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Justice by Design: Integrating energy justice and responsible research and innovation (RRI) to deliver just energy futures

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ABSTRACT

The deployment of low-carbon energy systems will have a variety of social and environmental impacts. Notwithstanding this, current just transitions work continues to focus on the mitigation of harm following fossil fuel industry closures, largely neglecting the potential impacts of future energy developments. While energy justice scholarship scrutinises low-carbon energy sources, it remains largely focused on the mitigation of injustice retrospectively, whereas explorations of future energy types and their potential justice implications are lacking. To address this gap, this paper presents 'Justice by Design': an interdisciplinary conceptual framework and practical methodology. Justice by Design integrates energy justice with responsible research and innovation to better anticipate justice in future energy systems, with a view to actively designing and hence delivering just (energy) transitions. We propose that Justice by Design can be used methodologically to scrutinise energy sources, energy technologies, energy projects and place-specific energy system changes. The paper begins by providing critical overviews of just transitions, energy justice and responsible research and innovation literatures. We then present the Justice by Design conceptual framework and methodology, alongside guidance for its implementation. This is followed by discussion on its applicability and limitations. Justice by Design can support the proactive identification of injustice risks while prompting practitioners to seek out justice-building opportunities – setting out an anticipatory justice approach throughout energy system redesign.

1. Introduction

With a central role to play in global greenhouse gas emissions – producing approximately 75 % of global emissions in 2020 [1] – a transition in the energy sector is crucial to respond to the climate crisis. In 2022, global investment in energy transition technologies reached a record high of \$1.3 trillion [2]. Investments and planning remain justified largely on technical and economic grounds, typically neglecting the justice impacts of energy decisions and the futures they will create. This is despite the mounting evidence presented by energy justice (EJ) and just transitions (JT) scholarships on the justice dimensions of energy production and use. With a projected global investment of +\$300 trillion into different energy sources over the next two decades, it is crucial that decision-makers consider the justice implications of energy transition pathways – or they risk reinforcing old injustices and incarnating new ones [3].

The energy transition is being accompanied by a proliferation of decarbonisation targets. These generally imply phasing down fossil fuel

use and developing low-carbon energy systems in their place. In this context, mainstream narratives from government and industry tend to uphold technological innovation as the cornerstone for success [e.g. [4]], alongside discourses prioritising large-scale projects and green growth [e.g. [5–8]]. Viewed through this lens, innovations continue to be considered as “something inherently positive and a determining factor of economic growth and long-term prosperity,” despite growing awareness of their normativity and potential undesirable impacts [9, p.2]. Against this backdrop, it is concerning that energy-innovation processes largely fail to discuss, let alone integrate, considerations of justice [10]. Such bold national and international commitments to renewable energy deployment, anticipated investment in low-carbon innovations and the overarching, hegemonic green economy narrative beg the questions:

- What futures are being 'locked-in' [[11 p.910]; [12]] through the design, development, and deployment of these future energy technologies and systems?

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- And, importantly, what are their justice implications?

In this paper, we present Justice by Design, a conceptual framework and methodology which integrates EJ and responsible research and innovation (RRI) in view of achieving JTs. The objective is to combine these three scholarships' conceptual value and methodological practice. The Justice by Design conceptual framework and methodology is intended for both academic and non-academic audiences who will be referred to throughout as "practitioners". We define "practitioners" as: (action) researchers, energy technology and project developers, community groups, funders, investors and policymakers (though this is non-exclusionary). This conceptual framework and methodology can enable practitioners to directly engage with the justice risks and opportunities of future energy sources, technologies, and systems as these undergo design and development. Hence, creating the possibility of locking injustice out, and locking justice in. We follow Romero-Lankao et al. [10, p.2] in understanding energy transition innovations as "composed of technologies, infrastructures supporting their use, specific business and financing models, social practices, and policy instruments and regulations". Thus, through Justice by Design, practitioners can explore not only energy sources and their adjacent infrastructures, but through these, the network of socio-technical dimensions that make up energy transitions.

This paper begins by introducing the interdisciplinary approach and synthesising JT, EJ and RRI scholarships. Both EJ and JT have revealed energy system (in)justices through technological, social, and geographical case studies. However, these works are mostly set in retrospect, after energy infrastructures or policies have been deployed [e.g. [13–15]]. We highlight significant gaps in existing research and practice, including the retrospective nature of JT and EJ analyses and their lack of anticipatory explorations of energy systems change ([16,17] are recent exceptions). This, we argue, limits their ability to deliver actionable outcomes. Instead, we take a forward-facing view of energies and systems still under development. To do so, we build on interdisciplinary work [18–21] which explores the practical potential of RRI framings in conjunction with EJ and JT thinking. Finally, we present Justice by Design as a novel conceptual framework and a methodology. In doing so, we extend the approach taken by various scholars [e.g. [16,18,22–27]] to bridge distinct literatures into integrated approaches.

2. Developing an interdisciplinary conceptual framework and methodology: the approach

There is a growing awareness of the value of combining conceptual frames [28]. This often builds on a systems, relational, and co-dependent view of the world - an approach captured by the Science and Technology Studies (STS) field since the 1960s. In this spirit, we bring together knowledge from across justice, energy, innovation and transitions disciplines.

Even in places which have led the way towards so-called "just transitions" (such as Scotland, e.g. [29]), policy processes continue to plan JT actions in terms of injustice mitigation. Additionally, despite the spread of empirical work highlighting the harm that can be caused by renewable energy deployment [e.g. [30–32]], policy implementation of the JT continues to focus largely on the impact of fossil fuel closures (e.g. jobs and energy affordability). While these are crucial aspects of ensuring justice in our transition away from fossil fuels, they do not address the implementation of justice in the move towards low-carbon energy systems. Within the energy industry, the implementation of JT is still not widespread, most commonly referenced by renewable energy developers in relation to their projects' job creation potential. Moreover, while (renewable) energy project deployment is required by law to

exhibit awareness of potential environmental impacts, often through Environmental Impact Assessments, these assessments fail to consider issues of justice.¹

There is a pressing need to integrate justice considerations into energy systems planning. To do so, it will be essential to anticipate the justice dimensions of energy types, technologies and projects, which are the building blocks of future energy systems; alongside a whole systems approach to place-based change. Anticipation is an integral part of innovation processes. Thus, we turn to the field of STS and specifically to RRI. With a long history, RRI presents a conceptual model of "anticipation, first and second order reflexivity, inclusivity, deliberation and responsiveness" [[33,p.1570]; [34,p.4]]. This sets out a model to scrutinise innovations throughout their development, reducing risks, uncertainty and unearthing new possibilities [35]. RRI has historically paid close attention to synthetic biology, nanotechnology, geoengineering and ICT [e.g. [36–38]]. Surprisingly, however, there seems to be limited RRI engagement with energy innovations.²

To date, we are aware of only six papers that explore the JT or EJ alongside RRI. These include two review papers in 2018 and 2019 [40,41]; Jenkins et al.'s [18] conceptual analysis of EJ, RRI and value sensitive design, and Sovacool et al.'s [19] exploration of RRI alongside EJ and social practice theory. Particularly relevant for this work, Jenkins et al. [18,p.9] suggested that EJ can support RRI in the definition of "responsibility" or even "designing for justice", implying the possibility of embedding justice into technologies from their conception. Finally, Arkhurst et al. [20] and Dutta et al. [21] explored the integration of EJ and RRI into evaluative early-stage energy research metrics. Relatedly, recent works have explored co-design methods for just energy technology outcomes [16] and others have engaged with anticipatory justice dimensions of future energies via the lens of imagined publics [17]. More broadly, Romero-Lankao et al. [10] addressed the justice-energy-innovation gap by applying EJ across the multilevel perspective in the context of energy transition innovations, and Dong et al. [42] suggested a causal, positive relationship between "renewable energy technology innovation" and EJ. These works demonstrate the identified value of interdisciplinary frameworks to address systemic challenges like the energy transition, and the palpable gap that is the justice-energy-innovation nexus in theory and practice. Justice by Design builds on and furthers the field.

A note to clarify our selected terminology. We have named the conceptual framework and adjacent methodology 'Justice by Design'. While combinations of 'justice' and 'design' have briefly been used before (e.g. [43] from a design perspective) this is not, to our knowledge, a coined term nor one in widespread use, particularly in the energy literature. In using it here, we appeal broadly to 'design' to convey that justice considerations should be at the *core* of energy-related planning, as an indispensable part of design, delivery and decision-making processes. With this, we stand in strong opposition to the tokenistic "add-on" of scattered justice considerations after the fundamental, and often irreversible technological, project or energy system plans have been locked in. Such add-on activity often materialises in late or under-resourced 'stakeholder engagement' consultation processes within

¹ Increasingly, project developers are also undertaking socio-economic impact assessments which focus on job creation and Gross Value Added (GVA) by the project to the local, regional, or national economy. Other existing frameworks exhibiting improved industry practices include lifecycle assessments and social lifecycle assessments. These however, all remain far from the mainstream and are not focused on analyses of justice.

² As an illustrative example, a special issue on RRI in industry in the journal Sustainability (2018) focused on industry sectors that are "characterised by high research innovation-intensity... as well as high relevance in terms of their impacts on society and the natural environment: the Information and Communication Technology industry, the health care, and the food sector" [39, p.3]. Given widespread climate crisis and energy transition foci, it is surprising that energy was not included.

energy projects and are often typified as isolated social science work packages in otherwise techno-centric projects. Finally, we use ‘design’ to signify intentional anticipatory planning, not to be confused with the design field. The latter is diverse and longstanding, and we do not pretend to speak for design scholarships.³

To be clear, we only take EJ forward alongside RRI into our conceptual framework and methodology. However, we intentionally refer to and explore both JT and EJ as they are often used interchangeably [e.g. [47,48]] and because of the potential to integrate EJ and RRI in view of achieving JTs. We follow the pragmatic proposal that EJ provides the justice ‘scaffolding’ or critical guidance regarding key areas of concern, while the JT term remains the outwards-facing communication and mobilisation tool [29]. Until recently [e.g. [10,16–22]], neither JT nor EJ scholarships had explicitly engaged with innovation processes or emerging energy types. It is imperative that these literatures come together and resolve this. To do so, however, they must be equipped to operate in spaces of deep uncertainty and future-building – the space of RRI.

3. Just transitions, energy justice and responsible research and innovation

The following section will briefly review each concept, highlighting their heterogeneity, tensions and setting out their integration. Section 4 will present the integrated Justice by Design conceptual framework and methodology and outline its practical implementation.

3.1. Just transitions

Appeals to a JT emerged in the 1980s, driven by trade unions in the USA and Canada [49] to reconcile securing justice for workers with Environmental Justice imperatives which were closing industrial plants [50]. Since the late 20th century, the term has gained prominence in discussions regarding industrial transitions. In the last decade, JT has entered the mainstream in reference to transitioning away from fossil fuels. A search of the term “just transition” on the Web of Science database yields 1–6 publications per year from 2000 to 2017, followed by 43 in 2019, 142 in 2021 and 269 and 331 publications in 2023 and 2024 respectively.⁴ Today, the concept has taken on a multiplicity of meanings, from a strict focus on workers [e.g. [51]] to the decolonisation and de-marketisation of nature [e.g. [52]]. In policy practice, the term is often operationalised as synonymous to justice in the energy transition while focusing action on industrial worker transitions and energy affordability [e.g. [29,53]].

Many strands of the scholarship continue to define the JT in relation to the fossil fuel industry, workers, and communities [e.g. [54]]. A 2020 paper performing an extensive literature review of the JT concept concluded that “a review of just energy transitions must focus on labour and income” [55,p.2]. Contrasting reviews interpret the JT in more expansive ways. Stevis and Felli [56] highlighted how in its more proactive forms, the JT aims to offer an alternative to green growth and green capitalism. The authors illustrate the ideologised nature of the JT term and suggest that its variety reflects “the politics of its various advocates” [56,p.35]. Heffron and McCauley [57] suggested that the JT concept could encapsulate energy, climate and environmental justice perspectives; while Ciplet and Harrison [58] highlighted how justice concerns in JT discussions have extended beyond workers in manufacturing to encompass food justice, energy access, fossil fuel divestment or urban planning. In their review, Wang and Lo [59]

developed a conceptual JT taxonomy identifying: (1) JT as a labour-oriented concept, (2) JT as an integrated framework for justice, (3) JT as a theory of socio-technical transition, (4) JT as a governance strategy and (5) JT as public perception.

The literature also demonstrates that JT and EJ are sometimes used interchangeably or are defined alongside each other in varying ways [e.g. [47,60–62]]. This potential for conceptual tension and misunderstanding risks a “growing disconnect between their use in academia and their ability to ‘operationalise’ justice in the energy arena” [29,p.4]. Recent works [e.g. [29,63,64]] have explicitly referred to this tension alongside the potential complementarity of the concepts. While EJ literature will be reviewed below, it is important to highlight this here given it has implications for defining each of the terms and harnessing them in unison.

Going forward, this paper understands the JT as a “process in motion” [65,p.6] and, given its institutionalisation in mainstream discourse, an aspirational outcome. There is debate in the literature over the use of terms like ‘transition’ versus ‘transformation’ [e.g. [66,67]]. Our appeal to a JT is an appeal to a “great green transformation” [67,p.247] uprooting current ways of doing to bring forward more equitable, sustainable systems. Nonetheless, the terms “energy transition” and “just transition” are used throughout for two main reasons – the first, given that the change advocated for is complex and systemic, thus requiring an inevitable transitional process. The second, for practical applicability and pragmatism given the adoption of “energy transition” and “just transition” terminology worldwide. The JT, therefore, is a process and outcome to be achieved through approaches like EJ and RRI.

3.2. Energy justice

EJ builds on and departs from Environmental Justice and Climate Justice before it [68]. EJ seeks to “apply justice principles to energy policy, energy production and systems, energy consumption, energy activism, energy security, the energy trilemma, political economy of energy, and climate change” [69,p.175]. There are two main approaches to EJ. The “triumvirate of tenets” advocates for the application of distributional, procedural and recognition justice throughout the energy system [69,70]. The combination of these three justice pillars was first proposed under the frame of Environmental Justice [71]. Their articulation as EJ has related them to energy, focused on whole systems applications and placed more weight on recognition justice (occasionally referred to as “justice as recognition”). The pillars of distributional justice, procedural justice, and recognition justice have been widely described and developed by the EJ scholarship [e.g. [69,72–74]]. In short, distributional justice examines the spread of risks, harm, benefits and opportunities of energy configurations. Procedural justice focuses on the way in which energy processes unfold and the power dynamics within these, while recognition justice appeals to notions of respect and dignity for all beings, requiring acknowledgement of the existence and intrinsic worth of diverse and situated perspectives, worldviews and structural inequities. All three tenets are multi-scalar, spanning both space and time, and they are interdependent.

Recent works have seen the development of *triumvirate+* approaches, expanding the triumvirate to four or five tenets of EJ to incorporate restorative and cosmopolitan justice [e.g. [75,64] respectively]. While these efforts acknowledge the nuance of each justice concept, they risk diluting the triumvirate and its application. Instead, *within* the triumvirate [e.g. [10]], we acknowledge the equal worth of all humans as per appeals to cosmopolitan justice, but do not adopt it as a tenet. Moreover, we posit that the triumvirate inherently enables restorative action, in part because recognition justice must start from an acknowledgement of structural and historical harm and because all tenets are multi-scalar.

³ Design scholarship has long considered issues of sustainable and/or inclusive design [e.g. [44,45]], or even in direct relation to justice [e.g. [46]]. We encourage the potential for complementarity between Justice by Design and the design field going forward. This exploration lies outside the scope of this paper.

⁴ Searched on 11/02/2025.

Given that more-than-humans⁵ and future generations are commonly misrecognised, ignored and rendered voiceless, we also explicitly raise the imperative to include multispecies justice and intergenerational justice into EJ considerations, incorporated via their recognition and with implications across the tenets.

In parallel to triumvirate and triumvirate+ approaches, Sovacool and Dworkin [77] proposed eight principles of EJ: “availability, affordability, due process, good governance, prudence, intergenerational equity, intragenerational equity, and responsibility” [77,p.436], primarily explored through case studies [e.g. [78,79]]. The principles were expanded to 10 in a later review to include resistance and intersectionality [80]. However, the triumvirate of tenets formulation has been explored more widely with empirical case studies from across the world [reviewed in e.g. [81]]. For this reason, this work builds on the triumvirate of tenets, enriched with multispecies and intergenerational perspectives.

Over the past decade, EJ has been defined and applied as a conceptual tool, an analytical tool, and a decision-making tool [77]. It has also been explored within numerous case studies [e.g. [14,30,78,82–85]] with a strong focus on fuel poverty [e.g. [86–88]] and social or protected characteristics such as gender [e.g. [89,90]]. EJ has been positioned alongside other theoretical frameworks, such as systems-approach literature [91], transition frameworks [e.g. [10,62,83,92]] and political economy [93]. Nonetheless, and despite these advances, Kanger and Sovacool [94,p.2] argue that “existing literature on energy justice remains limited by its descriptiveness, i.e. empirical studies often producing extensive lists of injustices”.

Authors have engaged with applicability concerns, suggesting the politicisation of EJ to enable structural transformation [48]. Dimensions of politicisation have been furthered through explorations of energy, justice, and political ecology [95]. Thus, energy technologies and systems “can be mechanisms of extraction, symbols of capitalism and the expansion of wealth” while “conflict and struggle are part of the process of diffusing new energy technologies”, inevitably creating winners and losers even when there is net social gain [95,p.551]. Finally, the critical role of responsibility in unpicking power dynamics remains underexplored [e.g. [14,96]]. Authors are approaching applicability dimensions via developing metrics, policy-oriented and legally oriented studies, amongst others [64,97,98]. Justice by Design goes some way towards addressing descriptiveness and responsibility concerns, further detailed in Section 4.

Early critiques highlighted EJ’s narrow focus, with reiterated calls for whole systems thinking and a move beyond anthropocentric and Western-centric accounts. Ongoing mobilisation of whole systems thinking [69,91] expanded EJ’s reach across the supply chain [e.g. [72,99]]. A whole systems approach brings transversality to energy system justice considerations. For example, elucidating ethical tensions between policies supporting electric vehicle (EV) uptake in the West [e.g. [100]] and the processes of cobalt mineral extraction in the Democratic Republic of the Congo to produce EV batteries, often undertaken with exploitative and child labour practices [101,102]. A critical stance further characterises whole systems approaches as normative and political, aiming to identify and challenge the extra-local processes shaping energy (in)justice [72,p.222]. Debates regarding EJ’s anthropocentrism, Western-centrism and overall institutionalisation are politicised and ongoing [e.g. [103,104]].

Constructive dialogues around the refinement of EJ (such as those discussed above), continue to push EJ and have arguably succeeded at

increasing its ambition e.g. by striving to engage with more-than-humans and beyond mainstream ontological perspectives [e.g. [81,103,105–109]]. Examples include Malakar et al.’s [107] study of temporality in energy policy by integrating EJ and the Hindu *Bhagavad Gita*. Castán Broto et al. [105] advanced EJ with postcolonial critiques of development while harnessing a situated, place-based approach to energy transitions in Mozambique. Gafa et al. [106] engaged with specific criterion such as “affordability”, questioning universality by redefining it to reflect place-based realities through case studies in rural Benin, Senegal and Togo.

3.3. Responsible research and innovation

In 2011, the European Commission developed a definition of RRI [37,110] with themes which have since evolved into “public engagement, open access, gender, ethics, science education” [111] and have been applied to numerous EU-funded projects over the past decade, including energy projects [e.g. [112]]. Here, however, we explore the main – and distinct – conceptual model of RRI, comprising four key pillars: anticipation, reflexivity, inclusive deliberation and responsiveness [[113], p.2; 33, 36]. We follow Lubberink et al. [34] to expand this to five pillars, separating inclusivity from deliberation. This places greater normative emphasis on each but has little further impact on the model itself. Through these pillars, RRI becomes an outwards and inwards facing commitment to a specific, iterative vision and process of innovation.

Anticipation refers to genuinely asking “what if?” and requires systemic thinking. This will increase the resilience of actioners, society, and the innovation itself, considering plausible implications of the innovation while unveiling potential additional opportunities [33]. It does not make predictions but “can highlight possible alternative paths” [9,p.6], envisioning desirable futures and shaping agendas to organise resources that can target these [34]. Reflexivity is closely related to anticipation and turns to intent – a form of self-audit process throughout which the practitioner questions their own motivations, those of the project funder and of the broader innovation ecosystem fuelling the development. Importantly, it entails critically scrutinising one’s biases and assumptions, such that the researcher/innovator engages in second-order reflexivity to assess how their underlying belief systems and ideologies are influencing decision-making [34]. Awareness of ones’ own responsibilities and accountability of actors involved in the research/innovation process is also a necessary feature of reflexivity [9,p.7].

Inclusivity, alongside deliberation, propose open and diverse engagement with a multiplicity of actors from the onset. This includes those that may be harder to reach, for substantive (not instrumental) reasons [114] (inclusion); while ensuring quality discussions that are transparent, respectful, and credible (deliberation). Criteria proposed to judge dialogue quality include the intensity of engagement and the care taken in group composition, the openness and diversity of the group and the quality of discussions [33]. Inclusive, diverse and genuine engagement becomes a crucial pillar of innovation’s accountability to society, but also of co-responsibility between practitioners and society, helping to realise a “collective responsibility to control and direct innovation into a direction that is ethically acceptable, societally desirable and sustainable” [34 p.1], *our emphasis*. RRI’s emphasis on stakeholder engagement has been critiqued due to the challenges involved in enacting holistic and inclusive deliberation processes [115] and given inevitable participant power asymmetries [116]. Nonetheless, extensive, robust work across academic fields on the value of participation [e.g. [117–123]] (including by EJ and JT scholarships) demonstrates the worth of inclusive, committed dialogue to approximate more beneficial outcomes.

Finally, an innovation process that is responsive, as per the fifth pillar of RRI, is one that mobilises this self and collective reflexivity, inclusive deliberation, and overall anticipatory exercise to set the

⁵ Puig de la Bellacasa outlines the challenges even with the term ‘more than human’ [76,p.2]. While no term is completely satisfactory, this was deemed more appropriate than terms like ‘nonhuman’, which may echo the artificial hierarchies that continue to define modern human perceptions and interactions with the environment.

direction and influence decision-making going forward [36]. In addition, to be responsive, the innovation initiative must set flexible grounds for direction to change over time where necessary, establishing RRI as an iterative process.

RRI has been extensively explored conceptually [e.g. [33,34,36,114,116,124–127]]. It has also been explored alongside other interdisciplinary fields, such as EJ, value sensitive design and social practice [e.g. [18–21,128]]. There has been a particular focus on its operationalisation, creating new tools like the Constructive Sustainability Assessment [115], and often in relation to the private sector [e.g. [34,39,113,129]]. With regards to the energy arena, however, RRI has rarely been operationalised in academia. Rare case studies include community energy storage [130], adoption levels of solar PV [131] or assessing the ‘responsibility’ of biofuels [124]. RRI has also been used to assess the energy sector generally [e.g. [128,132]] and has been theorised alongside social justice thinking and renewable energy [40,41]. Beyond specific technologies, RRI has also been identified as having a role in “socio-technical transformation processes... such as the transition of the energy system toward carbon neutrality” [9,p.2].

The RRI model has been critiqued for its ingenuity [116] in proposing such a stakeholder-driven approach to innovation [e.g. [115,126]]. Authors have furthered this critique structurally, given that RRI was created within the existing hegemonic paradigm of techno-economically driven outcomes. Hence, RRI statements about inclusion “had to cohabit with other kinds of openly exclusive approaches” to innovation, given “the commitment of European innovation policy with knowledge production aimed at industrial exploitation and economic competitiveness” [133,p.28]. For RRI to actually “mean something” and have tangible impact, researchers/innovators must change their existing practices which exist against a backdrop of established norms, infrastructures and institutions that *themselves* structure behaviour [134, p.178]. RRI continues to be legitimised primarily on macro-economic arguments of jobs and growth [116], perpetuating the ‘growth is progress’ narrative [127,p.236]. As such, this could position RRI awkwardly in the role we propose. How can a model which is unfolding within the present techno-economic hegemony (which fails socio-ecological justice) serve to disrupt it?

RRI is inevitably embedded in the current landscape [11]. However, we argue that awareness of such pre-conditioning is *in itself*, an expression of reflexivity. This enables the researcher, innovator, or any other practitioner to exercise caution when selecting priorities, while questioning assumptions of the existing socio-economic order. We also note that a model like RRI, if genuinely implemented, will warrant more than tweaking siloed areas of decision-making. Instead, genuine RRI demands a cultural shift, explicitly engaging with and questioning ideologically driven power dynamics and existing models of extraction, consumption and worth. By integrating RRI into a whole systems, justice-driven framework for future-building (which this work proposes we do), the counternarrative gains space within the paradigm, creating opportunities for transformative futures driven by an ultimate goal of prioritising justice.

4. Justice by Design: a conceptual framework and methodology to build justice into energy systems

This work argues that a conceptually robust and practical approach to justice needs to sit at the core of decision-making with regards to energy transition design and implementation. And even, where necessary, determine whether infrastructures are or are not deployed. In this way, justice has the potential to become operationalised instead of remaining an academic exercise or a tokenistic “add-on” to already made technical decisions. This longstanding aspiration within academia and activism is seldom delivered in practice. Recent work [e.g. [10,20,21]] has begun to bridge the justice and “energy innovation” arenas. We take this further by integrating EJ, a method for (in)justice

identification; with RRI, a method designed specifically for innovation and hence inherently equipped to deal with uncertainty and anticipation.

Justice by Design is proposed as an integral part of design, development and deployment processes across energy types, technologies, projects, and broader energy systems change. For simplicity, within Figures, Tables and the remaining sections we refer to these various types and features of energy developments as the ‘energy idea’.⁶ The methodology itself is adaptable to places and contexts. By adopting Justice by Design, practitioners can anticipate risks of future injustice, while also inquiring into the potential to build justice *into* energy futures.

The overall objective is for Justice by Design to be an integral part of energy transition decision-making processes and actions. As per Fig. 1, by placing the identified energy idea at the centre, practitioners can ask EJ questions of it through RRI anticipatory, reflexive, inclusive and deliberative approaches, to identify risks of injustice and opportunities to build justice in. Sections 4.1 and 4.2 provide detailed explanations of the Justice by Design methodology, including example methods by which it can be mobilised in different contexts. This is followed by discussion in section 4.3 on its applicability, its value and the challenges facing its implementation.

4.1. Adopting Justice by Design

At the core of Justice by Design sits the irrevocable value of collective deliberation, present across EJ, RRI and JT literatures. As such, Justice by Design is first and foremost, qualitative. The methodology can be operationalised through a variety of methods and, notwithstanding its qualitative focus, outputs from deliberative exercises could also be combined with mixed method approaches to triangulate and enrich overall outcomes, as will be further detailed below. In its simplest form, however, Justice by Design entails firstly, a recognition of people as knowledge-holders and knowledge-makers [e.g. [16,122,123]], actioned through the facilitation and participation in deliberative exercises with a variety of stakeholders.⁷ Its responsiveness function (Fig. 2, stages 5–6) becomes an integral part of the process, setting the direction and influencing decision-making going forward.

Upon adopting Justice by Design, practitioners operating in the energy arena should gain justice-related insights and identify action-pathways related to a variety of socio-technical, material and ecological dimensions of the energy idea. Practitioners may seek insights into the energy source itself, for example, to consider the physical, material characteristics of different energy types in relation to their accessibility to different groups or place-specific energy needs [e.g. [135,136]]. They could also explore energy technologies undergoing design and development, from low Technology Readiness Levels (TRL) (TRL 1–3) through to technological commercialisation (TRL 8–9) [137]. Practitioners could also apply Justice by Design to projects across their life-cycle stages, from design and installation through to re-powering or decommissioning. Finally, Justice by Design could guide decision-making throughout the design and delivery of place-based energy transitions.

⁶ ‘Energy idea’ refers broadly to energy sources, technologies, projects or systems transformation. In short, any energy-related initiative and their adjacent socio-technical and ecological implications.

⁷ In contrast, surveys or questionnaires are not suitable methods through which to operationalise engagement stages of Justice by Design. These methods preclude collective deliberation and reflection in the ways envisioned by Justice by Design.

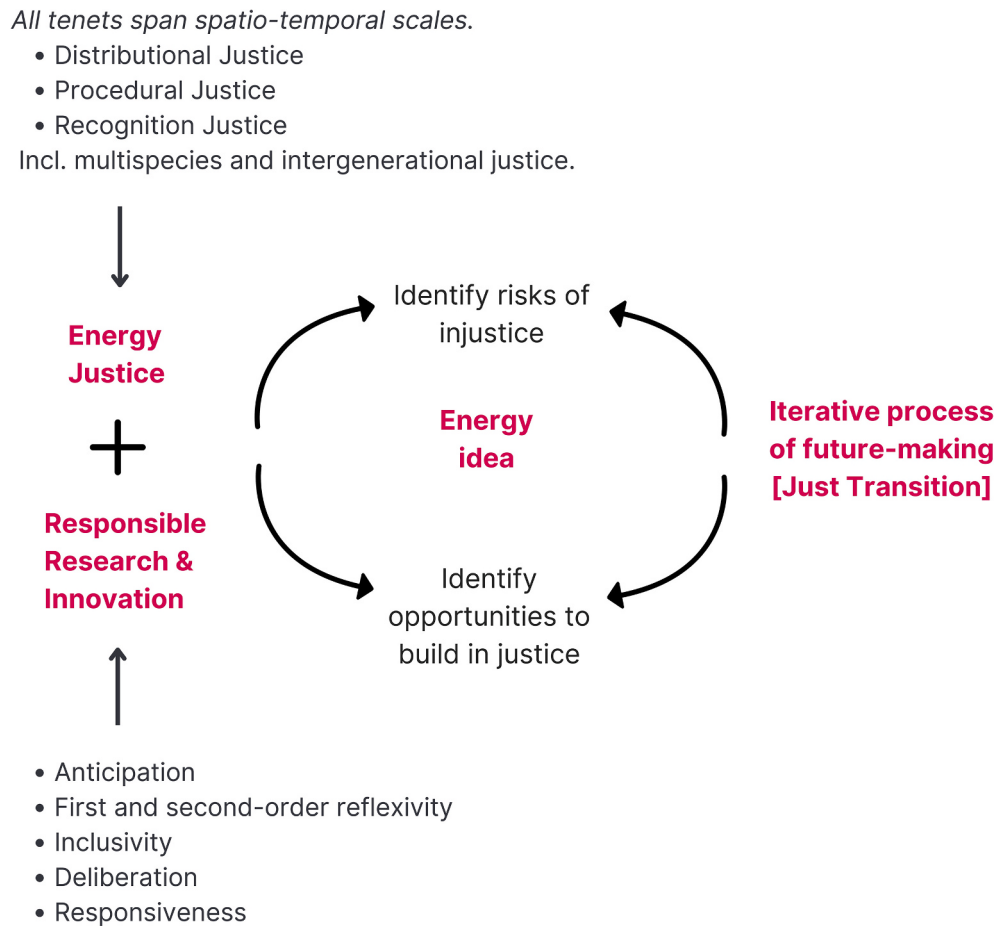


Fig. 1. Justice by Design conceptual framework.
(Source: authors.)

The methodology is envisioned as a staged process adaptable to contextual realities (as per Fig. 2). It has the potential to permeate decision-making processes. For example, innovation funders could integrate Justice by Design into decisions regarding the support for novel energy types or technologies (e.g. green hydrogen, floating offshore wind). Investors could integrate Justice by Design derived criteria into their portfolio selection processes, enabling targeted consideration of long-term risks and opportunities of energy-related investments for a JT. As an example, the Scottish National Investment Bank's (SNIB) 'missions' (one of which is Net Zero) all aim to support a JT, yet currently this is defined primarily in terms of job creation [138] - an essential, yet narrow focus of justice in the energy transition. Technology and project developers, including community-led energy initiatives, could underpin technology or project scoping with Justice by Design. It is equally applicable across local, regional and national authorities engaging with the justice dimensions of various energy future scenarios (the City of Amsterdam's adoption of the 'Doughnut' to guide social and economic recovery [139] is an analogous example).

4.2. Mobilising Justice by Design: a reflexive, anticipatory justice inquiry

Participant selection for practical Justice by Design exercises will depend on the specific context of the energy idea and/or location. Instead of prescribing a list of stakeholders, we make recommendations for practitioners based on three principles. First and foremost, practitioners should work to deconstruct expert-oriented biases

pervasive in conventional energy planning [e.g. [140]] and embrace plural knowledges and lived experiences as important sources of knowledge [e.g. [16,122,123]] including in the energy arena. Professional and technical energy-related knowledge will contribute essential information which will often have justice implications. However, technocratic processes and knowledge should not crowd out the voices of so-called "non-experts". Secondly, participants should be treated with equal respect and weight. Justice by Design is intended to enable collective reflection and knowledge-making. If there are energy technicians and civilians around the same table, practitioners should be aware of power hierarchies and asymmetries. The assertion of technically grounded arguments, for instance, may inadvertently silence alternative perspectives. We recommend that practitioners actively challenge 'expert' assumptions and broader biases about what energy outcomes should look like. Thirdly, practitioners should involve people who could be impacted by the energy idea across space and time (as far as is feasible⁸), making targeted efforts to involve harder to reach voices and to engage across dissenting, differing perspectives and realities.

⁸ There will always be practical limitations to this, e.g. regarding the voice of species, future generations and those impacted up and downstream by mining and waste activities. Justice by Design encourages critical and deep reflection on this, alongside proactive effort. Genuine consideration of inclusion/exclusion hierarchies within energy processes is already a step towards more just outcomes.

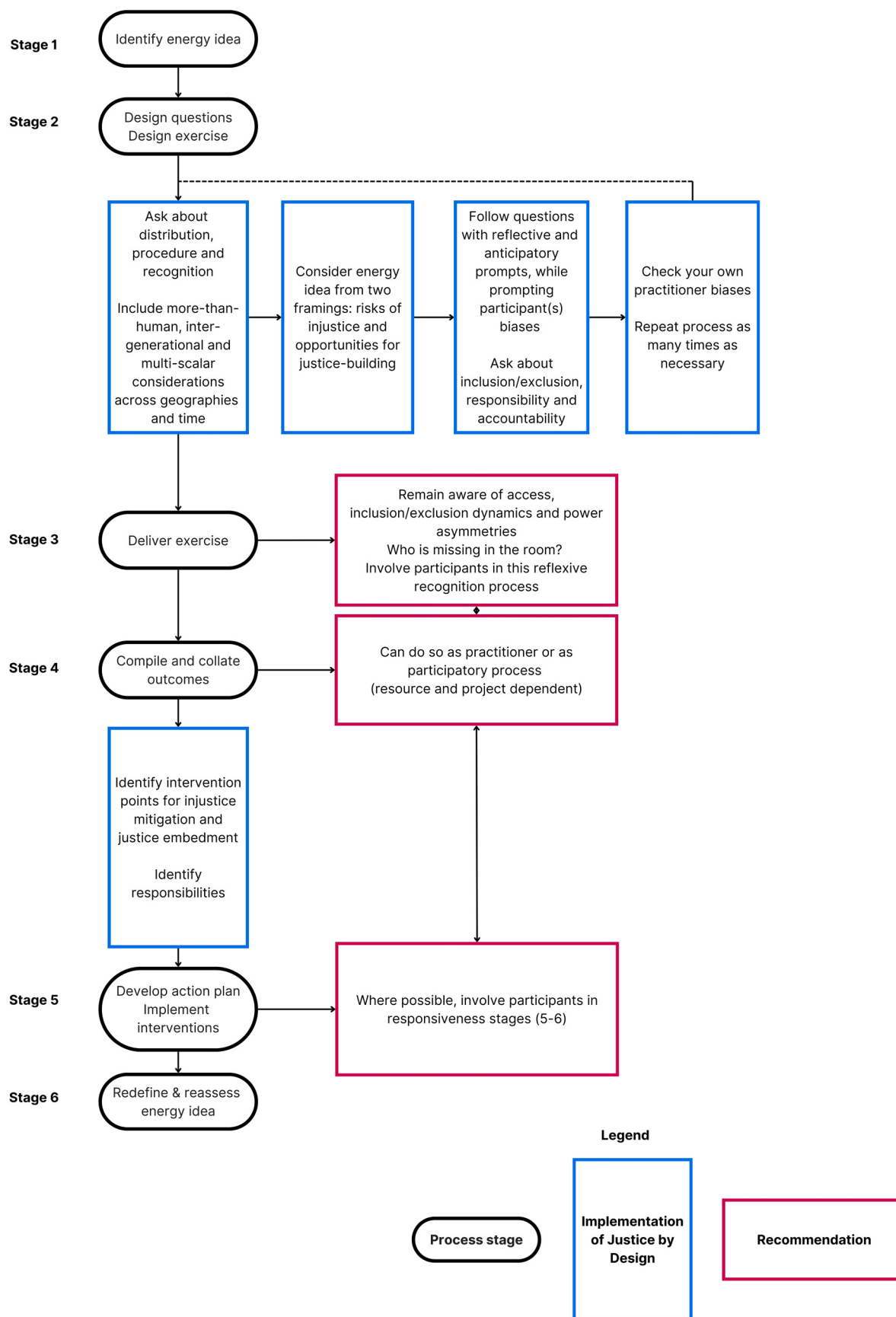


Fig. 2. Justice by Design methodology, process diagram.
(Source: authors.)

Practitioners should understand Justice by Design as a framework underpinning energy innovations and system redesign, not as a one-off engagement exercise. With this in mind, the core methodological focus is to engage in reflexive, anticipatory deliberation across dimensions of justice. First, the practitioner should identify the energy idea (Fig. 1; Fig. 2, stage 1). This could be an energy source (e.g. geothermal energy), an energy-generating technology (e.g. wave energy converter), a potential energy project (e.g. deployment of a hydrogen generation facility) or even, planning for an energy transition in a particular place. Secondly, the practitioner should develop questions based on each of the three tenets of EJ: distribution, procedure and recognition. Examples of starter questions exist in peer reviewed literature [e.g. [10,22,141]] and include “Where and how are the costs and benefits of the transition being distributed?” or “How are non-human actors engaged in dialogue?” (both taken from [141]). Inspiration can also be drawn from existing EJ case studies. In addition to these starter questions, we suggest removing technical jargon such as ‘justice’ and the three tenet terms when engaging in Justice by Design-led deliberation (e.g. Table 1). We also note that practitioners should include multispecies, future generations, and pan-supply chain considerations explicitly, proactively drafting questions that inquire into these dimensions. The practitioner should also draft questions inquiring both into potential injustices and into the possibility of building justice into the energy idea. Thus, complementing injustice identification and mitigation with the mobilisation of a proactive framing of justice as something to strive for.⁹ Table 1 offers guidance on how to discuss the tenets of EJ in an anticipatory way while intentionally avoiding justice jargon to increase accessibility (Fig. 2, stage 2). The guidance is non-exclusive and non-exhaustive. It can also serve practitioners and organisations internally, to consider what reframing an energy idea through a Justice by Design lens may entail.

EJ example questions in Table 1 are already framed from an anticipatory perspective for practitioner ease. To further integrate RRI methods into the EJ inquiry outlined above, questions should include explicit prompts into practitioner and participant biases, digging into assumptions and commonly unquestioned visions of energy. Thus, integrating first and second-order reflexivity. Practitioners can also develop visioning questions or activities that reflect on the future, aiming to materialise imagined futures and expectations related to the energy idea. This will increase reflexivity and overall anticipation. Questions should also prompt reflection on actor responsibility and accountability [9]. The process of drafting these questions (and designing the deliberative exercises e.g. interviews or workshops) by the practitioner should be iterative and reflexive. Moreover, the practitioner should engage in first and second-order reflexivity to check their own biases throughout question/activity design, including awareness of inclusion/exclusion dynamics, power asymmetries and accessibility. Practitioners may find additional support by referring to evaluative indicators for the implementation of RRI¹⁰ [e.g. [9]] upon integrating RRI within their justice inquiry. Table 2 offers examples of anticipatory questions while Table 3 offers examples of first and second-order reflexivity prompts. The latter are provided for different sectors, such as policy and industry, to illustrate how these can be tailored to different contexts and participants. Both tables are non-exclusive and non-exhaustive, and support stage 2 in Fig. 2. They should be used alongside questions outlined in Table 1, to integrate anticipation and reflexivity further into the EJ inquiry.

⁹ Recent work [142] alludes to the value of this by proposing energy policy improvements, following retrospective EJ analysis of various case studies.

¹⁰ For example, the category of “Reflection” includes 6 indicators. Indicator 1 is “Critical reflection of problem definition”, and evaluative rubrics range from: “No procedure or declared interest in conducting reflective practice” (low) to “Structured, purposeful periodic analytical review of problem definition.” (very high) [9,p.9].

Table 1
Guidance for an anticipatory energy justice inquiry.^a

The guidance in this table aims to support practitioners considering recognition, distribution and procedural justice in relation to an energy idea, while avoiding justice jargon. The table pragmatically separates the three tenets into distinct categories. In practice, the tenets overlap and are interdependent. Practitioners will note the overlaps across tenets within the guidance.	
Justice tenet	Questions - Terminology
Distribution	• Who will carry the burdens/risks of [insert energy idea]? • Who will reap the benefits/opportunities created by [insert energy idea]? • What about the spread of positive impacts and harms, across the world, of this [insert energy idea]? And over time?
Procedure	• What do you expect processes will look like to design/deliver [insert energy idea]? • Who will have decision-making power? • Who will be left unheard? • Could [insert energy idea] influence engagement/participation processes? For better or worse? • Are ecosystems given sufficient voice in these processes? What about future generations? In what ways does this materialise in practice? What is their weight in decision-making? • Who has access to information about [insert energy idea]? What dimensions of the [insert energy idea] are not disclosed? • How do you anticipate evaluating a successful [insert energy idea]?
Recognition	• What is the social, cultural, historical context of the place where [insert energy idea] is planned? • In what ways do the voices across extraction and waste zones, ecosystems, people suffering climate change today/in the future... influence [insert energy idea]? • In what ways do voices in positions of power (shareholders, lobbies, political interests) in the energy sector influence [insert energy idea]? • Who/where in [insert place] has been historically harmed or burdened by energy? Who/where has benefited? ◦ How do you see [insert energy idea] impacting this – for better or worse? • To what extent is this considered/prioritised in: funding, policymaking, [insert energy idea] design processes? How could it be? • Who is missing in the room? What would they think?
Recognition – Unheard voices examples	Questions – Terminology
Future generations	• What might [someone living in - insert year/someone many generations down the line] ask that we do or do not do in relation to [insert energy idea]? • To what extent is this prioritised today, why or why not?
More-than-humans, including extinct species	• What would [species, ecosystems, landscapes] considerations look like? • How might they be recognised? Can you empathise with them? • What would they [species, ecosystems, landscapes] ask of us as we design and develop [insert energy idea]?
Climate migrants ^b	• Consider [insert energy idea] in the context of the climate crisis. Consider the perspectives of people displaced from their homes and countries. What would they ask that we do, or do not do in relation to [insert energy idea]? • What would they recommend that we prioritise?

^a Questions in Tables 1, 2 and 3 have been developed through researcher reflection. They draw on existing tools such as the RRI self-reflection tool [144] and take inspiration from the Haudenosaunee nations’ core value of the ‘Seventh Generation’ [145] which understands and respects the world we live in as borrowed from future generations. Questions also take inspiration from futuring exercises in different fields (e.g. [146,147]).

^b Climate migrants are included as a pressing example of those rendered “faceless” [143,p.285]. All unheard voices examples highlight often ignored perspectives. They are non-exclusive and non-exhaustive. (Source: authors.)

Table 2
Illustrative questions/activities on anticipation.

These examples follow on from discussion across distribution, recognition and procedure (e.g. Table 1), which prepare the groundwork for imagining just/unjust futures. Across questions/activities below, the practitioner is inviting the individual/group to engage in their ideal of justice and to then reflect on it from various perspectives.	
Perspective	
Visioning the future: place-specific	Questions/activities for anticipation
All participants	Imagine a just/unjust energy future in [insert place] [can insert year]. • How did we get there? • What does it look like? • Do you see specific energy types within it?
Reflexive prompts	Why or why not? • What aspects of the world, as it is today, have you left unquestioned? What have you changed? • Could your imagined 'just future' cause harm elsewhere? ◦ Is this acceptable, necessary, avoidable? ◦ How might this change your vision? ◦ What does this new vision ask of you? Of others?
Reflexive prompts on responsibility and on justice interdependence	• Are there elements in your imagined 'just future' which you dislike, but would be willing to accept? ◦ Why or why not? Under what conditions? • Who benefits from your 'unjust future'? ◦ Are these benefits legitimate? Justified? Why or why not? Under what conditions?
Visioning the future: technology/project specific	Questions/activities for anticipation
All participants	• Can you foresee [insert energy idea] contributing to an unjust transition? • How might [insert energy idea] contribute to a just transition? • What needs to be in place to avoid/enable this?
Reflexive prompts – as above, and in Table 3.	

(Source: authors.)

Underpinned by the Justice by Design conceptual framework, these questions/activities can now be mobilised in practice. Methods to do Justice by Design include semi-structured and unstructured interviews, workshops or other deliberative spaces that suit the context and practitioner facilitation skills. The exercises should continuously return to the question, “who is missing from the room, who’s voice is left unheard?” while involving participants in this discussion. Justice by Design exercises should shed light on intervention points (risks of injustice that need mitigating and opportunities to build justice in), while determining responsibilities for these. Through responsiveness, as per stages 5 and 6 (Fig. 2, Table 4), the proposed energy idea will evolve, taking a new form enriched by this process.

Finally, a note on responsibility. Across all three bridged literatures, there is an appeal to collective dialogue and decision-making for better outcomes. Moreover, both EJ and RRI have argued for the expansion of the conceptualisation of responsibility [14], reorienting the role of responsibility away from consequentialism and towards the purpose and motivations behind an innovation instead [35]; or in this case, behind a potential energy idea. The very act of engaging with a methodology like Justice by Design should increase levels of collective ownership and responsibility in an intangible sense, connecting the practitioner and multiple stakeholders to an energy idea and reducing uncertainty and risks through the inclusion of diverse voices.

Table 3
Reflexivity prompts, including sectoral examples.

These prompts should follow on from distributional, recognition and procedural justice questions regarding the energy idea in question. This list is non-exclusionary and non-exhaustive. It provides examples as a starting point, to stimulate practitioner reflection and creativity.	
General prompts – for all audiences*	
• Why do you think this is? • Is there anything that you are taking for granted, or taking to be true? • Can you imagine places, peoples, scenarios where this might not be the case? • Had you considered this before? • Why or why not? • What are you prioritising? • Is there anything about this which you had not realised? • Is there anything you believe should change? • Can it change? • Is anyone responsible today? • Who should be responsible? • What is your scope of action and what pressures do you face? • In what ways are you responsible and how are you held to account? • How can energy processes address changing needs over time, given the lifespan of the [insert energy idea]? • What opportunities does this create? • What are the risks of not doing so?	
Reflecting on/with unheard voices - for all audiences*	
• Would they ask us not to develop [insert energy idea] at all? • Can you imagine a scenario where [insert voice] are legitimately opposed to what you are proposing? • If we listened to [insert voice], how could this change the design/deployment of [insert energy idea]? • How might we listen to [insert voice] in practice? What are the barriers?	
Sector dimension	Practitioner example – industry prompts
Energy sector legacies	How is [insert energy idea] disrupting or cooperating with legacies of inequality in relation to energy? • Could it, or should it be? • How might this change?
Energy lifecycle processes	How traceable are the raw materials in your [insert energy idea]? • How aware are you of processes of extraction or disposal? • What influence has this had on the design process? • What opportunities are there? • What risks are created by [insert energy idea] otherwise?
Energy business models	Have you considered the implications of the business model you use on the potential impact that [insert energy idea] could have? • What assumptions are you making? • What alternatives might you be locking out? Why? Imagine an alternative business model. • What does it look like? • What implications does it have for the [insert energy idea]? • What social and ecological implications could it have? • How comfortable would you feel with adopting such an approach? • How capable would you feel? Why?
Localised impacts of the energy idea	How familiar are you with the local context where you plan to implement [insert energy idea]? • How do your suggested positive local impacts or contributions relate to local needs? How have these been decided on? • What assumptions are you making? • What aspects should you become more familiar with?

(continued on next page)

Table 3 (continued)

Sector dimension	Practitioner example – industry prompts
Evaluating the energy idea	How would you evaluate the success of [insert energy idea]? What about its failure? • Where do these evaluative priorities come from? • Is anything problematic with this approach? • Is anything missing that should be included? • How does this condition the design and delivery of the [energy idea] in the first place?
Sector dimension	Practitioner example – policy prompts
Energy sector legacies and futures	Could benefits in [insert place] from [insert energy idea] be in detriment to another place, people, time, nature? • Is this justifiable? • If not, what could be done to avoid this? Should more be done to reduce power asymmetries in relation to energy? • What assumptions are you making? • What are you prioritising, and what are you leaving out? • Is there potential to do so via [insert energy idea]?
Unheard voices	What assurances are in place for future generations (of all species) within your current energy transition plans? • What assumptions are you making? • Are you considering future generations locally or worldwide? • How might this change your [insert energy idea]?

(Source: authors.)

A further matter relates to responsibility for the technology, project or initiative, from the implementation of justice intervention points through to liabilities and legal accountability. These generally relate to influence capabilities, ownership models, finance and risk, all of which will likely surface through a Justice by Design inquiry and the follow-on compilation of action points (Fig. 2, stage 5). This discussion spans beyond the scope of this paper, yet we acknowledge it as important and requiring further exploration.

While there are multiple ways of engaging with responsibility through Justice by Design, we suggest involving actors with power in the process and including questions about responsibility throughout deliberative exercises to prompt first and second-order reflexivity. This is in line with indicator-based models of RRI which highlight the importance, as part of reflexivity, of the actors involved becoming “aware of their own responsibilities as well as accountability” [9,p.7]. It also responds to the methodology’s practical potential to identify responsibilities of justice “by whom?” [14,p.837]. Questions of responsibility should be exercised with caution, care and empathy, particularly when engaging with people who may find themselves in vulnerable situations, or with less power and influence in current energy system processes. Nonetheless, responsibility issues will be an essential feature of delivering Justice by Design, particularly at stages 4–6 (Fig. 2, Table 4) to compile intervention points and to develop and implement action plans.

Detailed briefly in Section 4.1, Table 4 includes more examples of potential practitioners, energy ideas and timelines alongside examples

of how to undertake Justice by Design exercises (as per Fig. 2). Overall, as per Sections 2, 3 and examples in Table 4, Justice by Design requires a shift in ways of doing towards adopting a justice-oriented approach to the development of energy ideas. Methodologically, while the deliberative exercises are essential, this does not exclude integration with alternative methods at different moments. Combining mixed qualitative and quantitative methods such as spatial mapping (e.g. of energy resources, infrastructures and/or needs), population data, statistical analysis or surveys and questionnaires could support the design stages of the Justice by Design inquiry (stages 1–2) (although as per above, these methods are inappropriate for the deliberative exercises themselves). Mixed methods could also be mobilised during data analysis to derive actionable outcomes (Fig. 2, stage 4; Table 4). Finally, findings identified via Justice by Design may also be contrasted with additional quantitative/qualitative data for triangulation. This demonstrates the flexibility of this methodology for practitioners with a range of skills and within interdisciplinary teams, organisations and groups, while maintaining robustness provided by the underpinning conceptual framework.

The novel value of Justice by Design is its integration of justice and innovation frameworks, EJ and RRI respectively. Through these, Justice by Design can engage with justice considerations in an anticipatory way - *before* impacts are locked into future energy systems. This anticipatory lens to justice also creates space to consider alternative, actionable possibilities, enabling practitioners to encompass pertinent approaches focused on mitigating injustice while simultaneously operationalising a positive justice framing. Thus, combining the dismantling of extractive and exploitative infrastructures alongside “building and supporting infrastructures that materialise being otherwise, in ways that enable life chances and careful, responsible relations” [148,p.238].

4.3. Discussion, applicability and limitations

The multi-scalar spread of impacts (across space and time) is challenging to grasp, yet this is imperative to understand the real reach of socio-technical and ecological energy configurations. In this paper we propose the use of a methodology which encourages anticipation, reflection and overall empathy via the three tenets of EJ across geographical and temporal scales. Geographically, this prompts consideration of transboundary impacts embedded within the life-cycle of energy ideas, from energy extraction to waste processes. Existing energy assessments and mitigations tend to focus on localised impacts (e.g. Environmental Impact Assessments, Socio-Economic Impact Assessments, employment-related commitments or community benefit payments). Similarly, the Lifecycle Assessment approach does not situate impacts geographically. Instead, Justice by Design reframes these approaches significantly by encouraging deep thought on the futures created by energy ideas at local and global scales. This could encourage policymakers, for example, to think critically about the transboundary impacts of their local decarbonisation and JT objectives *beyond* the place’s immediate interests. In tandem, recognition-led reflection on historical inequities alongside explicit consideration of future generations incorporates temporality dimensions. Critical consideration of JT and low-carbon energy initiatives across spatiotemporal scales is largely excluded from mainstream policy and industry narratives today. These are crucial to ensure that a just energy transition in one place and time is, to the extent possible, not offshoring injustice elsewhere or pushing it down the line.

Table 4

Justice by Design methodology: stages and illustrative examples. Source: authors.

Energy idea	Practitioner				
	Technology developer	Project developer	Investor/funder	Policymaker	Community group
Illustrative 'energy ideas'	Development of a new energy technology/ Improvement of existing one	Scoping future energy projects/ Purchasing/repowering existing projects	Financing energy innovations/projects	Designing energy transition plans in [X] location/ Legislating for renewable energy	Planning a community energy project/ Activism in relation to an energy idea
Example 'energy idea' timelines	TRL 1–9	Scoping/planning → decommissioning/repowering	Portfolio design → ongoing investment/ Design funding criteria → stage gate process	Strategy design team (working groups, evidence for policy development) → delivery	Self-organising → engagement/delivery of 'energy idea'
Justice by Design	Illustrative 'energy idea' examples by practitioner				
Stage 1 - Identify energy idea (the focus of the Justice by Design inquiry)	A tidal energy converter prototype	A windfarm project in a specific location	Investing in 'net zero' portfolio for carbon offsetting/ Grant funding for green hydrogen innovation projects	Local idea for decarbonisation/ Net zero strategy for [X] location/ Subsidy for renewable energy e.g. UK Contracts for Difference	A community owned solar farm in [X] Partnering with a private energy project/ Community opposition to [energy idea]
Stage 2.1 – Develop questions/activities based on Justice by Design	- Identify initial list of participants - Design questions/activities Include: - Distributional considerations - Procedural considerations - Recognition considerations - Responsibility considerations Examples in Table 1. Underpinned by, followed by or included within: - Visioning activities – see Table 2 for examples. - First and second-order reflexive practice – see Tables 2 and 3 for examples. Engage in first and second order reflexivity throughout. Question your biases.				
Stage 2.2 - Identify methods	- Interviews (multiple types) - Workshops/open forum/collaborative activity/arts-based activity Include consideration of inclusion/exclusion practices and accessibility (e.g. appropriate financial or alternative compensation measures for participation).				
Stage 3 - Deliver exercises	Deliver exercises				
Stage 4- Identify, compile, and collate interventions and responsibilities	- Identify actions (including contacting to identified missing participants). - Identify intervention points for the energy idea - consider scope for change within existing timelines. - When is it possible to implement the given changes? Who needs to do this? When are things 'locked in'? - Identify responsibilities for delivery – including stakeholders beyond the leading organisation.				
Stage 5- Respond to intervention points, mitigating injustice and promoting just outcomes	- Feedback to participants on intervention points (interventions may sit across different timelines throughout the energy idea). - Establish links/involve directly influential stakeholders (e.g. small energy innovator reaching out to a grant funder) where relevant. - Build flexibility into the process considering energy idea timelines, prioritise according to key intervention points and moments of 'no return' e.g. signed contracts, built infrastructure. - Build necessary flexibility into 'energy idea' pathways e.g. into contracts, by including scope for Justice by Design iterations.				
Stage 6 - Re-assess the energy idea	- Continue to progress along the development timeline (TRLs, project timelines, funder stage gates, community negotiations and planning). - Build on initial Justice by Design exercise; intervention points should permeate across departments and responsibilities relating to energy idea delivery. - Continue to mobilise Justice by Design to anticipate risks and opportunities at key points of energy idea timelines throughout.				

Temporally, there is a risk that Justice by Design may be providing a snapshot of realities and considerations at a specific point in time. This sits against a backdrop of fluid – albeit slow changing and at times, resistant [149] values, within a context of growing environmental and technological uncertainty. This tension, however, exists in every process

of decision-making underway in the present. As such, Justice by Design goes some way to resolve this by recognising said fluidity and uncertainty, embracing it as part of the process. Additionally, risk mitigation is built into the methodology's core. Starting with inclusive deliberation increases the diversity of perspectives and lived experiences assessing

the energy idea in question. Visioning and reflexive prompts encourage empathy over time and space, with human and more-than-human beings.¹¹ Moreover, effective, iterative deliberation and action are intrinsic to Justice by Design via responsiveness, which upholds the need to “change shape or direction in response to stakeholder and public values and changing circumstances” [33,p.1572].

There are challenges to Justice by Design implementation, from adoption through to iteration and responsiveness. Amongst others, these pertain to existing interests and standardised methods, resources and the often-diffuse nature of innovation itself. Yet, these challenges are not insurmountable. Practically, the Justice by Design methodology often fits well within the character of energy ideas as developed today. A proposed onshore wind farm project, for instance, will have a projected lifespan, which offers opportunities for iterative Justice by Design. Justice by Design plans can be integrated a priori during project formulation and can be protected within planning regulation or contractually within the project itself. For energy technologies the picture is muddier, given that technological innovation can happen simultaneously across different geographies, rhythms and scales. Practitioners in different organisations could independently adopt the Justice by Design methodology throughout the design and testing of their prototypes. The widely established TRL framework for technological development may offer a pragmatic ‘timeline’ which could be underpinned by Justice by Design, with readily existing efforts in this arena [20,21]. Given this diffuse nature of emerging innovations, however, there may be a greater role for funders and regulators to incentivise such justice-led approaches in these contexts (examples in Table 4).

To be clear, while Justice by Design is grounded in processes of collective deliberation and reflexivity, it is not a method for public engagement. Instead, it is a methodology for the design and delivery of energy technologies, projects and systems more broadly (‘energy ideas’) – which upholds collective reflexivity and anticipation as vital to achieving just outcomes. In this context, while this paper advocates participation, we do not romanticise the concept. Power asymmetries between participants [116] make ensuring ‘holistic’ and ‘inclusive’ engagement challenging [115]. Stakeholders may mistrust engagement processes or may only become interested after the design is already set [151]. These challenges are accentuated by conventional engagement tools which tend to be non-binding, unremunerated, and occur in the later stages of an energy idea’s development, if at all. Inappropriate participation can be shallow, extractive and fatiguing for participants, and participation does not necessarily equate to stakeholder power [152,p.635]. The Justice by Design methodology incorporates explicit prompts on accessibility, responsibility and responsiveness, which go some way in mitigating these risks. While issues of practitioner bias exist, we contend that this is true of all decision-making processes. To mitigate bias risk, stage 2 of Justice by Design (Fig. 2, Table 4) insists on practitioner second-order reflexivity and iteration alongside collective deliberation with diverse voices.

A practical challenge is one of resources. By its very nature, the methodology is fluid, and application must be context dependent. Practitioners will need to spend time and resources familiarising themselves with the justice dimensions of energy while embedding the Justice by Design methodology within current practices, including the incorporation of deliberative exercises to influence decision-making. This contrasts with real-world energy (innovation) development which is often resource constrained and prioritises techno-economic feasibility [e.g. [153]]. Despite increasing references to “wider impacts” in funding applications (e.g. see the UK Government Innovation Funding Service) or the development of ‘whole systems’ tools like “Horizons” [154], these

continue to be an “add-on” instead of structurally transforming funding priorities and evaluation processes. More positively, they also signal to a slow but real shift in attention to these dimensions. Alongside growing media and institutional awareness beyond academic spheres [e.g. [101,155,156]] this is, we contend, an opportune time for practitioners in the energy arena to be creative, ambitious and disruptive.

Finally, some of the justice dimensions identified through Justice by Design may pertain to systemic and structural issues (e.g. global markets, legislation, supply chains, geopolitics, economic systems, financial markets). These issues may lie beyond the capacity for action held by practitioners. Even here, Justice by Design adds value. Engaging with these systemic problems builds collective awareness, interest and responsibility, instead of rendering these issues unquestionable. This could also give way to novel perspectives and approaches to begin to address existing, systemic barriers. As such, we agree that by recognising the entanglements with broader social, political and economic systems, justice-driven lenses (such as Justice by Design) can help “legislators, regulators and social activists reshape these market dynamics” [10,p.5], and, we suggest, researchers, funders and technology and project developers too.

5. Conclusions

To design and deploy the sustainable energy systems of the future, it is essential that we embed new methodological lenses that prioritise justice into the design of energy technologies, projects and wider energy systems change. The risk is clear if we do not do so – failures of anticipation risk reinforcing existing injustices and creating new ones. Said another way, while the negative impacts of the closure of certain industries may be partly mitigated by existing approaches to JT, there will be a limited understanding of the injustices arising from the development of novel energy innovations. Furthermore, we will also forgo the opportunity to build more just and resilient energy systems overall.

In this paper we present Justice by Design, a novel conceptual framework and methodological approach. The interdisciplinary conceptual framework integrates EJ, RRI and JT. It offers a coherent vision and a practical methodology to drive forward actionable, more just energy futures. Justice by Design aims to do so through key building blocks of energy transitions: energy sources, technologies, projects, place-based transitions and the socio-technical and ecological dimensions that constitute them.

We are not blind to the challenges related to the implementation of Justice by Design, particularly given mainstream approaches to energy developments. Despite these, we defend its value and appeal to practitioners to engage in its implementation. The methodology requires a shift in approaching energy ideas altogether. The staged process outline and its accompanying guidance (Fig. 2, Tables 1–4) serve as a practical guide for practitioners to engage with and implement anticipatory considerations of justice. Thus, departing from existing energy-related approaches to social license and community wellbeing which often fall short of identifying and tackling root issues¹²; while also offering practical ways for practitioners to engage with the complex trans-boundary, temporal and more-than-human dimensions of energy.

There is no question about the need to take responsibility for future energy systems and their implications. Energy and related infrastructures do not exist in a techno-rational, “moral vacuum” [79,p.1]. They are not merely an amount of kilowatt hours produced, or a Gross Value-Added figure in an economy but are instead irreducibly interwoven with social and ecological systems. Funders, policymakers, industry practitioners and researchers must be bold to grasp the energy transition as an opportunity to break away from traditional approaches,

¹¹ While we acknowledge the challenges pertaining to speaking for others [150], if genuinely mobilised such approaches can serve as pragmatic prompts to consider individual biases and interests beyond one’s immediate reality while actively exercising instances of multispecies relationality.

¹² Examples include current approaches to “community benefits” from energy projects, for instance, which are increasingly being questioned by communities themselves [157].

where these have enabled and ignored the enactment of historical injustices that still prevail. It is time for honest recognition and action. Justice by Design offers an ambitious yet actionable methodology in this direction, joining efforts to respond to the socio-ecological crises of today.

CRediT authorship contribution statement

Lara M. Santos Ayllón: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Kirsten E.H. Jenkins:** Writing – review & editing, Supervision, Conceptualization. **Sandy Kerr:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

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Data availability

No data was used for the research described in the article.

References

- [1] Climate Watch Data, (2023) 'Global Historical Emissions', [online]. Available at: <https://www.climatewatchdata.org/gHG-emissions?breakBy=sector&chartType=percentage&end year=2020&start year=1990>.
- [2] IRENA, (2023), 'Investment', Available online: <https://www.irena.org/Energy-Transition/Finance-and-investment/Investment#:~:text=Global%20investment%20in%20energy%20transition,World%20Energy%20Transitions%20 Outlook%202023>. Accessed: January 2023.
- [3] K. Jenkins, D. McCauley, A. Forman, Energy justice: a policy approach, Energy Policy 105 (2017) 631–634, <https://doi.org/10.1016/j.enpol.2017.01.052>.
- [4] Gates, B., Gates, M., (2016) 'Two Superpowers We Wish We Had', Gates Notes, [online], 22 February. Available at: https://www.gatesnotes.com/2016-Annual-Letter?WT.mc_id=02_22_2016_20_AL2016_MED-media_WT.tsrc=MEDmedia.
- [5] European Climate Foundation, (2018) 'Innovation can help deliver EU competitive climate leadership', 19 November, [online]. Available at: <https://europeanclimate.org/resources/innovation-can-help-deliver-eu-competitive-climate-leadership/#:~:text=%E2%80%9CInnovation%20not%20only%20drives%20the,of%20energy%20demand%20by%202050>.
- [6] European Commission, (2021a) 'Innovation and technology – key enablers for transition to climate neutrality', JRC, [online], 23 November. Available at: https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/innovation-and-technology-key-enablers-transition-climate-neutrality-2021-11-23_en.
- [7] Reuters, China pledges high-tech support for climate, environmental problems, Reuters, [online], November 2 (2022). Available at: <https://www.reuters.com/business/cop/china-pledges-high-tech-support-climate-environmental-problems-2022-11-02/>.
- [8] UK Government, (2023) Powering up Britain - The Net Zero Growth Plan, [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1147457/powering-up-britain-net-zero-growth-plan.pdf.
- [9] T. Buchmann, P. Wolf, M. Müller, M. Dreyer, F. Dratsdrummer, B. Witzel, Responsibly shaping technology innovation for the energy transition: an RRI indicator system as a tool, Frontiers in Research Metrics and Analytics 8 (1157218) (2023) 1–16. Available at: <https://doi.org/10.3389/frma.2023.1157218>.
- [10] P. Romero-Lankao, N. Rosner, C. Brandtner, C. Rea, A. Mejia-Montero, F. Pilo, F. Dokshin, V. Castan Broto, S. Burch, S. Schnur, A framework to centre justice in energy transition innovations, Nat. Energy 8 (2023) 1192–1198. Available at: <https://doi.org/10.1038/s41560-023-01351-3>.
- [11] F.W. Geels, From sectoral systems of innovation to socio-technical systems: insights about dynamics and change from sociology and institutional theory, Res. Policy 33 (6–7) (2004) 897–920. Available at: <https://doi.org/10.1016/j.respol.2004.01.015>.
- [12] K. Antje, P. Przemyslaw, B. Mariusz, O.M. Ilona, Calling energy inequalities into the transition agenda, Energy Res. Soc. Sci. 101 (103144) (2023) 1–10. Available at: <https://doi.org/10.1016/j.erss.2023.103144>.
- [13] C. Damgaard, D. McCauley, J. Long, Assessing the energy justice implications of bioenergy development in Nepal, Energy Sustain. Soc. 7 (8) (2017) 1–16. Available at: <https://doi.org/10.1186/s13705-017-0111-6>.
- [14] K. Jenkins, D. McCauley, C.R. Warren, Attributing responsibility for energy justice: a case study of the Hinkley point nuclear complex, Energy Policy 108 (2017) 836–843. Available at: <https://doi.org/10.1016/j.enpol.2017.05.049>.
- [15] J. Vega-Araújo, R. Heffron, Assessing elements of energy justice in Colombia: a case study on transmission infrastructure in La Guajira, Energy Res. Soc. Sci. 91 (102688) (2022) 1–15. Available at: <https://doi.org/10.1016/j.erss.2022.102688>.
- [16] A. Truworth, A. McCarrel, J. Wieliczkievicz, S. Cellan, W. Peterson, S. Anderson, B. DuPont, M. Grear, Who will be making wave energy? A community-driven design approach toward just and sustainable energy futures in Alaska, Energy Res. Soc. Sci. 115 (2024) 1–18. Available at: <https://doi.org/10.1016/j.erss.2024.103615>.
- [17] T.S.G.H. Rodhouse, E.H.W.J. Cuppen, A.F. Correljé, U. Pesch, A new carrier for old assumptions? Imagined publics and their justice implications for hydrogen development in the Netherlands, Technological Forecasting & Social Change 204 (2024) 1–13. Available at: <https://doi.org/10.1016/j.techfore.2024.123412>.
- [18] K.E.H. Jenkins, S. Spruit, C. Milchram, J. Höffken, B. Taebi, Synthesizing value sensitive design, responsible research and innovation, and energy justice: a conceptual review, Energy Res. Soc. Sci. 69 (101727) (2020) 1–14. Available at: <https://doi.org/10.1016/j.erss.2020.101727>.
- [19] B.K. Sovacool, D.J. Hess, R. Cantoni, Energy transitions from the cradle to the grave: a meta-theoretical framework integrating responsible innovation, social practices, and energy justice, Energy Res. Soc. Sci. 75 (102027) (2021) 1–16. Available at: <https://doi.org/10.1016/j.erss.2021.102027>.
- [20] B.K. Arkhurst, C.R. Houghteling, N.S. Dutta, A. Clarke, K. Fu, K. Anderson, E. Gill, Evaluating energy justice metrics in early-stage science and technology research using the JUST-R metrics framework, Frontiers in Environmental Science 11 (1206013) (2023), <https://doi.org/10.3389/fenvs.2023.1206013>.
- [21] Dutta, N. S., Gill, E., Arkhurst, B. K., Hallisey, M., Fu, K., Anderson, K., (2023) 'JUST-R metrics for considering energy justice in early-stage energy research,' Joule, 7, pp. 431–449. Available at: doi:<https://doi.org/10.1016/j.joule.2023.01.007>.
- [22] M.D. Caballero, T. Gunda, Y.D. McDonald, Energy justice & coastal communities: the case for meaningful marine renewable energy development, Renew. Sust. Energ. Rev. 184 (113491) (2023) 1–12. Available at: <https://doi.org/10.1016/j.rser.2023.113491>.
- [23] J. Hoffman, M. Davies, T. Bauwens, P. Späth, M.A. Hajer, B. Arifi, A. Bazaz, M. Swilling, Working to align energy transitions and social equity: an integrative framework linking institutional work, imaginaries and energy justice, Energy Res. Soc. Sci. 82 (102317) (2021) 1–10. Available at: <https://doi.org/10.1016/j.erss.2021.102317>.
- [24] E. Noboa, P. Upham, Energy policy and transdisciplinary transition management arenas in illiberal democracies: a conceptual framework, Energy Res. Soc. Sci. 46 (2018) 114–124. Available at: <https://doi.org/10.1016/j.erss.2018.07.014>.
- [25] A. Hui, G. Walker, Concepts and methodologies for a new relational geography of energy demand: social practices, doing-places and settings, Energy Res. Soc. Sci. 36 (2018) 21–29. Available at: <https://doi.org/10.1016/j.erss.2017.09.032>.
- [26] S. Oliveira, A. Chatzimichali, E. Atkins, L. Badarnah, F. Bagheri Moghaddam, From individuals to collectives in energy systems — a social practice, identity and rhythm inspired lens, Energy Res. Soc. Sci. 105 (2023) 1–5. Available at: <https://doi.org/10.1016/j.erss.2023.103279>.
- [27] M. Eklund, K. Khalilpour, A. Voinov, M.J. Hossain, Understanding the community in community microgrids: a conceptual framework for better decision-making, Energy Res. Soc. Sci. 104 (2023) 1–15. Available at: <https://doi.org/10.1016/j.erss.2023.103260>.
- [28] S. Sareen, S. Shokgrozar, Desert geographies: solar energy governance for just transitions, Globalizations (2022) 1–17. Available at: <https://doi.org/10.1080/14747731.2022.2095116>.
- [29] L.M. Santos Ayllón, K.E.H. Jenkins, Energy justice, just transitions and Scottish energy policy: a re-grounding of theory in policy practice, Energy Res. Soc. Sci. 96 (102922) (2023) 1–22. Available at: <https://doi.org/10.1016/j.erss.2022.102922>.
- [30] D. McCauley, R.J. Heffron, M. Pavlenko, R. Rehner, R. Holmes, Energy justice in the Arctic: implications for energy infrastructural development in the Arctic, Energy Res. Soc. Sci. 16 (2016) 141–146. Available at: <https://doi.org/10.1016/j.erss.2016.03.019>.
- [31] A. Mejia-Montero, M. Lane, D. van Der Horst, K.E.H. Jenkins, Grounding the energy justice lifecycle framework: an exploration of utility-scale wind power in Oaxaca, Mexico, Energy Res. Soc. Sci. 75 (102017) (2021) 1–12. Available at: <https://doi.org/10.1016/j.erss.2021.102017>.
- [32] K. Yenneti, R. Day, O. Golubchikov, Spatial justice and the land politics of renewables: dispossessing vulnerable communities through solar energy mega-projects, Geoforum 76 (2016) 90–99. Available at: <https://doi.org/10.1016/j.geoforum.2016.09.004>.
- [33] J. Stilgoe, R. Owen, P. Macnaghten, Developing a framework for responsible innovation, Res. Policy 42 (9) (2013) 1568–1580. Available at: <https://doi.org/10.1016/j.respol.2013.05.008>.

- [34] R. Lubberink, V. Blok, J. Van Ophem, O. Omta, Lessons for responsible innovation in the business context: a systematic literature review of responsible, social and sustainable innovation practices, *Sustainability* 9 (5) (2017) 1–31, 721. Available at: <https://doi.org/10.3390/su9050721>.
- [35] R. Owen, P. Macnaghten, J. Stilgoe, Responsible research and innovation: from science in society to science for society, with society, *Sci. Public Policy* 39 (6) (2012) 751–760. Available at: <https://doi.org/10.1093/scipol/scs093>.
- [36] R. Owen, J. Stilgoe, P. Macnaghten, M. Gorman, E. Fisher, D. Guston, A framework for responsible innovation, in: R. Owen, J. Bessant, M. Heintz (Eds.), *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society*, 1st edition, John Wiley & Sons, Ltd., UK, 2013, pp. 27–50. Available online: <https://doi.org/10.1002/9781118551424.ch2>.
- [37] R. Von Schomberg, Towards Responsible Research and Innovation in the Information and Communication Technologies and Security Technologies Fields, European Union, 2011. Available at: <https://www.academia.edu/6721615/Towards-Responsible-Innovation-in-the-ICT-and-Security-Technologies-Fields>.
- [38] K. Chatfield, K. Iatridis, B.C. Stahl, N. Paspallis, Innovating responsibly in ICT for ageing: drivers, obstacles and implementation, *Sustainability* 9 (6) (2017) 971, <https://doi.org/10.3390/su9060971>.
- [39] A. Martinuzzi, V. Blok, A. Brem, B. Stahl, N. Schönherr, Responsible research and innovation in industry-challenges, insights and perspectives, *Sustainability*. MDPI (2018) 1–9, <https://doi.org/10.3390/su10030702>.
- [40] R. Carbajo, L.F. Cabeza, Renewable energy research and technologies through responsible research and innovation looking glass: Reflexions, theoretical approaches and contemporary discourses, *Appl. Energy* 211 (2018) 792–808. Available at: <https://doi.org/10.1016/j.apenergy.2017.11.088>.
- [41] R. Carbajo, L.F. Cabeza, Sustainability and social justice dimension indicators for applied renewable energy research: a responsible approach proposal, *Appl. Energy* 252 (113429) (2019) 1–26. Available at: <https://doi.org/10.1016/j.apenergy.2019.113429>.
- [42] K. Dong, S. Yang, J. Wang, X. Dong, Revisiting energy justice: is renewable energy technology innovation a tool for realising a just energy system? *Energy Policy* 183 (113820) (2023) 1–15. Available at: <https://doi.org/10.1016/j.enpol.2023.113820>.
- [43] Cheng, C. Tsai, J., Yang, Y. E., (2018) 'Climate Justice by design: Perceived and Actual Institutional Capacity in Green Infrastructure for Climate Change Adaptation'. Edra49: Social Equity by Design. Oklahoma City, June 6–9. Available at: <https://edra.confex.com/edra/EDRA49/meetingapp.cgi/Paper/4908>.
- [44] A. Heylighen, Sustainable and inclusive design: a matter of knowledge? *Local Environ.* 13 (6) (2008) 531–540. Available at: <https://doi.org/10.1080/13549830802259938>.
- [45] E.M. Kingma, R. ter Hofstede, E. Kardinaal, R. Bakker, O. Bittner, B. van der Weide, J.W.P. Coolen, Guardians of the seabed: nature-inclusive design of scour protection in offshore wind farms enhances benthic diversity, *J. Sea Res.* 199 (2024) 1–11. Available at: <https://doi.org/10.1016/j.seares.2024.102502>.
- [46] I. Van de Poel, F. Secomandi, E. Abraham, N. Van Uffelen, M. Feenstra, C. Liem, A. Melnyk, R. Rocco, A. Moreno Inglés, Design for justice, in: *White Paper, Delft Design for Values Institute*, 2024 [online].
- [47] P. Newell, J. Phillips, D. Mulvaney, 'Pursuing Clean Energy Equitably.' Human Development Research Paper, 2011/03, 2011, pp. 1–74. <https://hdr.undp.org/content/pursuing-clean-energy-equitably>.
- [48] N. Healy, J. Barry, Politicizing energy justice and energy system transitions: fossil fuel divestment and a just transition, *Energy Policy* 108 (2017) 451–459. Available at: <https://doi.org/10.1016/j.enpol.2017.06.014>.
- [49] P. Newell, D. Mulvaney, The political economy of the 'just transition', *Geogr. J.* 179 (2) (2013) 132–140. Available at: <https://doi.org/10.1111/geoj.12008>.
- [50] V. Silverman, Sustainable alliances: the origins of international labor environmentalism, *International Labor and Working-Class History* 66 (2004) 118–135. <http://www.jstor.com/stable/27672961>.
- [51] Prospect UK, 'Just Transition for energy workers', Prospect UK, [online]. Available at: <https://prospect.org.uk/get-involved-in-the-union/just-transition-for-energy-workers/>.
- [52] The Indigenous Environmental Network, (2017), 'Just Transition', The Indigenous Environmental Network, [online]. Available at: <https://www.ienearth.org/justtransition/>.
- [53] European Commission, (2021b), 'The Just Transition Mechanism: making sure no one is left behind', [online]. Available at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism_en.
- [54] K. Harrahill, O. Douglas, Framework development for 'just transition' in coal producing jurisdictions, *Energy Policy* 134 (110990) (2019) 1–11. Available at: <https://doi.org/10.1016/j.enpol.2019.110990>.
- [55] García-García, P., Carpintero, O., Buendía, L., (2020), 'Just energy transitions to low carbon economies: a review of the concept and its effects on labour and income', *Energy Res. Soc. Sci.*, 70(101664), pp.1–16. Available at: doi:<https://doi.org/10.1016/j.erss.2020.101664>.
- [56] D. Stevis, R. Felli, Green transitions, just transitions? Broadening and deepening justice, *Kurswechsel* 3 (2016) 35–45. Available at: www.kurswechsel.at.
- [57] R.J. Heffron, D. McCauley, What is the 'just transition'? *Geoforum* 88 (2018) 74–77. Available at: <https://doi.org/10.1016/j.geoforum.2017.11.016>.
- [58] D. Ciple, J.L. Harrison, Transition tensions: mapping conflicts in movements for a just and sustainable transition, *Environmental Politics* 29 (3) (2020) 435–456. Available at: <https://doi.org/10.1080/09644016.2019.1595883>.
- [59] X. Wang, K. Lo, Just transition: a conceptual review, *Energy Res. Soc. Sci.* 82 (102291) (2021) 1–11. Available at: <https://doi.org/10.1016/j.erss.2021.102291>.
- [60] D. McCauley, R. Heffron, Just transition: integrating climate, energy and environmental justice, *Energy Policy* 119 (2018) 1–7. Available at: <https://doi.org/10.1016/j.enpol.2018.04.014>.
- [61] Heffron, R., Körner, M-F., Wagner, J., Weibelzahl, M., Fridgen, G., (2020) 'Industrial demand-side flexibility: a key element of a just energy transition and industrial development', *Appl. Energy*, 269(115026), pp. 1–13. Available at: doi: <https://doi.org/10.1016/j.apenergy.2020.115026>.
- [62] G. Goddard, M.A. Farrelly, Just transition management: balancing just outcomes with just processes in Australian renewable energy transitions, *Appl. Energy* 225 (2018) 110–123. Available at: <https://doi.org/10.1016/j.apenergy.2018.05.025>.
- [63] S. Carley, D.M. Konisky, The justice and equity implications of the clean energy transition, *Nat. Energy* 5 (2020) 569–577. <https://www.nature.com/article/s41560-020-0641-6>.
- [64] R.J. Heffron, M.M. Sokołowski, Resolving energy policy failure: introducing energy justice as the solution to achieve a just transition, *Energy Policy* 187 (114042) (2024) 1–5. Available at: <https://doi.org/10.1016/j.enpol.2024.114042>.
- [65] D.M. Harris, J. McCarthy, A just transition to what, for whom, and by what means? Transition technology, carbon markets, and an Appalachian coal mine, *Energy Res. Soc. Sci.* 106 (103307) (2023) 1–9. Available at: <https://doi.org/10.1016/j.erss.2023.103307>.
- [66] K. Holscher, J.M. Wittmayer, D. Loorbach, Transition versus transformation: What's the difference? *Environ. Innov. Soc. Trans.* 27 (2018) 1–3, <https://doi.org/10.1016/j.eist.2017.10.007>.
- [67] R. Eckersley, Greening states and societies: from transitions to great transformations, *Environmental Politics* 30 (1–2) (2021) 245–265. Available at: <https://doi.org/10.1080/09644016.2020.1810890>.
- [68] K. Jenkins, Setting energy justice apart from the crowd: lessons from environmental and climate justice, *Energy Res. Soc. Sci.* 39 (2018) 117–121. Available at: <https://doi.org/10.1016/j.erss.2017.11.015>.
- [69] K. Jenkins, D. McCauley, R. Heffron, H. Stephan, R. Rehner, Energy justice: a conceptual review, *Energy Res. Soc. Sci.* 11 (2016) 174–182. Available at: <https://doi.org/10.1016/j.erss.2015.10.004>.
- [70] D.A. McCauley, R.J. Heffron, H. Stephan, K. Jenkins, Advancing energy justice: the triumvirate of tenets, *International Energy Law Review* 32 (3) (2013) 107–110. <https://dspace.stir.ac.uk/bitstream/1893/18349/1/IELR%202013.pdf>.
- [71] D. Schlosberg, Reconceiving environmental justice: global movements and political theories, *Environmental Politics* 13 (3) (2004) 517–540, <https://doi.org/10.1080/0964401042000229025>.
- [72] N. Healy, J.C. Stephens, S.A. Malin, Embodied energy injustices: unveiling and politicizing the transboundary harms of fossil fuel extractivism and fossil fuel supply chains, *Energy Res. Soc. Sci.* 48 (2019) 219–234, <https://doi.org/10.1016/j.erss.2018.09.016>.
- [73] A.M. Levenda, I. Behrsin, F. Disano, Renewable energy for whom? A global systematic review of the environmental justice implications of renewable energy technologies, *Energy Res. Soc. Sci.* 101837 (2021) 1–13. Available at: <https://doi.org/10.1016/j.erss.2020.101837>.
- [74] R. Tafon, F. Saunders, J. Zauha, M. Matczak, I. Stalmokaitė, M. Gilek, J. Turski, Blue justice through and beyond equity and participation: a critical reading of capability-based recognition justice in Poland's marine spatial planning, *J. Environ. Plan. Manag.* (2023) 1–23. Available at: <https://doi.org/10.1080/09640568.2023.2183823>.
- [75] N. Van Uffelen, B. Taebi, U. Pesch, Revisiting the energy justice framework: doing justice to normative uncertainties, *Renew. Sust. Energy. Rev.* 189, 113974 (2024) 1–8. Available at: <https://doi.org/10.1016/j.rser.2023.113974>.
- [76] Puig de la Bellacasa, M., (2017) 'Matters of Care: Speculative Ethics in More Than Human Worlds'. University of Minnesota Press, [online]. Available at: <https://ebookcentral.proquest.com/lib/ed/detail.action?docId=4745533>.
- [77] B.K. Sovacool, M.H. Dworkin, Energy justice: conceptual insights and practical applications, *Appl. Energy* 142 (2015) 435–444. Available at: <https://doi.org/10.1016/j.apenergy.2015.01.002>.
- [78] B.K. Sovacool, *Energy and Ethics: Justice and the Global Energy Challenge*, Palgrave MacMillan, UK, 2013.
- [79] B.K. Sovacool, R.J. Heffron, D. McCauley, A. Goldthau, Energy decisions reframed as justice and ethical concerns, *Nat. Energy* 16024 (2016) 1–6. Available at: <https://doi.org/10.1038/ENERGY.2016.24>.
- [80] B.K. Sovacool, M. Burke, L. Baker, C.K. Kotikalapudi, H. Wlokas, New frontiers and conceptual frameworks for energy justice, *Energy Policy* 105 (2017) 677–691. Available at: <https://doi.org/10.1016/j.enpol.2017.03.005>.
- [81] M. Lacey-Barnacle, R. Robison, C. Foulds, Energy justice in the developing world: a review of theoretical frameworks, key research themes and policy implications, *Energy Sustain. Dev.* 55 (2020) 122–138, <https://doi.org/10.1016/j.esd.2020.01.010>.
- [82] McCauley, D., Heffron, R., Holmes, R., Pavlenko, M., (2017) 'Energy justice: a new framework for examining Arcticness in the context of energy infrastructure development'. In: Kelman, I., (ed.) (2017) *Arcticness: Power and Voice from the North*, [online]. UCL Press, pp. 77–88. Available at: <https://www.jstor.org/stable/4411715>.
- [83] S. Sareen, H. Haarstad, Bridging socio-technical and justice aspects of sustainable energy transitions, *Appl. Energy* 228 (2018) 624–632. Available at: <https://doi.org/10.1016/j.apenergy.2018.06.104>.
- [84] B.K. Sovacool, P. Kivimaa, S. Hielschera, K. Jenkins, Vulnerability and resistance in the United Kingdom's smart meter transition, *Energy Policy* 109 (2017) 767–781. Available at: <https://doi.org/10.1016/j.enpol.2017.07.037>.

- [85] E.D.D. Rasch, M. Köhne, Practices and imaginations of energy justice in transition. A case study of the Noordoostpolder, the Netherlands, *Energy Policy* 107 (2017) 607–614, <https://doi.org/10.1016/j.enpol.2017.03.037>.
- [86] F. Bartiaux, C. Vandeschrick, M. Moezzi, N. Frogneux, Energy justice, unequal access to affordable warmth, and capability deprivation: a quantitative analysis for Belgium, *Appl. Energy* 225 (1) (2018) 1219–1233, <https://ideas.repec.org/a/eee/appene/v225y2018icp1219-1233.html>.
- [87] N. Simcock, J. Frankowski, S. Bouzarovski, Rendered invisible: institutional misrecognition and the reproduction of energy poverty, *Geoforum* 124 (2021) 1–9. Available at: <https://doi.org/10.1016/j.geoforum.2021.05.005>.
- [88] N. Willand, R. Horne, “They are grinding us into the ground” – the lived experience of (in)energy justice amongst low-income older households, *Appl. Energy* 226 (2018) 61–70, <https://doi.org/10.1016/j.apenergy.2018.05.079>.
- [89] Feenstra, M. (2021) ‘Gender Just Energy Policy: Engendering the energy transition in Europe’. Universiteit Twente. Available at: doi:<https://doi.org/10.3990/1.9789036551960>.
- [90] M. Feenstra, G. Özerol, Energy justice as a search light for gender-energy nexus: towards a conceptual framework, *Renew. Sust. Energy. Rev.* 138 (110668) (2021) 1–11. Available at: <https://doi.org/10.1016/j.rser.2020.110668>.
- [91] K.E.H. Jenkins, D. McCauley, R. Heffron, H. Stephan, Energy justice: a whole systems approach, *Queens Political Review* 2 (2) (2014) 74–87, <https://queenspoliticalreview.files.wordpress.com/2014/10/article-5-energy-justice-a-whole-systems-approach-p74-87.pdf>.
- [92] K. Jenkins, B.K. Sovacool, D. McCauley, Humanizing sociotechnical transitions through energy justice: an ethical framework for global transformative change, *Energy Policy* 117 (2018) 66–74. Available at: <https://doi.org/10.1016/j.enpol.2018.02.036>.
- [93] K. Jenkins, R.J. Heffron, D. McCauley, The political economy of energy justice: a nuclear energy perspective, in: T. Van de Graaf, B.K. Sovacool, A. Ghosh, F. Kern (Eds.), *The Palgrave Handbook of the International Political Economy of Energy*, Palgrave Handbooks in IPE, Palgrave, 2016, pp. 661–682. Available at: <https://doi.org/10.1057/978-1-137-55631-8>.
- [94] L. Kanger, B.K. Sovacool, Towards a multi-scalar and multi-horizon framework of energy injustice: a whole systems analysis of Estonian energy transition, *Polit. Geogr.* 93 (102544) (2022) 1–13. Available at: <https://doi.org/10.1016/j.polgeo.2021.102544>.
- [95] B.K. Sovacool, The political ecology and justice of energy, in: T. van de Graff, et al. (Eds.), *The Palgrave Handbook of the International Political Economy of Energy*, Palgrave Macmillan, eBook, 2016, pp. 529–558, https://doi.org/10.1057/978-1-137-55631-8_22.
- [96] S. Hall, K.E. Roelich, M.E. Davis, L. Holstenkamp, Finance and justice in low-carbon energy transitions, *Appl. Energy* 222 (2018) 772–780. Available at: <https://doi.org/10.1016/j.apenergy.2018.04.007>.
- [97] E. Baker, S. Carley, S. Castellanos, D. Nock, J.F. Bozeman III, D. Konisky, C. G. Monyei, M. Shah, B. Sovacool, Metrics for decision-making in energy justice, *Annu. Rev. Environ. Resour.* 48 (2023) 737–760. Available at: <https://doi.org/10.1146/annurev-environ-112621-063400>.
- [98] Sokolowski, M. M. (2024) ‘Enforcing energy justice through the legal system: a cascade of four conditions,’ pp. 49–54. In: Heffron, R.J., de Fontenelle, L. (eds.) (2024) *The Power of Energy Justice & the Social Contract. Just Transitions*. Palgrave Macmillan. Available at: doi:https://doi.org/10.1007/978-3-031-46282-5_8.
- [99] R.J. Heffron, D. McCauley, Achieving sustainable supply chains through energy justice, *Appl. Energy* 123 (2014) 435–437. Available at: <https://doi.org/10.1016/j.apenergy.2013.12.034>.
- [100] UK Government, (2021), ‘PM to Announce Electric Vehicle Revolution’, UK Government, [online]. 21 November. Available at: <https://www.gov.uk/government/news/pm-to-announce-electric-vehicle-revolution>.
- [101] P. Pattison, ‘Like slave and master’: DRC miners toil for 30p an hour to fuel electric cars, *The Guardian* (2021) [online]. 8 November. Available at: <https://www.theguardian.com/global-development/2021/nov/08/cobalt-drc-miners-toil-for-30p-an-hour-to-fuel-electric-cars>.
- [102] D. Searcey, E. Lipton, Hunt for the ‘blood diamond of batteries’ impedes green energy push, *New York Times* (2021) [online]. 22 June. Available at: <https://www.nytimes.com/2021/11/29/world/congo-cobalt-albert-yuma-mulimbi.html>.
- [103] B.K. Sovacool, S.E. Bell, C. Dagget, C. Labusky, M. Lennon, L. Naylor, J. Klinger, K. Leonard, J. Firestone, Pluralizing energy justice: incorporating feminist, anti-racist, indigenous, and postcolonial perspectives, *Energy Res. Soc. Sci.* 97 (102996) (2023) 1–8. Available at: <https://doi.org/10.1016/j.erss.2023.102996>.
- [104] A. Dunlap, C. Tornel, Pluralizing energy justice? Towards cultivating an unruly, autonomous and insurrectionary research agenda, *Energy Res. Soc. Sci.* 103 (103217) (2023) 1–8. Available at: <https://doi.org/10.1016/j.erss.2023.103217>.
- [105] V. Castán Broto, I. Baptista, J. Kirshner, S. Smith, S. Neves Alves, Energy justice and sustainability transitions in Mozambique, *Appl. Energy* 228 (2018) 645–655. Available at: <https://doi.org/10.1016/j.apenergy.2018.06.057>.
- [106] D.W. Gafa, Y.G. Egbendewe, L. Jodoin, Operationalizing affordability criterion in energy justice: evidence from rural West Africa, *Energy Econ.* 109 (105953) (2022) 1–10. Available at: <https://doi.org/10.1016/j.eneco.2022.105953>.
- [107] Y. Malakar, M.J. Herington, V. Sharma, The temporalities of energy justice: examining India’s energy policy paradox using non-western philosophy, *Energy Res. Soc. Sci.* 49 (2019) 16–25. Available at: <https://doi.org/10.1016/j.erss.2018.11.002>.
- [108] Van der Horst, D., Grant, R. J. R., Mejía Montero, A., Garnevičienė, A., (2021) ‘Energy justice and social acceptance of renewable energy projects in the global south.’ In: Batel, S., Rudolph, B., (eds) (2021) *A Critical Approach to the Social Acceptance of Renewable Energy Infrastructures Going Beyond Green Growth and Sustainability*. [online], Palgrave Macmillan. Available at: doi:<https://doi.org/10.1007/978-3-030-73699-6>.
- [109] G. Bombaerts, K. Jenkins, Y.A. Sanusi, W. Guoyu (Eds.), *Energy Justice across Borders*, Springer, Switzerland, 2020, <https://doi.org/10.1007/978-3-030-24021-9> [e-book].
- [110] R. Von Schomberg, A vision of responsible innovation, in: R. Owen, M. Heintz, J. Bessant (Eds.), *Responsible Innovation*, John Wiley, London, 2013, <https://doi.org/10.1002/9781118551424.ch3>. Available from:..
- [111] European Commission, (2020), ‘How to better align scientific research policy with societal values’, Cordis, [online]. Available at: <https://cordis.europa.eu/article/id/421782-how-to-better-align-scientific-research-policy-with-societal-values>.
- [112] MUSICA, Multiple Use of Space for Island Clean Autonomy Blue Growth Solutions [online]. Available at: <https://musica-project.eu/>, 2020.
- [113] B.C. Stahl, K. Chatfield, C. Ten Holter, A. Brem, Ethics in corporate research and development: can responsible research and innovation approaches aid sustainability? *J. Clean. Prod.* 239 (118044) (2019) 1–14. Available at: <https://doi.org/10.1016/j.jclepro.2019.118044>.
- [114] A. Fraaije, S.M. Flipse, Synthesizing an implementation framework for responsible research and innovation, *Journal of Responsible Innovation* 7 (1) (2020) 113–137. Available at: <https://doi.org/10.1080/23299460.2019.1676685>.
- [115] N.E. Matthews, L. Stamford, P. Shapira, Aligning sustainability assessment with responsible research and innovation: towards a framework for constructive sustainability assessment, *Sustainable Production and Consumption* 20 (2019) 58–73, <https://doi.org/10.1016/j.spc.2019.05.002>.
- [116] V. Blok, P. Lemmens, The emerging concept of responsible innovation. Three reasons why it is questionable and calls for a radical transformation of the concept of innovation, in: B.-J. Koops, et al. (Eds.), *Responsible Innovation 2: Concepts, Approaches, and Applications*, Springer International Publishing, Switzerland, 2015, pp. 19–36, https://doi.org/10.1007/978-3-319-17308-5_2.
- [117] S. Jasanoff, Technologies of Humility: citizen participation in governing science, *Minerva* 41 (2003) 223–244. Available at: <https://doi.org/10.1023/A:1025557512320>.
- [118] D. Otto, J. Chilvers, K. Trdicova, A synthetic review of the trust-participation nexus: towards a relational concept of trust in energy system transformations to net zero, *Energy Res. Soc. Sci.* 101 (103140) (2023) 1–10. Available at: <https://doi.org/10.1016/j.erss.2023.103140>.
- [119] A. Capaccioli, G. Pöderi, M. Bettega, V. D’Andrea, Exploring participatory energy budgeting as a policy instrument to foster energy justice, *Energy Policy* 107 (2017) 621–630. Available at: <https://doi.org/10.1016/j.enpol.2017.03.055>.
- [120] A. Stark, N.K. Thompson, G. Marston, Public deliberation and policy design, *Policy Design and Practice* 4 (4) (2021) 452–464. Available at: <https://doi.org/10.1080/25741292.2021.1912906>.
- [121] K. Sykes, P. Macnaghten, Responsible innovation – opening up dialogue and debate, in: R. Owen, J. Bessant, M. Heintz (Eds.), *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society*, John Wiley & Sons, Ltd, 2013, <https://doi.org/10.1002/9781118551424.ch5> [online]. Available at:..
- [122] J. Chilvers, H. Pallett, T. Hargreaves, Ecologies of participation in socio-technical change: the case of energy system transitions, *Energy Res. Soc. Sci.* 42 (2018) 199–210. Available at: <https://doi.org/10.1016/j.erss.2018.03.020>.
- [123] T. Wakeford, J. Sanchez Rodriguez, Participatory action research: towards a more fruitful knowledge, in: *Connected Communities*, Foundation Series, 2018 [online]. Available at: https://ore.exeter.ac.uk/repository/bitstream/handle/10871/36994/Action_Research_SP.pdf?sequence=1&isAllowed=y.
- [124] A. Balkema, A. Pols, Biofuels: sustainable innovation or gold rush? Identifying responsibilities for biofuel innovations, in: B.-J. Koops, et al. (Eds.), *Responsible Innovation 2: Concepts, Approaches, and Applications*, Springer International Publishing, Switzerland, 2015, pp. 283–303, https://doi.org/10.1007/978-3-319-17308-5_15.
- [125] A. Grinbaum, C. Groves, What is ‘responsible’ about responsible innovation? Understanding the ethical issues, in: R. Owen, et al. (Eds.), *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society*, 1st edn, UK, John Wiley & Sons Ltd, 2013, pp. 119–139.
- [126] B.-J. Koops, The concepts, approaches, and applications of responsible innovation: an introduction, in: B.-J. Koops, et al. (Eds.), *Responsible Innovation 2: Concepts, Approaches, and Applications*, Springer International Publishing, Switzerland, 2015, pp. 1–15, https://doi.org/10.1007/978-3-319-17308-5_1.
- [127] C. Voegtlin, A.G. Scherer, Responsible innovation and the innovation of responsibility: governing sustainable development in a globalized world, *J. Bus. Ethics* 143 (2) (2017) 227–243, <https://doi.org/10.1007/s10551-015-2769-z>.
- [128] Responsible innovation in energy projects: values in the design of technologies, institutions and stakeholder interactions, in: A. Correljé, E. Cuppen, M. Dignum, U. Pesch, B. Taebi, B.-J. Koops, I. Oosterlaken, H. Romijn, T. Swierstra, J. van den Hoven (Eds.), (2015) *Responsible Innovation 2: Concepts, Approaches, and Applications*, Springer International Publishing, AG Switzerland, 2015, pp. 183–200, https://doi.org/10.1007/978-3-319-17308-5_10. Available at:..
- [129] Dreyer, M., Chefneux, L., Goldberg, A., Von Heimburg, J., Patrignani, N., Schofield, M., Shilling, C., (2017) “Responsible innovation: a complementary view from industry with proposals for bridging different perspectives.” *Sustainability*, 9(10, 1719), pp. 1–25. doi:<https://doi.org/10.3390/su9101719>.
- [130] B.P. Koirala, E. van Oost, H. van der Windt, Community energy storage: a responsible innovation towards a sustainable energy system? *Appl. Energy* 231 (2018) 570–585, <https://doi.org/10.1016/j.apenergy.2018.09.163>.

- [131] A.D. Setiawan, R. Singh, Responsible innovation in practice: the adoption of solar PV in telecom towers in Indonesia, in: B.-J. Koops, et al. (Eds.), *Responsible Innovation 2: Concepts, Approaches, and Applications*, Springer International Publishing, Switzerland, 2015, pp. 225–244, https://doi.org/10.1007/978-3-319-17308-5_12.
- [132] Mehari, Y., Pekkola, E., Hjelt, J., Cai, Y., Stenvall, J., Ortega-Colomer, F. J., (2022) "Defining 'responsible' in responsible research and innovation: the case of quadruple helix innovation in the energy sector in the tampere region." In: Păunescu, C., Lepik, K-L., Spencer, N., (eds.) (2022) *Social Innovation in Higher Education. Landscape, Practices, and Opportunities*, [online], pp. 199–226. Available at: doi:<https://doi.org/10.1007/978-3-030-84044-0>.
- [133] A. Eizagirre, H. Rodríguez, A. Ibarra, Politicizing responsible innovation: responsibility as inclusive governance, *International Journal of Innovation Studies* 1 (1) (2017) 20–36, <https://doi.org/10.3724/SP.J.1440.101003>.
- [134] E. Fisher, A. Rip, Responsible innovation: multi-level dynamics and soft intervention practices, in: R. Owen, J. Bessant, M. Heintz (Eds.), *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society*, 1st edn, UK, John Wiley & Sons Ltd, 2013, pp. 165–183. <http://www.ambafraunce-uk.org/Franco-British-workshop-on>.
- [135] M. Balmaceda, P. Högselius, C. Johnson, H. Pleines, D. Rogers, V.-P. Tynkkynen, Energy materiality: a conceptual review of multi-disciplinary approaches, *Energy Res. Soc. Sci.* 56 (2019) 1–14. Available at: <https://doi.org/10.1016/j.erss.2019.101220>.
- [136] T. Mitchell, *Carbon Democracy, Political Power in the Age of Oil*, Verso, USA, 2013.
- [137] Nuclear Decommissioning Authority, *Guidance on Technology Readiness Levels*. UK Government [online]. 23 December. Available at: <https://www.gov.uk/government/news/guidance-on-technology-readiness-levels>, 2014. Accessed online: August 2023.
- [138] The Scottish National Investment Bank (SNIB), (2024) 'A Just Transition Putting people first', [online]. Available at: https://www.thebank.scot/sites/default/files/2024-05/SNIB070%20Just%20Transition_0524_FINAL.pdf.
- [139] Doughnut Economics Action Lab (DEAL), (2020), Amsterdam City Doughnut, [online]. Available at: <https://doughnuteconomics.org/stories/amsterdam-city-doughnut>.
- [140] K. Kama, Contending geo-logics: energy security, resource ontologies, and the politics of expert knowledge in Estonia, *Geopolitics* 21 (4) (2016) 831–856. Available at: <https://doi.org/10.1080/14650045.2016.1210129>.
- [141] S. Williams, A. Doyon, Justice in energy transitions, *Environ. Innov. Soc. Trans.* 31 (2019) 144–153, <https://doi.org/10.1016/j.eist.2018.12.001>.
- [142] M.M. Sokolowski, R.J. Heffron, Defining and conceptualising energy policy failure: the when, where, why, and how, *Energy Policy* 161 (2022) 1–10. Available at: <https://doi.org/10.1016/j.enpol.2021.112745>.
- [143] P. Tschakert, More-than-human solidarity and multispecies justice in the climate crisis, *Environmental Politics* 31 (2) (2022) 277–289. Available at: <https://doi.org/10.1080/09644016.2020.1853448>.
- [144] RRI tools, (2024), 'RRI Self-Reflection tool', [online]. Available at: https://rri-tool.s.eu/self-reflection-tool?p_p_id=srtportlet_WAR_SRTservicesportlet&p_p_lifecycle=0&p_p_state=normal&p_p_mode=view&p_p_col_id=column-1&p_p_col_pos=2&p_p_col_count=4&srtportlet_WAR_SRTservicesportlet_mvcPath=%2Fhtml%2Fform.jsp.
- [145] Haudenosaunee Confederacy, (2024), 'Values' [online]. Available at: <https://www.haudenosauneeconfederacy.com/values/>.
- [146] Doughnut Economics Action Lab, (2024), Doughnut Economic Action Lab, [online]. Available at: <https://doughnuteconomics.org/>.
- [147] The Bare Project, *The People's Palace of Possibility* [online]. Available at: <https://thebareproject.co.uk/work/palace/>, 2024.
- [148] D. Barney, Infrastructure and the form of politics, *Can. J. Commun.* 46 (2) (2021) 225–246. Available at: [10.22230/cjc.2021v46n2a3833](https://doi.org/10.22230/cjc.2021v46n2a3833).
- [149] P.A. Sabatier, An advocacy coalition framework of policy change and the role of policy-oriented learning therein, *Policy. Sci.* 21 (1988) 129–168. Available at: <https://doi.org/10.1007/BF00136406>.
- [150] E. Kirksey, S. Chao, Introduction: Who benefits from multispecies justice? in: S. Chao, K. Bolender, E. Kirksey (Eds.), (2022) *The Promise of Multispecies Justice* Duke University Press, Durham and London, 2022.
- [151] M. Ricci, P. Bellaby, R. Flynn, Engaging the public on paths to sustainable energy: who has to trust whom? *Energy Policy* 38 (6) (2010) 2633–2640. Available at: <https://doi.org/10.1016/j.enpol.2009.05.038>.
- [152] J.L. MacArthur, Challenging public engagement: participation, deliberation and power in renewable energy policy, *J. Environ. Stud. Sci.* 6 (3) (2016) 631–640, <https://doi.org/10.1007/s13412-015-0328-7>.
- [153] IEA-OES, Supporting ocean energy technology development and commercialisation: coherence application of guidance standards and certification, in: *Technology Collaboration Programme, 2022* [online]. Available at: <https://www.ocean-energy-systems.org/oes-projects/performance-metrics-international-framework-for-ocean-energy/>.
- [154] InnovateUK, (2018), 'Horizons toolkit', [online]. Available at: https://iuk.ktn-uk.org/wp-content/uploads/2020/08/Horizons_2018.pdf.
- [155] D. Marin, A. Dunlap, R. Roels, *Sacrifice Zones for Sustainability? Green Extractivism and the Struggle for a Just Transition*, European Environmental Bureau, 2023 online.
- [156] OES- Environmental, (2024), 'State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World' [online]. Available at: https://tethys.pnnl.gov/sites/default/files/publications/OES-Environmental-2024-State-of-the-Science-Report_1_0.pdf.
- [157] I. Grant, North Sutherland and Caithness at 'tipping point' with onshore wind turbines. *John O'Groat Journal and Caithness Courier*, [online]. 20 July, Available at: <https://www.johnogroat-journal.co.uk/news/north-sutherland-and-caithness-at-tipping-point-with-onsho-320737/>, 2023.