaert and MacCallum [18] emphasise that such transformation comes about through processes of empowerment, involving hitherto marginalised groups in collective decision-making. Similar moves towards emancipatory and transformative social innovation have been made under the headings of energy democracy [60,164], energy justice [58], and the opening up of 'practices of justification' [165].

There might be limits to such experimentalism-based intervention logics in energy systems. It can be questioned how well intervention logics based on principles of self-organisation, experimentation or counter-hegemonic change sit with continued expectations of energy security, energy efficiency, access to energy, affordability and consumer satisfaction [1]. It is thus particularly questionable to which extent social innovation thrusts against expertocracy are realistic and desirable in the context of energy systems. Whereas the 'delegation' of agency to technologies, experts and systemcontrolling organisations may have been excessive in certain aspects [135], societal demands for accessible, reliable, affordable, clean and safe energy provision keep reasserting evidence-based, control-oriented intervention logics. As a result, these logics may remain a part of social innovation in energy systems.

7. Conclusions and recommendations

In its recent uptake in energy research, practice and policy, narrow

instrumentalist understandings of social innovation seem to be prevailing. While we subscribe to the urgency of energy system transformation, we also emphasise that social innovation does not simply provide the missing parts of the energy transition toolbox. Challenging these narrow instrumentalist understandings of social innovation, we propose translations of the concept that are based on the rich tradition of critical SSH thinking in research on social innovation more general. Consequently, we developed a broadened understanding of social innovation in energy along the four dimensions of normativity, agency, 'objects' of innovation, and intervention logics. Inherently, each of the suggested broadened understandings – appreciating normative complexity, multi-actor involvement, socio-material intertwinement and experimentalism – carries recommendations for how to consider energy system transformations differently.

At the heart of this broadened understanding are twelve concrete considerations, as detailed at the right-hand side of Table 1. These considerations can inform a broader imagination and strategizing of structural changes in energy systems by energy research, practice, and policy. To this end, the considerations can be followed separately or can be combined. When combining them very ambitiously, the social innovation concept is obviously expanded towards a more than 'maximalist' (cf. [20]) strategy of energy system transformation. Results would converge with the insights that energy systems are embedded in broader systems-of-systems, intertwined with multiple societal issues and elements of many social practices. It would lead to the awareness that energy transitions can be an opportunity for rethinking society as a whole. However, in doing so, one runs the risk of losing touch with the practical needs, constraints and struggles that are also part of energy system transformation. Whilst the shadow sides of excessive instrumentalisation have been abundantly discussed, one can also have too little of it. Since we acknowledge the need for energy system transformation, a certain degree of instrumentalisation is called for. This brings us back to the constitution of social innovation as a concept that gains its meaning through a co-production process involving research, practice and policy.

To conclude, one could easily dismiss the concept of social innovation in its entirety for its instrumental uptake, but we hope to have shown that critical-constructive engagement with the concept is very well possible. Thus, rather than standing at the side-line and lamenting its instrumentalisation, it seems worthwhile to appreciate the concept as an entry-point for inserting SSH insights into energy research, practice and policy more generally. As a category of innovation, it slots in well with prevailing ways of making sense of energy matters. It has the potential to act as a boundary object between disciplines and across research, practice, and policy. Indeed, social innovation could be a useful point of reference for SSH researchers who are keen to do more to 'open up' what the social dimensions of energy systems (transformation) could be taken to mean. More generally, many efforts are currently being done to enhance the role of SSH, and enrich one-sided innovation paradigms [45,46]. After all, SSH insights need to be far more embraced if governments are to achieve the increasingly ambitious carbon targets being set. More critically considering social innovation is just one example of how this could be furthered.

Declaration of Competing Interest

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

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