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A review of dominant sustainable energy narratives

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ABSTRACT

The global energy system is presently unsustainable and, even worse, is on a trajectory moving away from becoming sustainable. Thus, changing the present energy system is crucial, and importantly, it is also a prerequisite for achieving most of the UN's Sustainable Development Goals. We argue that we need sustainable energy narratives to show how we can move towards achieving a sustainable energy system. These narratives are important because they form and legitimize policy and behaviour and can create the necessary momentum for political movement and behavioural change. We present 13 dominant sustainable energy narratives that frequently appear in the scientific literature and have the potential to change the current unsustainable trajectory. The narratives—which can be complementary, competing, or substitutional—fall into three groups. The first group addresses how to satisfy human needs, the second addresses how to ensure social justice, and the third addresses how to respect environmental limits. Narratives from all three groups are needed to achieve a sustainable energy system. We also discuss avenues for further research, including downscaling the dominant narratives to local narratives, analysing the interactions among narratives, creating meta-narratives, and incorporating the narratives into the literature on the transition to a sustainable energy system.

> 'A safe and sustainable energy pathway is crucial to sustainable development; we have not yet found it.'- *Our Common Future*, World Commission on Environment and Development (1987) [1], p.15]

1. Introduction

In the current global energy system, environmental limits are regularly exceeded [2], basic energy needs are not satisfied for many [3], and energy justice is not ensured for everyone [4]. In essence, the energy system is unsustainable, and even worse, it is on a trajectory to remain unsustainable [5]. This understanding has prompted the UN to launch 17 sustainable development goals (SDGs), one of which (SDG 7) portrays a world where affordable, reliable, sustainable, and modern energy services are universally accessible to all by 2030 [6]. Sustainable energy is by no means exclusively relevant for SDG 7. Rather, a recent study suggests that changing the present unsustainable energy system is a prerequisite for achieving *all* of the SDGs [7]. Specifically, the study identifies 113 of the SDGs' 169 targets that require actions to change the energy system. Thus, changing the present energy system is at some level more fundamental than achieving the individual SDGs.

But what exactly does sustainable energy mean? The short answer is, 'it depends'. It depends on what you mean by sustainable, on how you define energy, and on who you think should take the lead in the sustainable energy transition. The long answer is more complicated and must address three questions: (1) *Where* do we want to go? (2) *Who* is involved in a sustainable energy transition? And (3) *How* do we achieve sustainable energy?

To answer the first question, we must start with defining the core concepts of 'sustainable development' and translate them into the energy system. Therefore, a basic premise for this discussion is that a clarification of these core concepts is necessary *prior* to any larger discussion of sustainable energy. The easy answer to the second question is that many people will be involved, but key agents must lead. These agents should be empowered with the necessary authority (and resources) to take actions to drive change. To answer the third, we present a set of sustainable energy narratives, where a narrative is defined as 'a (short) well-written, trustworthy story of what we need to do to achieve a something or solve a problem. A narrative typically has five parts: setting, moral, plot, character, and resolution' [8], p.4, [9, 10]. The

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setting here is the energy system, the moral is sustainable development, the plot is to change the present unsustainable energy system, the character is the key agent or agents, and the resolution is the set of strategies and actions needed to solve the challenges posed by plot. References to narratives are becoming more common in energy and climate change research and policy, which is consistent with the more general 'narrative turn' in social sciences [11].

Narratives are not merely neutral descriptions. Dominant narratives capture how stories and rhetoric 'coalesce into stable meaning systems, institutional practices, and power structures that can constrain or shape agency' [12], p.30]. A dominant narrative can also legitimate the diffusion of, say, a specific large-scale energy technology [13,14]. Thus, narratives are important because they form and legitimize policy and behaviour, and can create the necessary momentum for political movement [15] and changes in behaviour [16]. These narratives can be *complementary* (each focusing on different sustainable energy imperatives), *competing* (each claiming to be the best solution to an imperative), and *substitutional* (each reducing the prospect of the other). They all belong, however, to the wider set of narratives that make up the sustainable energy literature and therefore deserve attention here.

It is important to stress that, for the energy sector to substantially contribute to achieving sustainable development, the individual narratives presented here must be combined to achieve the scale needed for action in the future and to implement a set of larger narratives (meta-narratives) that will meet society's requirements for sustainable energy. The underlying argument we make is that all agents must engage in coordinated actions on a scale and with a sense of urgency exceeding anything that has been done in the past. Moreover, the narratives we present in this paper form a basis for a richer discussion on how to enhance policy coherence for sustainable development in the energy sector.

Our specific objectives are as follows. (1) Show that a sustainable energy is part of a system that must cover all of three main imperatives of sustainable energy: satisfying human needs, ensuring social justice, and respecting environmental limits. (2) Show that the literature contains a variety of ways (i.e., narratives) to achieve sustainable energy, some of which are conflicting. Our goal is not to rank the narratives' credibility. Rather, it is to review the literature and present the dominant narratives. (3) Suggest avenues for further research as how to achieve a sustainable energy system.

The paper is structured as follows. Our methodology and terms are briefly discussed in Section 2. In Section 3, we discuss the core concepts needed to understand and define sustainable energy, including sustainable development, the energy system, the imperatives of sustainable energy, and key agents for facilitating change. We then present the dominant sustainable energy narratives in Section 4 and suggest lines of additional research in Section 5.

2. Methodology

We used a two-stage methodology. The first stage is a theoretical synthesis of the core concepts of sustainable energy. We present the core concepts that any discussion of sustainable energy must consider: sustainable development, the energy system, sustainable energy imperatives, and key agents (Section 3). We then present a conceptual framework within which the relevant sustainable energy narratives can be found.

The second stage is a review of the dominant sustainable energy narratives found in the literature (Section 4). The literature makes several distinctions within and between related terms such as 'stories', 'storylines', 'storytelling', 'discourse', and 'narratives' [11]. We prefer the term narratives, which is often used to denote 'what institutions [broadly defined] generate and reflect in general discourse about an issue' [11], p.3]. Broadly speaking, in our case, this is what people think we should do to achieve sustainable energy. That said, we agree with Riessman [17], who said that the distinctions between the terms are of minor practical importance and that they to a large extent can be used interchangeably.

It is important to note that the second stage is a *narrative* literature review, which 'synthesizes evidence familiar to an author on a given topic or theme' [12], p.23]. Thus, we do not provide detailed pathways towards a sustainable energy system, although a description of the policies, measures, behaviour changes, and business models and strategies related to these detailed pathways will be required. Here, we argue that narratives create momentum for change and are thus necessary but not sufficient conditions for change. We do not attempt to make a full assessment whether they are complementary, competing, or substitutional. We do, however, frequently (admittedly unsystematically) discuss the ranking and credibility of narratives as well as relevant policies and measures.

This review covers the *dominant* narratives found in the scientific literature. They are dominant in the sense that they frequently appear in the literature and have the potential to make a difference. Each narrative provides a story of how to achieve a particular imperative (in some cases several imperatives) and represents an archetype that has some primary characteristics that separate it from the other narratives. For example, the main characteristic of the narrative 'Renewables' is that it is based on renewable energy sources, which distinguishes it from the narratives 'Clean Fossil [fuels]' and 'Negative Emissions [technologies]'. Moreover, within each narrative, there can be several partial solutions—technological or other—that all share that same characteristic. For example, wind power, concentrated solar power, and algae-based biofuels all belong to the renewable narrative. Covering all of the partial solutions within each narrative is beyond the scope of this paper, but we provide examples to illustrate them.

Our data source is peer-reviewed articles, books, book chapters, and scientific reports spanning a variety of disciplines, including engineering, economics, sociology, and political science. The field is so wide that an exhaustive review is impossible, and some narratives may have been missed. Moreover, it is likely that other authors would have created a different set of narratives and used a different methodology for identifying them. Nonetheless, the narratives presented here are firmly anchored in basic concepts that should be the point of departure for any discussion of sustainable energy. Moreover, they provide good coverage of the current state of sustainable energy research. That said, we have deliberately avoided giving too many details in, for example, presenting the nuances of moral philosophy, covering the complexities in development studies and biodiversity conservation, or giving in-depth descriptions of energy systems and technologies. These details can, however, be found in the references cited in the review.

3. The core concepts

In this section we present the core concepts that any discussion of sustainable energy must consider: sustainable development, the energy system, sustainable energy imperatives, and key agents.

3.1. Sustainable development

Any conceptual understanding of sustainable energy requires a clear understanding of sustainable development, but two clarifications are necessary to begin this discussion. First, sustainable development and sustainability are not used interchangeably by all scholars. There are those who take the position that sustainable development prioritizes development whereas the core of sustainability is about the environment [e.g., [18]. Others have stated that sustainability refers to a goal and sustainable development is about the process that guides us to sustainability [e.g., [19]. Because these terms mainly express the same idea and have the same policy implications, we use them interchangeably. Second, we use the 1987 UN report from the World Commission on Environment and Development, *Our Common Future* [1], as the starting point for a definition of sustainable development. Notwithstanding the

recently adopted UN Sustainable Development Goals (which we believe are a tremendous political success), the 1987 report 'declared' the concept and provided global society with the authoritative definition of sustainable development. Thus, the content of sustainable development has been derived from what has been theorized and practically invoked from that declaration. Nothing, in our opinion, has changed the status of *Our Common Future* as the ultimate declaration of the ethical statement of sustainable development.

We have previously discussed the different interpretations of sustainable development [20–23]. We will not repeat that discussion here, but we do refer to our definition of the three imperatives of sustainable development: satisfying human needs, ensuring social justice, and respecting environmental limits [22]. To refine the definition of sustainable development, we also need to specify the themes that give substance to the imperatives. Holden et al. [22], p.26] stated, 'Some of the vagueness that many scholars have attributed to the concept of sustainable development results from wanting it to cover everything that is good and desirable'. It is very important, therefore, to rank these themes according to their importance. In our scheme, *key* themes are fundamental in achieving sustainable development and any actions that do not address a key theme are considered insufficient [22]. Secondary themes are important but subordinate.

We use two criteria to identify key themes [22]. First, the themes must be derived from theory. These theories should draw on philosophical texts about needs and justice, as well as on new scientific insights about environmental limits. Holden et al. [22], p.26] explained, there must be 'an ethical-theoretical rationale for identifying the themes, not a political-feasibility rationale'. Second, we only include the most important themes from the relevant theories. Table 1 shows the sustainable development imperatives (SDIs) and their key sustainability themes.

3.2. The energy system

In physics, energy is defined as the capacity for doing work, but this definition is not very helpful in this context. Thus, we use the concept of an 'energy system', which consists of two separate sub-systems: the energy supply system and the energy demand system [24].[1]

The energy supply system includes all parts that convert primary energy (such as coal, natural gas, and crude oil) to final energy (such as electricity, methane, and gasoline). The 'supply parts' include extraction and treatment of primary energy, conversion technologies, secondary energy, and distribution technologies.

The energy demand system includes all parts that convert final energy to end-use services (such as cooking, lighting, and mobility). The 'demand parts' include various end-use conversion technologies such as furnaces, light bulbs, and automobiles. To be consistent with the terms and concepts frequently used in the literature, we refer to these two sub-systems as *energy production* (the energy supply system) and *energy consumption* (the energy demand system).

The sub-systems should not be treated in isolation. Changes in one part of the system affect other parts, and a system perspective is crucial to understanding the practical complexity of the energy system and the mutual dependence of its separate parts. Effective intervention strategies to achieve sustainable energy must acknowledge this perspective. Moreover, it is now common to include the *actors* (or agents) as part of the energy system, such as organisations, networks, and institutions, thereby leading to a whole system approach to energy transition [25–27]. We discuss the agents in Section 3.4. The narratives include both energy sub-systems and the agents, and correspond to the whole system approach.

Table 1
The sustainable development imperatives (SDIs) and their key sustainability themes [22].

Sustainable development imperative	SDI-1: Satisfying human needs	SDI-2: Ensuring social justice	SDI-3: Respecting environmental limits
Key sustainability themes	• Eradicating extreme poverty • Enhancing human capabilities	• Ensuring rich participation • Ensuring fair distribution[a]	• Mitigating climate change • Safeguarding biosphere integrity

[a] Fair distribution should not be confused with distribution aspects of the energy supply system, such as electricity grids, pipelines for oil and gas, or trucks.

[1] The systems are not necessarily separate: a household or enterprise that generates electricity by using solar photovoltaic panels is part of both systems.

3.3. The imperatives of sustainable energy

A sustainable energy system must satisfy three elements: meeting energy needs, ensuring energy justice, and respecting environmental limits (Fig. 1). The three sustainable energy imperatives (SEIs) and six themes shown in Fig. 1 correspond to the similarly named SDIs and sustainability themes presented in Table 1.

The right side of Fig. 1 implies some sort of correspondence between the imperative of satisfying energy needs and energy consumption. We all need to consume energy in different forms to satisfy our needs for housing, transport, and food. Likewise, there seems to be a correspondence between the imperative of respecting environmental limits and energy production (the left side of Fig. 1) because the production of energy leads to transgressing the core boundaries of the key sustainability themes and therefore fails to respect environmental limits. For example, producing fuels from coal, crude oil, or natural gas inevitably leads to emissions of greenhouse gases, independent of how, where, or why the fuel is consumed. Similarly, the use of land to produce electricity from renewable energy sources leads to a loss of wildlife and harms biosphere integrity.

The imperative of ensuring energy justice is more complicated. Amartya Sen reminds us that justice is closely related to equality [28]. Thus, every normative theory of social justice demands equality in *something*, for example, access to energy consumption. That something, however, could also be the benefits and burdens of energy production, such as income from production facilities, emissions from coal power plants, and the loss of natural areas from wind power plants. Thus, the imperative of energy justice cuts across both energy consumption and energy production (both sides of Fig. 1).

The relationships between the sustainable energy imperatives and the energy system are more complicated and interrelated than shown in this simple representation. It is difficult to create exclusive one-to-one relationships between an imperative and a part of the energy system in part because the imperatives are closely related. For example, injustice (i.e., not having a fair share of energy resources) is interlinked with poverty (i.e., not having energy needs satisfied) and environmental degradation (i.e., energy production that does not respect environmental limits). Indeed, a world in which poverty and injustice are endemic will always be prone to ecological and other crises. Moreover, as a system approaches its ecological limits, poverty and inequalities will increase and competition for non-renewable raw materials, land, or energy can create tension [1]. In addition, energy production and consumption are closely related. If everyone consumed less energy, less energy could be produced (and vice versa). How we decide to split the (energy) cake might well affect both production levels and consumption patterns. The concept of 'prosumers' (described later) links energy production and consumption.

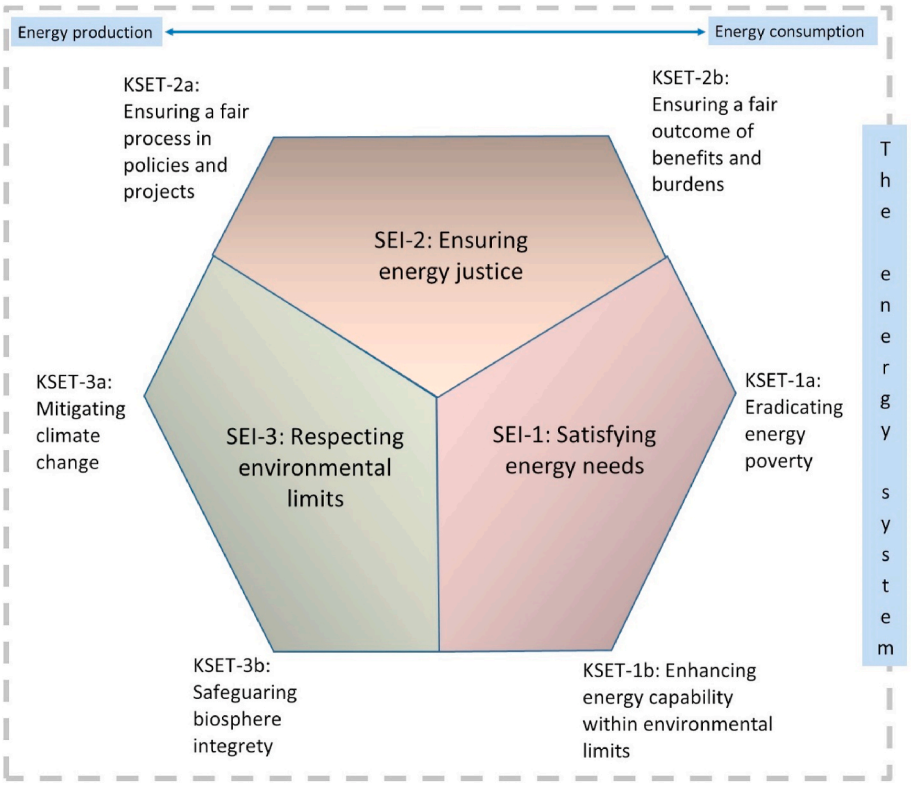

Fig. 1. Sustainable energy imperatives (SEIs) and key sustainable energy themes (KSET) for a sustainable energy system. The imperatives and themes correspond with the sustainable development imperatives (SDIs) and themes shown in Table 1.

3.4. Key agents

Although clear sustainable energy imperatives are important, someone must take the lead to act on those imperatives. A single agent may not have either the responsibility, opportunity, or the ability to implement an imperative, so it is vital to form strategic alliances and align interests among the agents [29]. Even though agents across many levels must contribute, someone must *take the lead*. We call these key agents, and they have the resources and power to begin to drive necessary changes forward [8].

We draw on Dryzek's framework of environmental discourses [30], which we discuss in Holden et al. [8], to categorize key agents. In brief, Dryzek presents three dominant (and competing) discourses. Solutions are coordinated through bureaucracy corresponding with the discourse of administrative rationalism, democracy (democratic pragmatism), and markets (economic rationalism) [8]. Here, we specify firms as the third main agent rather than the market [8]. In addition, our typology also aligns with those presented in other studies in which the following main agents can activate (green) transformation: public agents (the experts: politicians and bureaucrats), civic agents (the people), and private agents (the firms) [31–34].

4. Dominant sustainable energy narratives

In this section, we present 13 dominant sustainable energy narratives. Although most of them typically focus on a single key theme and on an isolated part of the energy system, some cross over imperatives, themes, and parts of the energy system. Their conceptual simplicity can conceal some of the substantial grey areas among the narratives. Although the resolutions and characters differ, they all share a common plot: to change the present unsustainable energy system. The setting for all sustainable energy narratives is the energy system as described in Section 3.2. The moral is the three SEIs and the corresponding key themes described in Section 3.3. The narratives are categorized by SEI and are shown in Fig. 2.

4.1. SEI-1: Sustainable energy must satisfy human needs

At the most fundamental level people must have their basic needs satisfied, such as food, shelter, and security [35–37], all of which require access to some form of energy. Moreover, access to energy is essential to almost all challenges and opportunities globally. Unfortunately, almost 1 billion people—13% of the global population—live without electricity, 50% of which live in Sub-Saharan Africa [38]. Lack of access to energy it not only a problem for developing countries though. The EU Survey on Income and Living Conditions estimated that 54 million European citizens (10.8% of the EU population) could not adequately heat their homes in 2012; a similar number were late in paying utility bills [39]. All of these people are considered to be energy poor.

There is, however, more to life than merely having the basic needs satisfied. Sen argues that seeing people's needs only in terms of basic needs gives a 'rather meagre view of humanity' [28], p.250] and that a 'richer' view is called for. A point of departure for a richer view is the capability approach [40–45]. Sen uses the concept 'basic capabilities', which is defined as 'the ability to satisfy certain elementary and crucially important functionings up to certain levels' [46], p.45]. Nussbaum [41], p.84] refers to basic capabilities as 'the innate equipment of individuals that is necessary for developing the more advanced capabilities'. In part, the concept refers to the opportunity not only to avoid poverty but also to meet or surpass a threshold of well-being [47].

At some point, however, the imperative to satisfy capabilities in terms of providing necessary energy runs up against the imperative of respecting environmental limits. *Our Common Future* acknowledged three decades ago that 'living standards that go beyond the basic minimum are sustainable only if consumption standards everywhere have regard for long-term sustainability. Yet many of us live beyond the world's ecological means, for instance in our patterns of energy use' [1], p.44].

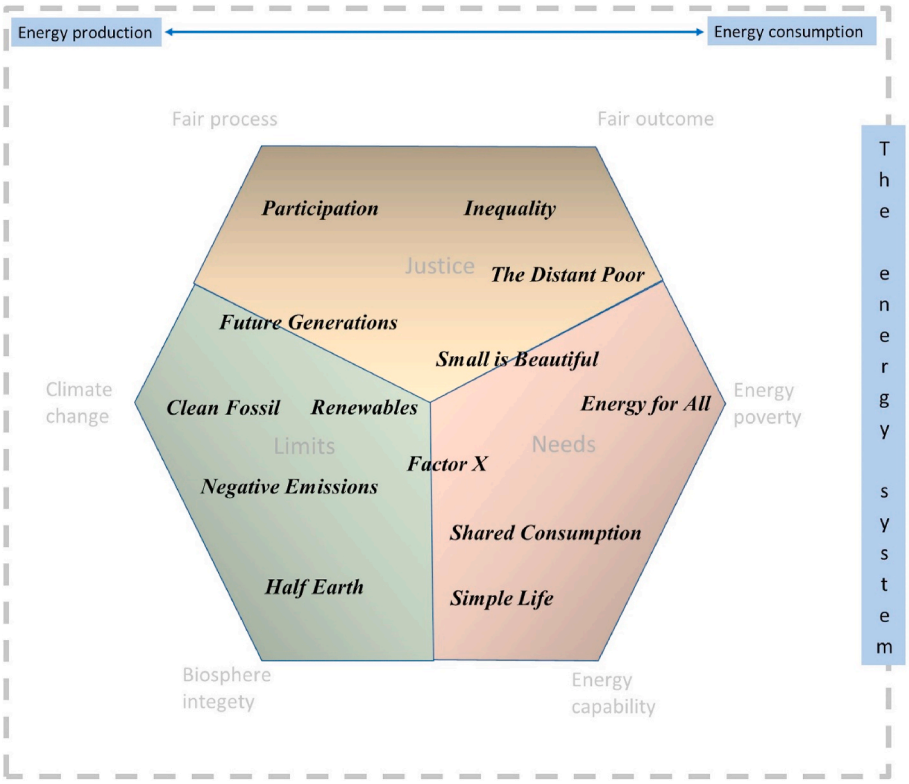

Fig. 2. The sustainable energy narratives placed in the context of the sustainable energy imperatives (justice, needs, and limits), key sustainable energy themes (shown outside of the hexagon), and the energy system. The imperatives and themes correspond with the sustainable development imperatives and themes shown in Table 1.

The literature suggests three main change strategies to maintain the environmental impacts of energy consumption within environmental limits: improve, shift, and avoid [See [48] for different approaches]. In everyday language, this means consume efficiently, consume differently, or consume less. Each of these strategies is at the core of the separate sustainable energy narratives. There are five narratives in this imperative. The first two relate to eradicating energy poverty and enhancing capabilities, and the latter three relate to maintaining those capabilities within environmental limits.

4.1.1. *Energy for All*

Eradicating energy poverty implies providing universal access to enough energy in general and electricity in particular. Such access could probably only be achieved through a more just global distribution of wealth and resources. Those who presently think that the world is heading in the wrong direction in this respect could perhaps find comfort in the words of Martin Luther King Jr.: 'The arc of the moral universe is long, but it bends towards justice'.

The key to universal access is in strengthening the grid to supply electricity to energy-poor people and settlements. However, blackouts and brownouts remain frequent even in grid-connected settlements, leaving communities dependent on expensive, polluting diesel generators. Thus, there is a need to develop on-site renewable energy solutions that can supply energy-poor areas and people with low-cost, reliable electricity [49]. Solar power is one potential solution, including stand-alone systems with battery banks and larger solar parks. These solutions have the additional benefit of creating an enduring economic asset for the host communities.

The key agents here are international institutions such as the UN, with economic and technological support from national politicians and bureaucrats.

4.1.2. *Small is beautiful*

In the aftermath of the 1973 energy crisis, the seed to a new narrative emerged. In his influential book, *Small is Beautiful*, Ernst Friedrich Schumacher made a harsh critique of Western societies' enthusiasm for centralisation, large-scale technologies, and exponential economic growth [50]. Schumacher's alternative was one of 'enoughness', appropriate use of small-scale technologies, self-sufficiency, and decentralized and small-scale village-based economics. The Small is Beautiful narrative shares many of the resolutions of the Energy for All narrative but differs in the sense that the former focuses on developed countries whereas the latter focuses on developing countries.

Several concepts in this area have been inspired by Schumacher's thinking (but not necessarily his political views). One emerging trend is to highlight the importance of resilience, such as in 'Transition Towns'. The core principle in these towns is to actively shift from oil dependency to the creation of local resilience [51] where communities are able to cope with shocks. The creation of local support structures (e.g., renewable energy) helps communities become more independent of centralized systems (e.g., fossil fuels) [52,53].

Another offshoot is the increasing numbers of 'prosumers', a term coined by Alvin Toffler in the early 1980s [54] encompassing people who produce their own goods (including energy) rather than purchasing them. The idea of the prosumer is actually primordial [55] and has ties to the traditional field of microgeneration [56]. Novel developments within the energy system, such as cost reductions for photovoltaics and batteries and incentives for environmentally friendly technologies, have led to a revival in its relevance. Thus, it is likely that prosumers will produce a greater share of electricity in the future energy system [57].

Two main barriers for the Small is Beautiful narrative are a lack of new business models and immature regulatory frameworks. Nevertheless, various forms of grassroot movements constitute the driving force of this narrative, which consequently place it in the realm of the people as the key agents.

4.1.3. Factor X

The essence of this narrative is elegantly captured in the 1998 book, *Factor Four*: *Doubling Wealth—Halving Resource Use* [58]. The authors of this book seek to increase resource productivity by a factor of four, which means that the world could enjoy twice the wealth that is currently available, while also cutting the stress placed on our natural environment in half. The book contains a wealth of examples of revolutionary technologies that could deliver the necessary efficiency improvement, such as ultra-fuel-efficient cars, low-energy homes, electronic books, and low-energy beef. The International Energy Agency (IEA) speaks about choosing 'the first fuel' [59], which is not a fuel in an ordinary sense but a reminder to not use fuel at all. In addition, according to the IEA, greatly improving energy efficiency across a wide range of fields will be the most important element leading the world towards sustainable development.

The 2009 book *Factor Five* examined the impact of recent industrial and technical innovations as well as policy developments [60]. *Factor Five* shows that it is possible to achieve 80% improvements in resource and energy productivity in buildings, industry, agriculture, food and hospitality, and transportation. More than merely possible, the book argues, increased efficiency is absolute necessary.

New technology is at the centre of this narrative (actually, several studies place technology *itself* as the main change agent [e.g., [61]). Clearly, there are several agents involved in this narrative. Politicians and bureaucrats implement regulations and incentives, firms commercialise new technologies, and green consumers buy them. But, is there a *key* agent here? Most likely, it is the consumer because they give legitimacy to the politicians' regulations and incentives, and they purchase the energy-efficient products that make green firms profitable.

4.1.4. Shared Consumption

This narrative questions the viability of the sharp increase in energy efficiency suggested by Factor X. According to the IEA, improvements in the amount of energy used per unit of economic activity (i.e., the energy intensity) of the global economy are slowing. The 2018 improvement rate in energy intensity of 1.2% was the slowest since the start of this decade and is far below the 3% rate that would be needed to help achieve sustainable energy goals [59].

There are at least two types of consumption shift strategies. The first dates back to the 1994 Oslo Symposium and stresses the need to change consumption patterns. The new patterns should shift consumption towards services and away from products, for example, to arts and movies and away from cars and refrigerators. However, services are increasingly becoming more energy-intensive, and advanced services heavily depend on products (e.g., streaming of a Netflix series requires a computer, a power grid, power plants, etc.). Local products, on the other hand, could be environmentally friendly. Thus, the distinction between products and services no longer seems entirely relevant.

The key word in the second type of shift is sharing. Although the sharing economy has the potential to create just and more sustainable societies, it is an open question whether and how that potential can be achieved [62]. Still, the sharing economy has some characteristics that are relevant for Shared Consumption: platform-based collaboration, peer-to-peer interaction, the emphasis on access instead of ownership, and making better use of idle capacities and under-utilized resources [63]. An energy system based on these characteristics can lead to lower environmental impacts and secure access to energy services that are currently unavailable to less affluent people.

Although regulatory frameworks and incentives will be needed, the key agents in this narrative are the market and the public. Businesses must develop feasible business models, and people must alter their current preference for private ownership and an insatiable desire for new products.

4.1.5. Simple life

Proponents of the Simple Life narrative argue that we must go beyond Factor X and Shared Consumption because neither of them would deliver the necessary reductions in emissions and resource use. We simply must undergo a transition to a society that consumes less energy and energy-intensive products.

There are several parallel and overlapping movements and research perspectives related to such a transition, including those related to degrowth [64], downshifting [65], voluntary simplicity [66], a simple life [67], sufficiency [68], and ecological economics [69]. Although these perspectives have differences, all of them share the common idea that we must reduce the level of consumption. A key question for all of them is under what circumstances will a transition appeal to broader groups in society. For example, how and when practices related to degrowth and downshifting would be perceived as socially acceptable, rather than instantly disregarded by a large group of people as merely being associated with 'tree huggers' [52].

Another key question is who could possibly initiate such a bold and ambitious transition. There is no easy answer to this question, but it is possible to see two ways forward. The first is to follow Thomas Hobbes' suggestion of a social contract between the state and the people and then let the almighty and ruthless Leviathan (i.e., the state) rule by an absolute sovereign [70]. Hobbes wrote that civil war could only be avoided by a strong undivided government. It is possible that we are now in what can be thought of as a 'state of war' with climate change and that we need strong governmental command-and-control policies, such as prohibitions, standards, and regulations.

However, Hobbes may have overlooked an important thing—morality [71]. Talcott Parsons said that members of a society share common norms and values [72], and emphasized that these are crucial to solving problems. They ensure that people's lives are not, as Hobbes portrayed it, 'nasty, brutish, and short'. This way of thinking is behind the global ethic in *Our Common Future*, which ultimately rests on people's sense of sustainability [22] and means that people are the key agent for change.

4.2. SEI-2: Sustainable energy must ensure social justice

Social justice is about distribution and boils down to two questions: 'who gets what?' and 'says who?' [71]. These questions correspond to the issues of justice as outcome and justice as opportunity in moral philosophy [28,71,73–76]. A third question, 'How to ensure justice?' is concerned with the formal policies, procedures, and legal framework that operationalize the answers to the first two questions (whatever they may be).

The first question is about *distribution* and concerns how we should divide the cake into shares. We have no intention of quantifying those shares here, but we do want to stress that there are benefits (such as access to energy and income from specific energy projects) as well as burdens (such as emissions and loss of land and biodiversity) to consider. A consideration of these benefits and burdens runs through all of the sustainable energy justice narratives.

The second question is about *opportunity* and concerns who should sit at the table when the benefits and burdens are being distributed and who should count as relevant moral subjects entitled to a share of those benefits and burdens. Our position echoes that of *Our Common Future* [1], which states that sustainable development must ensure justice between generations (intergenerational justice) as well as within each generation (intragenerational justice). Moreover, at a minimum, sustainable development must not endanger the natural systems (e.g., water, soils, and the atmosphere) that support life on Earth. Thus, a sustainable energy distribution (and sustainable development in general) must include the voice of those immediately affected by a specific energy development or policy, but it must also consider subjects with low or absent voices. Consequently, there are four groups whose benefits and burdens should be considered: local communities directly affected by an energy project or policy, the distant poor, future generations, and non-human animals and nature [77].

This imperative has five narratives. Environmental justice theories and movements [78] serve as an inspiration for the first two through the concept energy justice, a relatively recent item on the social science research agenda [79]. This agenda seeks to apply justice principles to relevant agents in various parts of the energy system. It primarily has a community focus in the sense that it assesses the benefits and burdens of people immediately affected by an energy development or energy policy. The other three narratives focus on subjects with low or absent voices.

4.2.1. Participation

In terms of opportunity, energy justice may be deemed fair because the *process* for creating benefits or causing burdens by the government or private individuals is considered fair. Energy justice understood as a fair process has three tenets: formal, procedural, and recognition [77,79,80]. Formal justice is 'a system of publicly declared laws, supported by sanctions or punishments and the social institutions (courts, prisons, and a supporting bureaucracy) that are essential to them' [77], p.11]. A requirement of formal justice is that 'the state should operate as a kind of umpire, guarding citizens against interference in their liberties and protecting their contracts' [77], p.11]. Formal energy justice implies that the development of, for example, a wind park operates within the prevailing legal framework for licencing applications, any relevant planning and building requirements, and any relevant laws that apply to wind parks.

Procedural justice concerns access to, inclusion in, and influence of decision-making processes at all levels, and also includes 'softer' non-regulatory influences such as practices, norms, values, and behaviours [81]. Relevant mechanisms of inclusion in decision-making processes are through local knowledge mobilization, greater information disclosure, and better institutional representation [79]. Procedural energy justice implies that the development of a wind park includes the local knowledge of affected indigenous communities, transparent public hearings throughout the planning process, and a representation of minorities' interests.

Recognition-based justice considers the sections of society that are ignored or misrepresented. Recognition-based injustice appears as cultural and political domination and various forms of degradation, including insults and devaluation. Misrecognition also occurs, in two primary forms: non-recognition and disrespect [79]. Recognition-based energy justice implies 'the recognition of the specific needs of particular social groups, such as the elderly, infirm, and chronically ill' [79], p.181]. Moreover, it prevents developers and investors from deriding 'local campaigns against, for example, wind farms as "not-in-my-back-yard" (NIMBY) protests by self-interested and misinformed individuals' [79], p.181]. The key agents are discussed in the next narrative.

4.2.2. Inequality

Energy justice understood as a fair outcome (distribution) recognizes that energy needs to be included within the list of things that we value and acknowledges that benefits (e.g., income) and burdens (e.g., loss of biodiversity) resulting from producing or consuming energy are limited resources. Sovacool proposed that, 'how we distribute the benefits and burdens of energy systems is pre-eminently a concern for any society that aspires to be fair' [82].

What, however, is a fair distribution of benefits and burdens? Principles that have been proposed include that they should be distributed absolutely equally, according to need, and in proportion to merit or desert [77]. Each of these three principles, when applied to energy, can deliver absurd outcomes, equivalent to suggesting giving an equal amount of food to new-born babies and fully-grown adults. We need a better principle, and the 'difference principle' of John Rawls looks promising. This principle (the first part of the second of his two famous principles) requires that social institutions be arranged so that any inequalities of wealth and income work to the advantage of the least-advantaged members of society (as compared to their state under strict equality). In energy terms this means that we can accept inequalities in benefits and burdens if those inequalities maximize the benefits for the most disadvantaged (e.g., indigenous people) and minimize the burdens for the worst affected (e.g., people living close to a wind farm).

Energy justice includes the goodwill of all agents. Nevertheless, it is governments and their experts that draw up the level playing fields needed for this narrative, and thus they are key agents in this respect.

4.2.3. The distant poor

If anything, sustainable development is a call for bettering the conditions of the distant poor. This narrative is based on an ethic of global citizenship, which includes justice for not only the unfortunate person who lives under a windmill but also for the hungry girl on the other side of the world. She too depends on access to energy to satisfy her basic needs, and she too depends on ensuring participation and fighting inequality.

The difference between community energy justice (presented in previous two narratives) and justice for the distant poor is one of focus. The focus in this case is on the world's poor in developing countries rather than on the underprivileged in developed countries. It has been studied in academic disciplines such as development studies [e.g., [83] and human security [e.g., [84]. Whereas the former emerged as an academic discipline in the second half of the twentieth century in large part due to increasing concerns about economic prospects for the third world, the latter emerged more recently and argues that the foundation of security should be at the human level, not the national level. The United Nations Development Programme's yearly *Human Development Report* is considered a milestone publication in the field of development studies and human security.

The governments of the developed countries are the key agents in this narrative not only because they possess the necessary resources that poor countries need to satisfy basic capabilities, but because they have a moral responsibility to do so. This implies a redistribution of resources and a deployment of energy technologies in developing countries.

4.2.4. Future generations

Well-being and justice for future generations play a critical role in the vision of sustainable development articulated in *Our Common Future,* which states, 'the results of the present profligacy [remember this was 30 years ago] are rapidly closing the options for future generations' [1], p.8]. Three decades later, conditions have certainly not improved, but why should we care for future generations?

There are at least two reasons we should care. First, formal justice requires impartiality. The idea that it is wrong for an individual to make an exception of themselves can easily be extended to the principle that it would be wrong for one generation to privilege itself, leaving nothing for future generations [77]. Second, there is responsibility. We agree with Edith Brown Weiss [85] who said that we hold the Earth in trust for future generations, and trust implies responsibility.

There are three conservation principles involved [77]. Conservation of *options* means not closing options for future generations, for example, by making irreversible changes to the climate, biodiversity, or the non-renewable resources stock. Conservation of *quality* means to preserve and protect things necessary for the survival of future generations, including clean air, water, and soil. Conservation of *access* means to balance justice requirements between and within generations, for example, to avoid environmental conservation programmes that would benefit future generations generally but whose burdens weigh most heavily on the poorest countries in the present. Taken together, these principles strongly favour shifting the current high-volume, fossil--fuel-based energy system to one characterised by increased energy efficiency in all sectors and increased deployment of renewable energy sources.

Who could possibly speak for the future generations? Today's decision makers do not seem too keen to do so, probably because most of

them 'will be dead before the planet feels the heavier effects of acid precipitation, global warming, ozone depletion, or widespread desertification and species loss' [1], p.8]. Future generations, on the other hand 'do not vote; they have no political or financial power; they cannot challenge our decisions' [1], p.8]. A way forward means being 'conscious of the connectedness of past and future and the pointless ephemerality of a one-generation view' [77], p.20]. In this narrative, we must think about partnerships not only between the living, but also between the living and those who have yet to be born [86]. A possible key agent is an ombudsman, that is, an official who is charged with representing the interests of future generations.

4.2.5. *Half earth*

Climate change and human land-use change represent major threats to non-human animals and nature, that is, to biodiversity [87,88]. But why should we care for non-human animals and nature? An obvious reason is that we heavily depend on the services that animals and nature provide (e.g., air, food, materials, and water). It is thus in our own interest to care for them because they are instrumental to our survival. Alternatively, we could care for animals and nature simply because they matter; that is, they have intrinsic value and should therefore be protected.

There are other reasons as well. We are much more powerful than other species, so we have responsibility towards them as a form of stewardship [18], and responsibility implies we must be concerned for their welfare. We also agree with the English philosopher Jeremy Bentham [89] in that the relevant question to ask for the moral significance of animals is not, 'Can they *reason* or *talk*?' but 'Can they *suffer*?' Yes, animals can suffer, and they are therefore included in our moral universe, which ultimately means that their welfare matters.

In the book *Half-Earth*, the biologist Edward O. Wilson suggests a way forward [90]. He argues that we can only save the living part of the environment (i.e., safeguard biosphere integrity) and achieve the stabilization required for our own survival by setting aside at least half the planet in reserve.[2] Wilson argues that increasing the amount of suitable habitat is the crucial factor in the life and death of species. Importantly, the way to achieve this already exists—using the protected-area system that most countries already have. Although the coverage of these areas is slowly increasing from the current rates (a little less than 15% of land area and 2.8% of ocean area), it is not sufficient to stop the acceleration of species extinction. Wilson insists that we aim much higher—we need to reach at least 50% to ensure that life on Earth enters the safe zone. In addition, these protected areas must include 'hot spots' where the largest number of endangered species exist. Human intervention will be necessary in some of the protected areas because they are so degraded that their original life must be restored. Restoration ecology will therefore be a necessary element in the Half-Earth narrative.

Protecting half of the land and sea is not enough though. We simultaneously need to halt rising population and reduce the ecological footprint of individuals. Increasing education and gaining some degree of social and financial independence for women would reduce average fertility and eventually population. Decoupling economic activity from material and environmental throughputs would reduce human's ecological footprint. Wilson has hopes for the evolution of the free market system and the way it is increasingly shaped by new technology. He argues that the 'brn' (biology, nanotechnology, and robotics) industries have the potential to reduce ecological footprints and thus safeguard biosphere integrity (although he acknowledges that they could also destroy it).

Who will speak up for the insects, the birds, and the trees as we construct our powerplants, hydropower dams, and wind parks? Only a government backed by voters who care can do that. In time, perhaps Bentham will be proved right: 'The time will come when humanity will extend its mantle over everything which breathes … ' [89]. That time would require no less than a major shift in reasoning, with a much greater commitment given to the rest of life. Indeed, Wilson argues, that would be humanity at its most noble.

4.3. *SEI-3: Sustainable energy must respect environmental limits*

Currently, more than 80% of the world's total primary energy supply (TPES) comes from fossil energy resources, such as coal, oil, and natural gas [91]. Thus, fossil fuels are firmly embedded in the fabric of society, and they are not likely to go away any time soon. Even in the IEA's sustainable development scenario, more than half of TPES would come from fossil fuels in 2040. Meanwhile, in its latest report, the IPCC urges an 80% reduction from the present level of global CO_2 emissions by 2040 and proposes achieving negative emissions by the end of this century [92].

Meanwhile, nature itself is under pressure. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [89] argues that although more people in more places are being supplied with food, energy, and materials than ever before, 'this is increasingly at the expense of nature's ability to provide such contributions in the future. The biosphere, upon which humanity depends, is being altered to an unparalleled degree across all spatial scales. Biodiversity—the diversity within species, between species, and of ecosystems—is decreasing faster than at any time in human history' [88], p.10]. Changes in land and sea use, which often are the unavoidable result of energy production and energy distribution systems, is the driver of change in nature and has the highest impact on altering biospheres and declining biodiversity [88].

The challenge is clear—we must find ways to produce the energy we need (and will need) while simultaneously reducing CO_2 emissions and avoiding biodiversity loss. This requires rapid and widespread changes across all parts of the energy system. We present three narratives about how we can make those changes. National and local governments will take the lead here. They have the scientific and administrative expertise to begin to change the relevant physical and political systems.

Since Jules Verne published *The Mysterious Island* in 1874, enthusiasts have presented hydrogen as an abundant, clean, and inexhaustible source of energy. In Peter Hoffmann's words, it is the 'forever fuel' [93]. Although that may well come true at some point in the future, for hydrogen to become a *sustainable* fuel, we need to produce hydrogen from, for example, natural gas with zero or negative emissions (consistent with the Clean Fossil and Negative Emissions narrative) and/or from water by electrolysis (consistent with the Renewable narrative). Thus, the success of any possible 'hydrogen' narrative is contingent on these other narratives.

4.3.1. *Clean fossil*

It is clear we must find a way to *eliminate* CO_2 emissions from the burning of fossil fuels, such as coal, oil, and natural gas. This means that merely reducing emissions by substituting one type of fossil fuel for another (e.g., replacing coal with natural gas) is not a clean fossil fuel option. Although a better option than coal, natural gas still cannot offer the necessary CO_2 emission reductions. The IEA suggests three options to reduce emissions from the existing stock of powerplants: (1) retrofit them with carbon capture and storage (CCS) or biomass co-firing equipment; (2) repurpose them to focus on providing system adequacy and flexibility while reducing operations; and (3) retire them early [59]. The latter two options are about phasing out fossil fuel and are discussed later. Option 1, CCS, is at the crux of clean fossil fuels.

With CCS, CO_2 from fuel combustion and industrial processes is captured and transported via ship or pipeline to be used in the

[2] In the text, we have justified the Half-Earth narrative by referring to justice as it relates to non-human species. Ultimately, this narrative is about maintaining biodiversity and thus respecting environmental limits and could therefore be one of the narratives in SEI-3. This illustrates an important point: many narratives can be justified by several reasons and frequently cross imperatives and themes.

production of other products or to be stored in deep geological formations [94]. According to the Global CCS Institute, there are currently 43 large-scale CCS facilities either operating or in the planning stages: 18 in commercial operation, 5 under construction, and 20 in various stages of development [95]. There were, however, only two large-scale CCS power projects operating at the end of 2018. Thus, the development and use of CCS in the power sector remains well off any trajectory towards reaching sustainable development [96]. Various types of incentives (e.g., tax credits) and policy measures will be needed to encourage CCS development.

Although not a *biological* fossil fuel, nuclear materials for power production are a *mineral* fossil fuel [97]. With close to zero lifetime CO_2 emissions per produced kWh, nuclear power is prominent in the Clean Fossil narrative. The IPCC's sustainable development scenario suggests that the share of nuclear power must double by 2030 and triple by 2050 [92]. Of course, nuclear power has several other well-documented environmental impacts, including the potential for catastrophic accidents that could have devastating effects on biodiversity.

4.3.2. Negative emissions

Gains from the Clean Fossil narrative, however, will most likely not be sufficient. The IPCC suggests that limiting the global temperature increase to 1.5 °C cannot be met without large negative emissions from the middle of the century onwards [92]. This means that CO_2 must be removed from the atmosphere and stored in biomass, soil, suitable geological formations, and deep ocean sediments or be chemically bound to certain minerals.

Bio-energy with carbon capture and storage (BECCS) has received attention in several integrated assessment model studies [98]. BECCS uses biomass with CO_2 fixated through photosynthesis to produce heat or power from combustion or to produce synthetic natural gas or hydrogen from biomass. CCS technologies are then used to capture the CO_2, which is ultimately injected into suitable geological formations for permanent storage [99,100]. There are only five BECCS facilities currently operating [101], and they all produce ethanol from agricultural products, primarily corn. The dedicated storage of CO_2 in geological formations is ongoing or planned in two of the facilities, but the other three supply CO_2 for Enhanced Oil Recovery.

A standardized accounting framework is needed with BECCS. In addition, stricter climate policies and a higher carbon price are needed to enable BECCS development and deployment, possibly allowing for commercial operations. Finally, government frameworks are needed to set a sufficiently high value on negative emissions [98].

4.3.3. Renewables

Renewable energy resources (hereafter renewables) have the potential to offer significant reduction in CO_2 emissions [102]. The IPCC suggests that 50–60% of electricity must be based on renewables by 2030, increasing to 60–80% by 2050. This is a massive increase from the current 25%. In addition, the renewable share of heat production and non-electric transport must increase significantly. Moreover, according to the IEA, the transition to renewables will have extensive effects on development, stimulating the global economy and creating millions of jobs; in addition, there will be other far-reaching health and welfare benefits [59]. However, studies suggest that material and land-use requirements per unit power generated for renewable-energy technologies can be higher than those for power generated by conventional fossil-fuel sources [103]. Thus, potential conflicts are possible, which is a powerful reminder that there are no quick and fixes to solving all environmental issues.

Cost reductions for solar photovoltaics and wind power have caused a rapid increase in the use of renewables in the past years [104]. The electricity sector shows the greatest potential for renewables, with solar photovoltaics and wind making larger contributions to power generation, in addition to the substantial contribution of hydropower. There is an intimate relationship between electrification of the society (e.g., electromobility) and increased use of renewables. However, infrastructure and energy production systems will also need to evolve for electrification to be a successful strategy.

It is very important to point out, however, that electricity accounts for only a fifth of global energy consumption. Integrating the use of renewables into the transportation and heating sectors remains a critical task [104]. Nevertheless, the IEA sees renewables at the core of the transition to a less carbon-intensive and more sustainable energy system [104].

One study has raised some concern about the dominant role of renewables in the future energy system [105]. The authors find it unlikely that renewables can provide anywhere near the projected energy demand (1000 EJ) by 2050. They conclude that the global shift to renewables will have to be accompanied by large reductions in overall energy use. Nevertheless, we would still need to increase the share of renewables in the future. According to the IEA [104], the case for accelerated use of renewables requires that governments address three main challenges: '(1) policy and regulatory uncertainty, (2) high investment risks in developing countries, and (3) system integration of wind and solar' [104, p.2].

5. Summary and additional research

Fig. 2 presents the sustainable energy narratives spread across the sustainable energy imperatives and parts of the energy system. The placement of a narrative does not mean it fits exclusively in that one part of the system or imperatives. Each narrative could well cover several imperatives and different parts of the energy system, but the main focus of the individual narratives is indicated in the figure. The important point is that a sustainable energy system requires not just *one* narrative. Rather, it requires a diversity of narratives that together cover the imperatives of needs, justice, and limits as well as all parts of the energy system from production to consumption.

In this article, we review the dominant sustainable energy narratives found in the literature. Importantly, we do not rank the narratives' credibility in terms of their feasibility (are they possible?), acceptability (do we approve of them?), and centrality (do they deliver sustainability?). Thus, we do not offer clear policy recommendations. Rather, we stress that sustainable energy cannot focus on isolated themes (e.g., mitigating climate change) but must cover a diversity of narratives that satisfy human needs, ensure social justice, and respect environmental limits. Moreover, we acknowledge that several narratives offer conflicting solutions to the same problem (e.g., whether Factor X or Simple Life can satisfy human needs while simultaneously respecting environmental limits), which creates openings for conflict among those who want to tell the appropriate (i.e., sustainable) narrative.

We see the need for at least six lines of further research. First, we need to operationalize the narratives into concrete strategies, policies, means, and measures. The narratives are mainly motivational and directional, and detailed descriptions are needed on how to turn the stories into actions.

Second, we need to downscale the global narratives to local narratives. It is difficult to find a comfortable match between all narratives and, say, a small firm, a small municipality, or a group of individuals. Thus, it is important to develop local narratives without losing the broader perspective, which means to support the maxim 'think globally, act locally'. This maxim focuses on the impasse between simultaneously thinking about global challenges and taking necessary actions locally to face those challenges. Agents need to consider the entire planet's health when acting in their own firms or communities.

Third, we need to analyse in depth whether the narratives are complementary, competing, or substitutional. For example, Renewables and Energy for All are complementary narratives, whereas Factor X and Simple Life are competing narratives. We need empirical evidence to assess the credibility of the narratives. Substitutional narratives are particularly problematic because there can be no trade-offs between the

sustainable energy imperatives (and themes) [22]. Each imperative is equally important and thus a prerequisite for achieving a sustainable energy system. Presently, there is evidence showing that when low-carbon transitions unfold, other injustices related to equity, distribution, and fairness arise [7,106]. Similarly, there are difficult trade-offs between satisfying present and future generations' needs and capabilities [1,77]. Finding ways to avoid these trade-offs is of utmost importance to create a sustainable energy system.

Fourth, we need to create meta-narratives. These narratives comprise individual narratives with positive synergies while simultaneously avoiding trade-offs. One example of a meta-narrative is electric public transport, which combines Factor X (electric buses are more efficient than diesel buses), Shared Consumption (sharing means of transport instead of using privately owned cars), Fair Distribution (transport is more accessible for people who cannot afford a car), and Renewables (providing the electricity is made from renewable energy sources).

Fifth, we need to incorporate the narratives in the literature on sustainable energy transition [107–112]. The transition literature currently focuses mostly on technological solutions for a low-carbon transition and needs to expand to include the imperatives of energy needs and energy justice, as well issues of securing biosphere integrity.

Sixth, and probably most difficult, we need create the realization that something is indeed owed to the contemporary poor, future generations, and other living creatures [77]. Thus, we need to acknowledge the moral imperatives of sustainable development. John Rawls refers to two moral powers: people's capacity for a sense of justice and their capacity for a conception of good [73]. At some level, most of us have a sense for what is just and unjust. We argue that people have a moral power, which we have called a 'capacity for a sense of sustainability. Perhaps we should call this a sense of unsustainability—we sense that poverty is wrong, we sense that it is wrong when injustice is being done, and we sense that destroying the natural environment is wrong' [22], p.14]. This may be what has made the concept of sustainable development, in the words of Jim MacNeill, Secretary of the World Commission on Environment and Development, and chief architect and lead author of *Our Common Future*, part of the 'everyday lexicon of humankind'—we intuitively recognize unsustainability. Hopefully, we also intuitively recognize an unsustainable energy system.

Declaration of competing interest

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

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