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Review

Framing in Renewable Energy Policies: A Glossary

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Abstract: The transformation of a power supply, a social-technical system suffering from a heavy lock-ins, requires structural adaptations which are extremely complex. All actors in social acceptance processes have either strong vested interests in the current system or are challenging these. In strategies developed by those actors, so-called 'frames' play a key role. These are biased problem definitions and mental shortcuts, tools to affect the course of decision-making processes. Examples are "clean coal", "smart grid", "base-load", or "decentralized". Framing is fundamental to political processes, including those of decision making on renewables. This review presents a glossary of significant frames used in social acceptance processes of renewables' innovation in power supply systems. The identified frames are classified and presented with, in each entry, one significant frame discussed and analyzed in relation to its most associated frames. Overall, the contrast comes to the fore between the paradigm of the current heavy centralized and hierarchically managed power supply system, on the one hand, and the newly emerging concepts around distributed generation on the other hand. Within these two clusters and in between, certain frames are focused on issues of ownership and control of infrastructures, while others concern allocation of space for establishing infrastructure.

Keywords: centralized power; distributed generation; microgrids; community energy; virtual power plants; demand response; intermittency; coproduction; common goods; prosumer; P2P

1. Introduction

This glossary aims to present an inventory of examples of significant frames that can be recognized within the unfolding policies that claim to bring about the transformation of our energy systems from fossil fuels towards zero carbon. These frames are pushed by various actors—stakeholders in energy systems—to affect fundamental choices regarding energy supply and consumption. Originally these choices were investigated with a focus on acceptance of wind-generated electricity and the proximity of wind turbines [1,2]; however, soon the crucial contribution of community acceptance in all processes associated with renewables' innovation was recognized. Social acceptance is a complex concept covering all dynamics of decision-making about its object, 'renewable energy innovation', unfolding in processes at multiple levels. The level of socio-political acceptance is paramount [3,4].

Framing is fundamental to all political processes. The 35 years of research into social acceptance of energy innovation have demonstrated that hardly any domain is as political as energy. From the global to the local level, the energy domain is marked by intense clashes between mainstream socio-economic and political interests, ideology, and political choices [5]. The aim to transform energy systems towards renewables mandates geo-political considerations [6]. Framing is an important phenomenon to analyze when studying socio-political acceptance of energy innovation processes. As socio-political acceptance concerns the institutional conditions that also determine market and community acceptance, the frames applied at the political level also concern these levels [3,7].

2. Framing in Renewable Energy

2.1. Where it Started

It is no surprise that energy interests underlie the ideologically defined frames of climate change denial [8]. Irreconcilable frames can be recognized while comparing science-based blogs on global warming and climate change denial blogs [9]. Climate change denial is an extremist's frame associated with the ideology and strategies of pseudoscience [10], strongly reinforced by fossil fuel interests [11]. Politically motivated opposition to carbon pricing in the US, for example, resembles what has been identified as "solution aversion": the tendency to be more skeptical of environmental problems whose policy solutions contradict or challenge underlying ideological predispositions.

Whereas the strategy of agenda setting is primarily about affecting the salience of issues, framing is considered an extension of this as it also tries to affect the salience of attributes within issues [12]. For example, in the domain of energy the impact has been established of particularly negatively framed information on acceptance by the public of adaptations in transmission lines required for implementing renewables [13]. Framing is often studied as targeting public opinion, for example as the way issues are defined and presented by political actors in mass media [14]. Wider applications concern framing in the emergence of social movements [15]. Applied to the entire domain of policy making, as in this article, framing is defined as "a mental structure of beliefs, perceptions and appreciations that people use to make sense of the world around them" [16] (p. 23).

Actors try to affect the perception of the issue by others, biased by their own perspective. The association with a political context makes it highly relevant for the energy sector. Long before climate change developed into a major energy issue, the phenomenon of framing in the energy domain arose with the emergence of the social acceptance of nuclear power in the 1960s [17]. At the time, nuclear power was already widely accepted and implemented, but the first doubts about its potential risks were raised among academics and particularly nuclear physicists [18]. Later, the dominant frame of "safe, abundant, and peaceful" was being contested also beyond the academic world. Community acceptance of reactors and nuclear waste repositories was becoming increasingly problematic, and challenging frames developed rapidly in light of conflicts over new nuclear facilities. Within these political struggles nuclear power became strongly framed [19]. The strong dynamics of acceptance in these processes and the strategy of framing are illustrated by the fact that the currently dominant framing of nuclear as "low-carbon technology" only became mainstream among its proponents much later [20].

Starr's proposition was that "public safety can be focused upon a tangible quantitative, engineering design objective" [17] (p. 1237). This so-called revealed preference approach can still be recognized in frames applied to address public acceptance of energy risks, also concerning other "low-carbon technologies" like carbon capture sequestration/storage (CCS (Section 5.3)) [21–23]. Starr's article kicked off a new academic field of risk studies that stemmed from the idea that rational decision-making is best performed through experts' formalization of past policies as prescriptions for future action [24] (p. 150). Within the new tradition it became a challenged frame, as risk studies soon turned towards the insight that risks are social constructs, and acceptance is not a technocratic (Section 5.4) problem but rather a social issue [24–26].

2.2. Renewables' Innovation

In addition to technological risk, many aspects within the wide range of decisions in social acceptance processes can be approached from different perspectives, all highlighting the inevitable urgency to analyze issue framing. For example, the term "innovation" should be understood as "disruptive innovation" [27], i.e., beyond the mere incremental improvement of products. Innovation is neither invention nor diffusion of technology, but rather the development of new ideas materialized in products and services that become accepted in society and replace other products and practices [28]. Innovation in energy supply reaches far beyond new products, such as the construction or installation of devices like photovoltaic (PV)-panels, wind turbines, charging stations for electric vehicles etc. The process extends to the fundamental reconstruction and transformation of complex socio-technical systems (STS) [29,30]. STSs are constructed of scientific and technological as well as socio-economic, cultural, and organizational components. A typical description of the power grid is that, besides being a huge machine, it is also an infrastructure, a cultural artifact, a set of business practices, and an ecology, and all these elements are waiting to be transformed [31]. For energy supply systems, the technologies also concern rapidly emerging innovations crucial for implementing and integrating renewables, like new transmission, storage, grid intelligence, and demand response (Section 5.6). The social meaning of these technologies, as well as the innovative practices associated with their development and application (i.e., "social innovation" [32,33]), is contested and has become the subject of framing.

2.3. Transforming Power Supply and Framing

The transformation of the power supply STS is often described in terms of "transitions". From that perspective, it is inevitable to look at the political economy of energy [34]. Multi-level perspective (MLP) is a fundamental concept in transitions analysis, describing the mutual relations among processes, structures, and actors at different levels in innovation processes. The transformation of the energy provision is extremely complex and requires major institutional changes—i.e., structural adaptations–at multiple levels of governance. Recent enhancements of the MLP of transitions emphasize strong resistance among "policymakers and incumbent firms that can be conceptualized as often forming a core alliance at the regime level, oriented towards maintaining the status quo" [30] (p. 26). Transformations of complex STS imply institutional changes, which in turn require regime changes. Geels [30] explains how such complex socio-technical transitions cannot unfold exclusively based on incremental niche development. The required regime changes clearly also comprise fundamental governance changes, so politics and power appear to be key in spurring social acceptance of the crucial element of structural changes in socio-technical transitions [35].

3. What is Framing?

Politics at multiple levels of the transformation of the energy STS is primarily about dominant positions and power structures. Where political power is exercised in developed societies with an open character—liberal democracies—the effective design, use and communication of ideas is crucial. Within that context framing emerges as a powerful strategy. The different dimensions of energy issues are full of value-laden elements, and hence, the frames about relevant domains of decisions about renewables, such as ecology [36], place-making [37], effectiveness of market forces [38], and risk management [24,39] are all social constructions. Decisions that engage with these constructs generate conflicts in which stakeholders hold divergent core values.

Framing is the way an issue (or an attribute) is defined and presented by actors—biased by their own perspective—in order to affect the perception of the issue by others. In Section 2 the most comprehensive definition within policy studies has been introduced to use for this glossary, with frames as mental structures of beliefs, perceptions and appreciations [16]. Because people use frames to make sense of the world around them, framing is an effort to encourage or enforce certain interpretations while discouraging others. The setting of a problem frame about a complex issue, which affects multiple values and can be considered from a variety of perspectives, aims to simplify the issue around a single conceptualization, implying one particular solution strategy [40].

Issues can be framed in a variety of ways, for example, by shaping public opinion or by dismantling the legitimacy of opposing perspectives. Framing is the process in which certain selected aspects of a perceived reality are communicated, with the intent to promote a particular problem definition, causal interpretation, or moral evaluation [41]. Psychologically, most framing activities can be successful if they apply cognitive shortcuts, heuristics [42], that are based on the inclination of the individual towards simplified decision-making. Some of the frames in the entries in the glossary section are characterized by a strong appeal to such mental shortcuts.

Frames can be studied and structurally analyzed as elements of policy narratives [43] focusing on the way communicators present issues, or searching for messages with the intention to affect the interpretation by others. Alternatively, the aim of analysis may be the recognition and classification of biases, for example by amplifying or emphasizing certain aspects, while marginalizing or neglecting other aspects. This analysis and classification for the glossary focuses on the bias that can be traced in the academic peer reviewed literature, the domain that is supposed to cover all aspects as unbiased as possible.

This glossary is an inventory of existing significant frames that are applied in the processes of acceptance of the transformation of energy, in particular power supply systems, towards systems based on renewables. Decisions about energy are based on worldviews, or existing ideological frames, that underpin varying conceptions of reality and how knowledge is produced and digested [44]. The prime interest of this glossary, however, is not to describe the ideological frames, although some are ideologically inspired (e.g., worldviews on the relation between society and environment [45,46] (Chapters 4 and 9). Instead, we summarize the renewables energy frames that are used in energy debates. The research question is defined as follows:

> *Which dominant frames—and counter-frames—occur in the social, economic and political struggles around the transformation of the socio-technical system of energy supply, in particular electricity supply?*

The article has taken the form of a glossary in which the entries discuss a typical frame with some related framing or counter-frames. Most frames only selectively cover some elements of the transformation of power supply, and they are not necessarily congruent, in agreement with each other, or contiguous. In the concluding Section 6, some main trends are described.

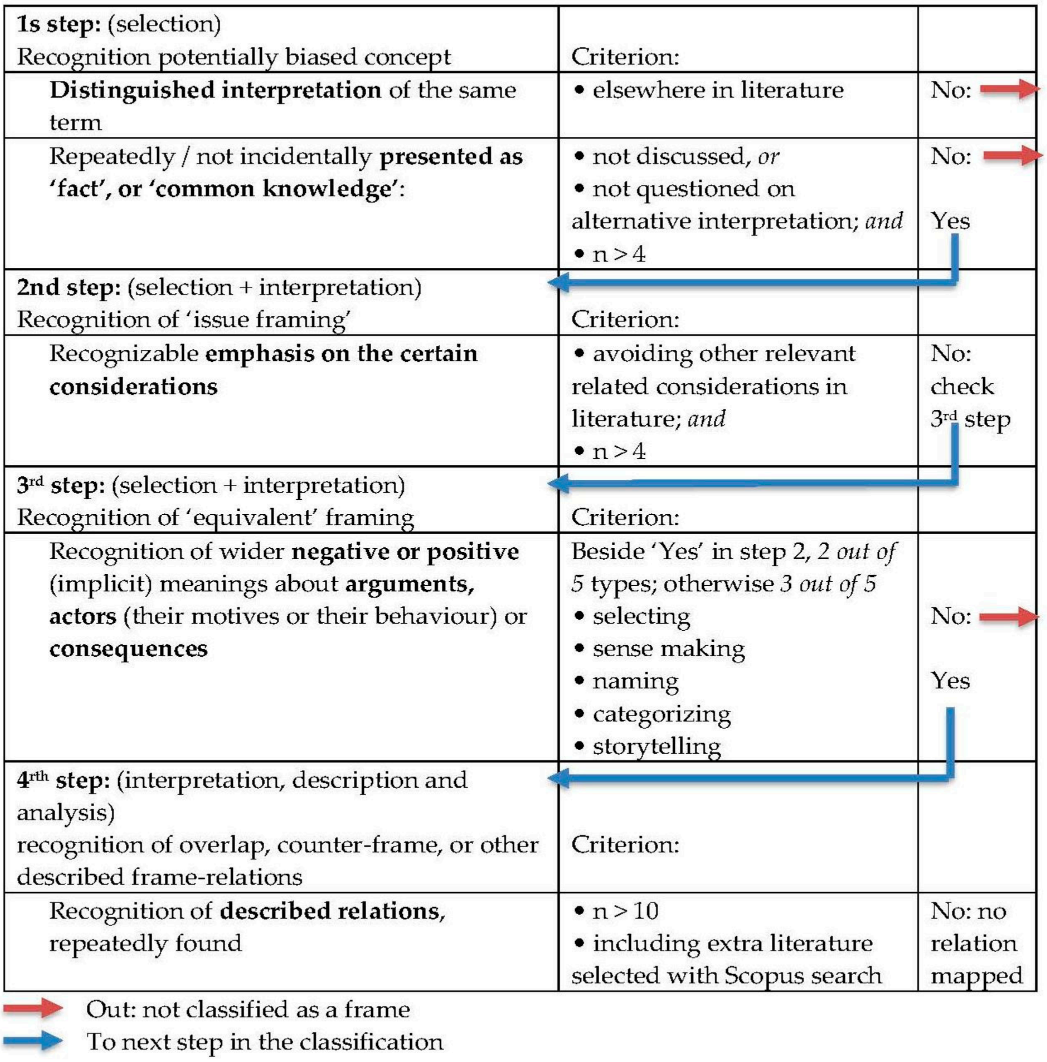
4. Method

4.1. The Concourse

The first version of the research question arose during the analysis of the first of five review articles, an elaboration of the social acceptance of renewable energy systems (RES) in intelligent grids in 2012 [47]. The idea arose from being confronted with many completely different, sometimes contradictory, interpretations of the prefix 'smart' (Section 5.13). The prime example of framing were legislators and energy companies embracing the remotely readable digital meters under the highly questionable claim that these would be 'smart meters' (Section 5.13). Being often confronted with this phenomenon in earlier research into social-political acceptance, the project was started for the systematic inventory of such labels within the consulted literature for this review [47].

The first step was the design of a classification scheme during the collection of all information in the literature used for writing that review. Secondly, it was used and further fine-tuned (Figure 1) in the work on four subsequent review articles. These covered the following topics: the co-production (Section 5.12) and land-use change (Section 5.11) for distributed RES infrastructure [48]; two articles as part of a critical discussion on the concept of social acceptance of renewable energy innovation [7,49]; and finally one on the elaboration of socio-political acceptance of distributed energy systems (Section 5.7) [50]. From frequently observed different terminologies indicating similar concepts, the image surfaced that these associate with implicit assumptions reflecting 'frames' in the policy domain. The use in the academic papers implies undesirable reinforcement: they tend to recur in conclusions or policy recommendations.

In the third step the final scheme for classification (Figure 1) was used to recognize and classify frames and their mutual relations in the vast collection of the peer-reviewed publications. The sample consisted of all the interdisciplinary literature used for the reviews, including those that did not appear in the reference lists (n = 440 + 275 = 715). Eventually, in the fourth step the identified frames have been described (Section 5) also by screening the literature once again in the Scopus database, using all variations found in the terms.



1s step: (selection) Recognition potentially biased concept	Criterion:	
Distinguished interpretation of the same term	• elsewhere in literature	No: →
Repeatedly / not incidentally **presented as 'fact', or 'common knowledge'**:	• not discussed, *or* • not questioned on alternative interpretation; *and* • n > 4	No: → Yes
2nd step: (selection + interpretation) Recognition of 'issue framing'	Criterion:	
Recognizable **emphasis on the certain considerations**	• avoiding other relevant related considerations in literature; *and* • n > 4	No: check 3rd step
3rd step: (selection + interpretation) Recognition of 'equivalent' framing	Criterion:	
Recognition of wider **negative or positive** (implicit) meanings about **arguments, actors** (their motives or their behaviour) or **consequences**	Beside 'Yes' in step 2, 2 *out of* 5 types; otherwise 3 *out of* 5 • selecting • sense making • naming • categorizing • storytelling	No: → Yes
4rth step: (interpretation, description and analysis) recognition of overlap, counter-frame, or other described frame-relations	Criterion:	
Recognition of **described relations**, repeatedly found	• n > 10 • including extra literature selected with Scopus search	No: no relation mapped

→ Out: not classified as a frame
→ To next step in the classification

Figure 1. Final classification scheme for recognition of frames in the academic literature.

4.2. *Recognizing Frames Based on Classes*

The classification scheme (Figure 1) was based on the following considerations. Like most other publications, peer-reviewed academic papers also rely on cognitive shortcuts, frames that may be associated with existing paradigms, research traditions, or methodological preferences. They may be explicitly presented but often are implicitly alluded to, and moreover, academic paradigms do not automatically qualify as political "frames".

The recognition as "frame" depended upon the association of the same phenomenon with any kind of bias. The existence of alternative interpretations was established in the first step, mostly by the recognition of these alternative meanings in other publications. Such alternative meanings are a necessary condition for bias, but not enough. An example based on differences in disciplinary approaches: some researchers on social acceptance are using the economics' paradigm of willingness to pay (WTP) to collect data with methods like conjoint analysis in choice experiments or contingent valuation. These researchers tend to consider the results as a proxy for social acceptance [51]. The consequence is an implicit definition of social acceptance as viewpoints (a variable from rejection to support) held by individuals, which is only one element of social acceptance processes. Moreover, those viewpoints are subject to the single disciplinary perspective that valuation of all aspects of renewables can be narrowed down to a financial consideration. This use could be labelled as a "frame" only if it was associated with a wider story, for example selective claims that exclude other perspectives relevant for decision-making—frequently observed in the WTP papers.

To classify as a frame, more selective interpretation is needed, which is assessed in the next steps of Figure 1. "Framing" has the strategic goal to make others associate the problem with particular aspects in the decision-making process. The objective is to serve the final goal: Another kind of decision, but the effectiveness of framing starts with the affected interpretation by others, in our case the academic community. The first classification that has been applied is the "effectiveness of frames", the distinction between issue-framing effects and equivalence-framing effects. Emphasizing a subset of potentially relevant considerations while selectively avoiding others can fundamentally shape one's opinion-forming. This process is called "*issue framing*" [52] and research on the relationship between mass media and politics shows evidence of its impact on public awareness of issues [53,54]. The "*equivalence framing*" strategy refers to the use of logically equivalent concepts or phrases to create preferences. An obvious example is the widely applied use of a clearly positive term like "smart" (Section 5.13). Any issue or solution set on the agenda with the label 'smart' immediately suggests that doing something else cannot be clever, so the alternatives will be inferior. An example of negative application is the use of prospect theory [55] to create "solution aversion" [56], by emphasizing potential costs over benefits or by using negative labels or information [13]. In the entries of "intermittency" (Section 5.10) and "nimby" (Section 5.11) (not in my backyard) we find the strong suggestion of problems instead of solutions. In step 2 and 3 (Figure 1) the presence of at least one of these two is classified, with a threshold to avoid classification based on incidental occurrence.

The second type of classification, applied in step 4 (Figure 1) is based on the recognition of the different functions of framing by actors in the policy arena: sense-making, selecting, naming, categorizing, and storytelling [57]. Most terms or phrases cover several functions, because of overlap in the stories associated with each frame. The entries presented in Section 5 define different elements of social acceptance of renewables' innovation, but they are frames because they simultaneously suggest much more. Usually the labels are the suspension point for a complete *story* and, hence, an entire perspective on an elementary part of the implementation of renewable energy. Using some label—*naming*—for different phenomena (for example, "green" (Section 5.9)) may imply a *categorization*. This can also become *sense-making* (green is good) and *selects* certain options as preferable solutions and others as unrealistic or undesirable.

The functional framing can best be illustrated by an example. The description of "intermittency" also covers part of the story about "baseload" (Section 5.10) power, which "must be supplied by constant and reliable sources of electricity. They are sometimes dispatchable as well, in order to cover for unreliable intermittent (Section 5.10) electricity sources" [58]. The description of intermittency and baseload in this quote is clearly part of a story, and it also contains strong sense-making by means of equivalence framing. In this case by using both the positive term 'reliable' selectively as well as its negative counterpart 'unreliable', also selectively. The five functions of framing are used as criteria, but as they are in practice hard to distinguish, as in fact they are overlapping, the threshold here is that there should be at least three that are recognizable.

4.3. *Assemblage and Interpretation: Towards a Glossary*

Eventually, in all articles consulted for the reviews (n = 715), frequently occurring terms or phrases were selected using the scheme in Figure 1. The application of frequency thresholds with regard to the number of articles in which the criteria have been recognized, seemed at first very arbitrary. In practice, however, there were hardly cases very close to the thresholds. In fact, it remained incidental—below the thresholds—or numbers clearly exceeded them.

Interpretation was started at the same time as the classification in steps 2 till 4. As the selection aimed at establishing potential bias and therefore had a strong selective substantive character, it was mainly qualitative. Once the full sample of the frames had been established, the interpretation was used to map the mutual interrelation between the frames based on their coincidence in the literature. This was a first preliminary version of the interpretation figure that is presented in the conclusion section. For the description, all terms have been subjected to a search in new literature—in Scopus, using different variations of the terms—to find adjacent publications in which the terms had been explained, applied or clarified. A striking fact was that this was possible for any of the terms, so their application in the literature was supporting the list of selected terms. Many of the references in this article originate from this last step and these are used because they are typical examples of the use or description of the respective frame.

4.4. All Terms in the Glossary

The final glossary is presented in Section 5, with each subsection as an entry. The list of frames is much longer than the number of entries (Table 1). In particular, because of the significance of the relations, such as opposite frames or strongly shared storylines, they have been described in groups based on one very pronounced or central concept (e.g., decentralization) or a significant distinction (public/private/common). Those are the headings of the entries and these are listed in alphabetical order in Section 5.

So, not all distinguished frames have their own entry, but each selected frame is placed in an entry that is strongly related to it. Sometimes frames are discussed in more than one entry. For example, the terms "centralized" and "decentralized" (Section 5.4) are opposite terms but two sides of the same coin and, therefore, they are described in one entry. Meanwhile, within 'decentralized' important distinctions have emerged. The term "distributed" has a different meaning compared to decentralized. Introduced by Ackerman et al. [59] as "distributed generation", it developed into integrated "distributed energy systems", which also include distributed storage and demand response (Section 5.6). Nevertheless, these "distributed energy systems" (Section 5.7) reflect the same core values as Ackerman's original definition. Therefore, it also is discussed in a separate entry with other frames particularly related to the meaning of "distributed" (Section 5.7).

Table 1. Overview of all selected frames.

Baseload (Section 5.10)
* Biofuels (Section 5.1)
Biomass (Section 5.1)
CCS (Section 5.3)
Central planning (Section 5.4)
* Central power plant (Section 5.2)
Centralized (Section 5.4) (system, model)
* Clean coal (Section 5.3)
Commodity (Section 5.12)
* Common good (Section 5.12)
Community energy (Section 5.8)
Coproduction (Section 5.12)
* Decentralized (Section 5.4)

* Decision support systems (Section 5.5)
Demand response (Section 5.6)
* Demand-side management (Section 5.6)
Distributed generation (Section 5.7)
* Distributed energy systems (Section 5.7)
* DSM (Section 5.6)
* Energy democracy (Section 5.8)
* Green power (Section 5.9)
Intelligent (micro)grid (Section 5.13)
* Intermittency (Section 5.10)
Landscape change (Section 5.11)
Microgrid (Section 5.13)
* Nimby (Section 5.11)
Power plant (Section 5.2)

* Private good (Section 5.12)
Prosumer (Section 5.7)
* Public Good (Section 5.12)
* Smart grid (Section 5.13)
Smart meter (Section 5.13)
Technocentric (Abstract)
Utility scale (Section 5.2)
Variable sources (Section 5.10)
Virtual power plant (Section 5.2)
Visibility (Section 5.11)
Visual impact (Section 5.11)
Visual pollution (Section 5.11)
* Peer-to-peer (P2P) (Section 5.14)

* Entries in Section 5; (all frames are linked to at least one describing entry).

5. Glossary: Discussion and Analysis of Frames

5.1. Biofuels

The most contested renewable energy sources are biomass and biofuels, organic materials that have captured and stored the energy of the sun through photosynthesis. The controversy starts with the initial classification: are they a renewable source or an energy carrier, i.e., energy "flow" or "fuel"? Their primary application is combustion, so they come closest to fuels; however, their energy content builds up during short time periods, unlike fossil fuels or uranium. Within the frame of biomass as a primary source and a fuel, its energy density is seen as high [60,61]. Looking at biofuels as a secondary source, in fact a storage system that while growing is harvesting a flow of renewables, its density (W/m^2) is extremely low compared to renewables like solar, hydro and wind [62]. It requires massive surfaces as well as water for harvesting modest quantities of energy [63].

The literature's current criticism of the classification of 1st generation biofuels as renewables is rooted in its opposition to the use of food crops (sugarcane, corn and vegetable oils), which are considered as unsustainable fuels [64]. Instead, for 2nd generation fuels lignocellulosic biomass is converted into liquid hydrocarbons, fuels with chemical similarity to those currently used in internal combustion engines [65]. With the similar density as energy carrier, and derived from agricultural and forestry residues and municipal waste, this frame presents them as potential renewable source. Feasibility assessments of this technology conclude that application requires substantial policy support and subsidies [66,67]. The fact that many countries subsidize and use biofuels indicates that there is substantial socio-political acceptance of framing biofuels as renewable energy. Because of their high energy density as a fuel, they can be easily utilized in the existing energy supply system (e.g., biodiesel (Section 5.1) in cars, woody biomass replacing coal in power plants (Section 5.2) [68] or district heating) [62]. This easy application makes biofuels popular among incumbents in the energy provision and policy realms alike, further entrenching the carbon-heavy lock-in pathway [69]. Community acceptance may be less high, as cultural, supporting and regulating ecosystem services are valued higher than the provisioning ecosystem service among members of communities around places where woody biomass is harvested [68].

The relative popularity of biomass among policymakers was illustrated by the European Union's (EU) early and hasty formulation of supporting policy for biofuels [70,71]. Biofuels, bioproducts and biorefining were considered key for the development of a bio-based green (Section 5.9) economy. This rapid and easy political and market acceptance for bio-based products soon became heavily contested [72]. Many more examples of policy framing biofuels as climate change mitigation tool and as renewable—with subsidies and tax exemptions even for ethanol and biodiesel—and in carbon emission accounting schemes the potential reductions by biomass are sometimes double counted [73].

5.2. (Central) Power Plants

The first power supply systems that emerged around 1880 were based on hydro and coal (Niagara Falls NY; Grand Rapids Mi; New York NY; London UK), geographically dispersed, not interconnected, and very local [74]. These highly decentralized (Section 5.4) systems grew rapidly into regional monopolies. Then growing local and regional interconnections and, above all, increased state intervention and control (Section 5.12), started a shift towards a centralized (Section 5.4) system [31,69]. Large-scale generation, high voltage transmission technologies, and adjacent economies of scale fueled this centralization.

Current grids are based on generation of electricity at large centralized facilities, usually located far away from end users, connected to a network of high voltage transmission lines. With the rapid development of electricity as the backbone of economic activity, increasing state intervention and control became an essential element of the system. Strong regulation accompanying privatization of generation (Section 5.12) and distribution as well as legally fixing the mandates of grid management and consumption (e.g., metering, tariffs, monopolization), completed the STS of the current centralized power supply (Section 5.4). This model is often perceived as the "natural" design of the power supply, with the highest efficiency due to economies of scale and natural monopolies. This is a frame, reflecting institutionalized technocratic (Abstract) thinking. Several key characteristics (e.g., the standard of supplying alternate current (AC) were the outcomes of hard economic and political struggles [69]. The centralized (Abstract), standardized and hierarchically controlled grid is under pressure now, partly because of the emergence of remote, large-scale RES installed as plants, such as wind farms and ground-mounted solar plants [31]. While the paradigm is being challenged by "distributed energy system" (Section 5.7) designs [75,76], it is still firmly anchored in the technology-fix and frames like centralized power plants. This framing still seems largely effective as long as in policies and studies on development of technological networks “social and political institutions tend to be taken for granted” [77] (p. 11).

Centralization as a “natural state” of power supply survives also as a frame in policies on renewables. This often leads to preferences for large power plants and also to the tendency that large-scale buildout of renewable energy would likely require “highly active, interventionist, developmentalist states” [78] (p. 2498) to secure sufficient land area for renewables plants, to subsidize the transition, and to coordinate policies and movements to invest in large-scale structures across national borders. Indeed, several cross-border, megastructure initiatives—like Desertec linking Europe to large wind and solar structures in North Africa—have been endorsed by a variety of stakeholders, but the feasibility of these initiatives has been low [79].

A frame focusing on power plants is the term “utility scale” (Section 5.2) plants for wind or solar [80], indicating large-scale applications. It seems to go without saying that the investment, ownership and management belong to the type of company that is usually called a “utility” (Section 5.12) [81]. However, in countries with a good renewables’ deployment track record, renewables were not installed by energy utilities but by initiatives from outside the realms of incumbents in the sector [82]. After all, utility is not a scale, but a function and a management model in the existing system producing “public” (Section 5.12) or “private” (Section 5.12) goods or services. The term neglects all other forms of deployment, including other forms of management of renewables at large scales.

These presumptions have consequences. With high capacities (>250 MW) of renewables concentrated in one location, system operators face the issue how to deal with the plant’s inherent variability (Section 5.10) [83]. This impact remains limited if capacity is installed in a larger geographic dispersion and with substantial amounts of distributed energy systems (Section 5.7), which balance variable power with local management and storage before entering the grid [84,85]. Such distributed energy systems based on geographically dispersed units managed in one system may be framed as “virtual power plants” [86]. Although these are described as a vehicle for delivering cost-efficient integration of distributed generation into the existing power systems [87], the concept of virtual power plant was developed to enhance the visibility and control of distributed systems to grid operators and other market actors (Section 5.12) and not as “citizen utilities” (Section 5.12) [88]. The latter may be considered as an effort to reframe electricity generation as “community energy” (Section 5.8).

5.3. Clean Coal

Framing CO_2-emitting sources as “clean” is the most obvious rationalization that downplays the necessity of zero-carbon energy systems, for example the oxymoron in China’s clean coal power plan [89]. Filtering pollutants like nitrogen and sulfur compounds and more efficient applications of heat through district heating does make coal-fired power plants (Section 5.2) more efficient and less dirty than decades ago, but CO_2 emissions are not reduced. Hence, CO_2 capture and storage (CCS) is being framed as part of clean coal [90], with the clearly stated objective to retain the importance of fossil fuels in the energy mix, particularly for “baseload” (Section 5.10), as these “can respond to changes in demand more readily than many other sources of electricity production” [91] (p. 130).

Clean coal and CCS are facing significant challenges to deployment across the globe [92]. Many newly built coal plants are positioned under the CCS/clean coal frame, but the reality of projects on the ground is quite different. In the Netherlands, for example, in the political struggle over constructing new coal plants, the detrimental effect of constructing them without CCS was shown in studies [93], but coal plants were framed as ‘clean’ because of linked CCS. Eventually, once it had been decided, they were constructed, but without CCS. The debate on climate change policy after the Paris-agreement immediately questioned the very existence of these new coal power stations, particularly under pressure of the so-called ‘Urgenda court rule’, which mandated the Dutch Government to increase reduction goals for CO_2 emissions [94]. Higher electricity prices for consumers have been proposed as a financial mitigating measure for the early closing of coal-fired plants [95]. Currently 2030 is set as the target to close them, but power companies are requesting huge financial compensation if they are forced to close them. The result might be that closing the coal plants will absorb a large section of the public budget for the real transformation of energy supply.

Simultaneously during this process on clean coal unfolding in the last decade, the Netherlands continued to be a laggard in renewables—second to last place in the European Union [96]. Policies under the clean coal frame tend to go together with emphasizing the drawbacks of renewables, as also observed for the United States [97]. Public awareness studies recognize that CCS is perceived as a technology competing with renewables and supporting policy is seen as delaying the development of renewable energy [98] (p. 14).

5.4. Decentralized

With the rapidly unfolding insight in the literature that the centralist model of power supply is on its way out, the "centralized" frame still maintains substantial political momentum. When exploring its alternatives, common practice is to use the opposite term "decentralized" [6]; however, this term merely suggests the location and scale of power generation units, i.e., this frame is restricted to the physical and spatial dispersion of infrastructures. Numerous authors suggest that the growth of locally sited infrastructures implies much more than this narrow definition foresees. "The decentralized options add a new dimension to system operations, enable new business models and facilitate local empowerment" [6] (p. 2). Thombs [99] unfolds a typology of four possible transitions determining the options for such empowerment—framing "energy democracy" (Section 5.8)—based on two dimensions of the STS of power supply: monopolistic vs. democratic, and centralized vs. decentralized. Indeed, the downscaling and distribution of responsibilities in governance by decentralizing power from national towards regional and local levels seems to improve renewables' deployment [100,101].

The implemented systems are based on renewable supply power to the grid in a very different way. "Distributed energy systems" (Section 5.7) neither imply centralization nor decentralization, but rather polycentricity in governance [102,103]. It also concerns fundamental shifts in the type of control and management, in particular because of the emergence of prosumers (Section 5.7) [104–106].

5.5. Decision Support Systems

Social acceptance of RES is about decision-making processes [3,4,7]. Numerous studies focus on how to support decision-makers, often with an implicit presumption about their centrality (Section 5.2) in renewable project decisions [107,108]. The support not primarily supports affected groups, but it tends to focus on the developers and–local, regional, national–authorities. Most support systems are hybrids of multiple criteria analysis (MCA) [109]. Most applications focus on technological criteria, resource availability, energy yield, and economic criteria limited to assumed cost-effectiveness. Input data are usually based on consideration of alternative sources, systems design, and locations. Usually they apply MCA-based models, combined with geographical information systems (GIS) to include environmental variables associated with the site [110].

Most MCDSS (multi-criteria decision support systems) apply hierarchical decision-modelling [111], and the instruments based on these models primarily support centralized planning and decision-making. This introduces bias, as acceptance processes are increasingly characterized by multi-layered and polycentric governance [50]. For example, most applications hardly integrate the balance between several sources, adjacent infrastructures (transmission, storage, demand response (Section 5.6)) and also neglect most social factors essential for distributed energy systems (Section 5.7). Typically, MCDSS studies try to assign suitable areas for single technology projects, with site and investors selected in advance. The models cannot handle the fact that the valuations of projects are not fixed, but dynamic in the processes of decisions-making, particularly in the dimension of community acceptance [112]. The possible resistance triggered by these pre-selections down the line is usually considered as a manifestation of local resistance based on "visual impact (Section 5.11), as well as . . . Never In My BackYard (Section 5.11) behavior" [107] (p. 1564). This centralist planning (Section 5.2) frame comes to the fore in the common response advocated in decision-support studies, for example that protests "must be overcome and transformed into a positive attitude towards the installation" [106] (p. 235). It is easy to say, but practically unfeasible, especially in hierarchically organized processes. This reflects the naive view that public information campaigns can help communities to understand the challenges of the project correctly [111].

Some applications recognize the importance of community acceptance, but only from the presumption of static attitudes, whereas the key of acceptance is that is about process, so dynamic perception and attitudes, mainly in response to action by other actors [50]. By introducing variables that represent criteria of acceptance, MCDSS includes criteria that may be important for affected stakeholders, but without involving them in the decision-making process itself. As the support from the support systems is directed at the decision-makers at the center of the decision, the implicit focus of the information also remains centralistic. They support decisions on RES projects that are in practice considered "power plants" (Section 5.2). There are models, however, that are designed to support participatory processes, for example, the application of PPGIS (public participatory GIS) [113].

5.6. Demand-Side Management

High renewables-based socio-technical power supply is based on variable (Section 5.10) resources. In order to balance these with each other and with consumption, flexibility is needed on all sides, including demand [114]. Adapting demand patterns to a variable electricity supply, in response to supply-side signals requires the introduction of demand response (DR). For DR, the main path-dependent institutionalized frame is demand-side management (DSM) [115]. Generation capacity and networks are not utilized in an optimal way, and there is ample room to adjust power demand patterns and increase system efficiency. The implicit meaning of the term "management" introduces certain bias, i.e., the top-down shaping of the behavior of consumers of all types. Even in the case of distributed energy systems (Section 5.7), the idea of DSM remains tied to the control from outside those systems. In this perspective, distributed energy systems are controlled as "virtual power plants" (Section 5.2), a grouping of smaller generation units that are handled as one single power plant by the grid managers [116]. Control still rests with power supply companies or the distribution system operators (DSO), and hence the predominant frame of DSM is that end users respond to signals and price incentives by those managers and modify energy use accordingly, possibly through an automated system.

DSM has a long history, with broad deployment of basic technologies and schemes. For example, remote switch on/off signals combined with time-of-day (TOD) or time-of-use (TOU) tariffs created incentives for installing more equipment, particularly devices that could be used by DS managers to boost operation during low price/consumption periods [117]. Contrary to the flexibility in both demand and supply needed for integration of renewables [114,118], in DSM the main utilization has been the optimization of inflexible baseload (Section 5.10) capacity. The main strategy was so called 'valley filling' [119], stimulating power absorption during low load periods at night with reduced TOD prices. This has played an important part in utility planning since the early 1980s. For example, a high share of electric water heating in households in France was stimulated, even combined with a high incidence of electric space heating [120] (p. 17). Thermal heated water was used to absorb power at night generated with nuclear baseload (Section 5.10) capacity. DSM is historically defined from the perspective of centralized (Abstract) power supply side actors and grid managers.

Power supply based on renewables requires an entirely different approach with variability in time and flexibility; for example, real-time pricing of electricity instead of fixed TOD tariffs [121]. Most studies on dynamic tariffs also look at lowering demand to reduce the burden on large-scale capacities (generation, transmission) in the public grid [116], and the effects of dynamic tariffs are highly dependent on enabling technologies that allow end-uses to be controlled remotely [2,122]. The deployment challenge is substantial as the willingness to accept this kind of control among customers is questionable [123], due to high level of intrusion on daily life [2], as well as the high level of distrust towards incumbents among households [124].

In the case of DR responding to supply of installed capacities of the end-users (prosumers (Section 5.7)) themselves, this may be different. An intelligent grid (frame: "smart grid" (Section 5.13)) would provide a "fully automated electric power system which has the authority to control and optimize the operation of all its interconnected elements, in order to operate generation, transmission, and distribution safely and efficiently" [125] (p. 66). Much of the infrastructures of distributed generation (Section 5.7) involve energy provision by prosumers to themselves [104]. With microgrids (Section 5.13) based on prosumer's capacities of generation and storage, the DR system must support the infrastructure and investments in the microgrid, in order to enhance the feasibility of the distributed energy system's infrastructures. The frames of DSM and DR within a microgrid do not run parallel. The ultimate questions are: who controls the DR system, and whose capacity is served? The answer to those questions are relevant for the acceptance of the system by the prosumers and are crucial for the willingness of consumers to cooperate in the co-production (Section 5.12) of distributed energy systems and become prosumers [48,50].

5.7. Distributed Energy Systems

While originally the term "distributed" was attributed to units of generation [59], its current meaning goes far beyond mere power generation systems to storage and other adjacent technologies that support renewables' generation. Usually it concerns small capacity units, not part of a centralized power system, located near the electricity load, close to end users [47,126]. Such distributed energy systems are not directly connected to the transmission network but can supply excess power to the distribution network [127,128]. Sometimes the term "distributed" has indeed replaced "decentralized" (Section 5.4) in the terminology of some policy agents. For example, the US Environmental Protection Agency states that distributed generation may serve a single structure, such as a home or business, or may be part of a microgrid (Section 5.13), such as at a major industrial facility, a military base, or a large college campus. When connected to the electric utility's low-voltage distribution network, distributed generation can help support the delivery of clean, reliable power to additional customers and reduce electricity losses along transmission and distribution lines [129].

The original definition's most fundamental characteristic was its recognition that distributed systems could be located at the customer side of the meter [59], which implies essentially that running these distributed systems does not take place under the control of a manager in the public grid. In the centralized (Abstract) grid the meter is legally defined as the ultimate point of the grid, literally in the end user's property, fully controlled by the grid manager, in a centrally defined tariff regime [130]. For distributed energy systems the crucial question becomes 'where is this meter located?' Does the grid managed meter still measure individual customer consumption, or is there an entire microgrid community at the other side of the meter [50,131,132]? Distributed Energy Systems or Resources encompass complete microgrids (Section 5.13) with multiple prosumers [87,133], common operated (Section 5.12) storage capacities (including electric vehicles), a common operated internal demand response (Section 5.6) system [134], and intelligent monitoring and control systems to balance the variable power of different renewables with local variable consumption and storage before entering the grid [50,84]. These distributed systems become the cornerstone of the intelligent grid, framed in policy as the smart grid (Section 5.13).

The juxtaposition of centralized vs. decentralized (Section 5.4) is fundamentally challenged by the conceptual ideas of the prosumer and distributed energy systems. This can be recognized in studies that still apply the terms "decentralization" or "virtual power plants" (Section 5.2) in examining the consequences of distributed systems managed by prosumer communities. The bottom line is that distributed systems seriously threaten the electric utilities' business model of centralized generation [135].

The term decentralized (Section 5.4) does not adequately capture the form, the management and control of such distributed systems in microgrids (Section 5.13). These systems emerge with a large geographical variety. They accommodate various aspects: physical (location and energy resources), social (composition of the community of prosumers; socio-economical context), and technical (applied energy infrastructures). Therefore, these microgrids are socio-technical systems that emerge with enormous variety, requiring high level of flexibility concerning their design and management. They should be locked-out of uniform standards, and hence their governance should start from an entirely different perspective—as polycentric, hybrid, flexible, and adaptive governance systems [50,103].

5.8. Energy Democracy

Looking from the perspective of how to shape the power supply system, the distributed energy system itself becomes a socio-technical system. While not yet common in policy circles, this concept is crucial for theories of innovation and transitions [136], with the social side receiving special attention. Similar to social-ecological systems [137], a distributed energy system (Section 5.7) has two physical and two social interacting subsystems. The latter are the community of users and the governance system [50]. A significant part of the multi-level governance system will operate as adaptive self-governance [102,138]. Systems that incorporate substantial solar power and common storage (Section 5.12) facilities, in particular, are based on co-production [50,131]. Prosumers (Section 5.7) make most investments (financial, social capital, and land for siting infrastructure), and if the infrastructures are co-produced (Section 5.12), the cooperating partners become energy and microgrid (Section 5.13) communities [47,139].

Taking society and communities as the starting points leads to the idea of "community energy" [140]. Here the priority is to enhance community values by finding a common and shared interest (Section 5.12) in any kind of project related to energy, not necessarily renewables. Generally, the objective is to exploit symbolic resources such as shared identity or desire for strong, self-reliant communities [141]. This frame emphasizes the power of bottom-up approaches rooted the civil society. In other words, most cases are projects with strong grassroots momentum, which seek to unleash the social capital of their community [142]. Therefore, community energy is sometimes "more about the community than the energy" [140] (p. 977). In this frame the energy part is often undefined. The focus of research is on the hard struggles of grassroots initiatives, facing firm obstacles even with relatively simple single source projects. Most of these obstacles are raised within the frame of locked-in centralized power system, which includes legislation and in policies. In fact, in the last decade these regimes have even become more hostile toward community initiatives such as cooperatives [143,144].

Because of the multiple, varied interpretations of the term "community" [145], the concept of energy community remains problematic. Often the idea is associated with the normative frame of "energy democracy", with also strong activist's roots. Energy democracy is usually described more as a movement rather than a clear concept [139]. The idea is associated with energy rights and energy or environmental justice [146]. The "energy democracy" frame is radical in that it demands accountability and democratization of a highly technocratic (Abstract) sector with substantial state involvement [147].

Both energy democracy and community energy are about the claim of access to and control over energy provision. Indeed, community ownership, particularly common ownership (Section 5.12) of renewables, can be a key driver of community acceptance [148–151]. In the Renewable Energy Directive II, the EU defines a renewable energy community as a legal, autonomous entity, based on open and voluntary participation, effectively controlled by community members in the proximity of the "renewable energy projects owned and developed by that community" [152]. Effective control would imply that the community could also decide who can access the electricity they generate; however, the legal frames generally still limit consumption to individual prosumership, prohibiting peer-to-peer (Section 5.14) sharing within the community, a crucial element of effective intelligent microgrids (Section 5.13).

The energy democracy frame is linked to the possibilities of involvement and more "power to the people" through the transformation of energy provision towards renewables [146]. A conceptualization of "energy democracy" states that "the prosumer (Section 5.7) becomes an idealized citizen of energy democracy" [148] (p. 32). Although described with the general notions of small-scale renewable generation units, the proximity between generation and end use, and the recognition of the distributed (Section 5.7) character of renewables, there is no clear conceptualization of the physical and technical design of the power supply. The frame remains focused on the STSs social side, but the efficacy of the community energy idea could increase as options for co-production (Section 5.12) of distributed energy systems in community microgrids (Section 5.13) multiply.

5.9. Green Power

While widespread and suggestive, the frame of the label "green" in energy remains a very fuzzy concept. Beside wider use, in the energy domain sources of energy can be claimed to be 'green', with derivates like 'green certificates' and 'green tariffs'. All are used for selling energy that are pushed forward by energy companies (Section 5.12) or policy actors as 'renewable' [153]. The presumption is that because of higher environmental awareness consumers have higher willingness to pay for, or stronger intentions to invest in, green power than for conventional energy [154,155]. The frame is in practice a policy claim as well as a marketing term [156]. The claims may be contested, and within the environmental movement itself it causes great disagreement [157] particularly around cases of biofuels (Section 5.1), woody biomass for power plants (Section 5.2), waste incineration, and hydro with severe ecological impact.

The implicit suggestion seems to be that the term "green" is put forward for all "sustainable energy", which appeals to a rigid and solid interpretation of ecological sustainability. Yet there is another type of use of "green", literally as a label restricted for its use to indicate biomass (Section 5.1) and biofuels. Possibly, in this case green literally makes the most sense, but because of the existing wide claims it is adding to more confusion. Indeed, in this case "green" is anything but ecologically sustainable, as shown with sustainable water use, for example [158].

5.10. Intermittency

Renewables are based on variable flows instead of carriers with sunk energy such as fuels. One of the most persistent and strongest frames, reinforced by our habituation to constantly available energy and power, is to emphasize the variability of supply by the flow of renewables by labeling it as "intermittent" [159,160]. The mental shortcut is that intermittent sources cannot generate for "baseload", which implies that we need continuously generating power stations or non-dispatchable power stations [58], in practice mostly coal and nuclear.

The baseload frame is part of the centralized power (Abstract) supply paradigm. It describes the planning of large-scale power plant (Section 5.2) capacity, based upon the projected consumption curve [161]. The minimum load in the entire grid defines the generation that is required 24/7. The effectiveness of this frame is illustrated by proposals to create a renewables' supply within the range of minimum demand without challenging the concept of baseload, by enhancing the capacity factor of wind through greater geographical spread and interconnection [162] or by applying types of renewables' energy conversion suitable for baseload (e.g., concentrated solar power) [163]. It has long been known that geographical dispersion and combining different sources may indeed increase the inclusion of variable resources (Section 5.10) [164,165]. Still, the frame remains they are fully intermittent, and in the baseload model of capacity planning, the costs of conventional generation are attributed as extra costs to renewables "as a result of increasing backup capacity requirements" [166].

Looking at the other side of the coin, the variability of renewables, their integration can be improved by introducing high grid flexibility [114,118]. The conceptual counterpart of variability is the "lumpy", inflexible, large-scale capacity (Section 5.2) of mostly baseload powerplants [167], that would produce increasingly large amounts of "unusable PV generation" [159]. Under current practices of centralized (Section 5.4) grid management, the easily applied strategy to spare the constantly spinning baseload capacity, is curtailment of renewables [114]. Consequently, this implies higher costs and higher investment risks for investors in renewables, putting their deployment at risk and reducing low carbon-generated power [168].

Instead, integration asks for hybrid systems with diverse renewable sources and flexible capacities of peak absorption and storage [169,170], for example distributed energy systems (Section 5.7) in which options for combining and balancing renewable sources, storage and demand response (Section 5.6) in microgrids are used [134]. Integrating these microgrids in the "smart grid" (Section 5.13) would mean the interconnection of systems that could possibly limit the "must-run baseload generators" [114].

5.11. Not in My Backyard (Nimby)

This frame is probably the oldest and most common among policymakers and developers. First articulated for nuclear and hazardous waste, it was it eagerly claimed by policymakers to explain the painful processes of constructing new plants (Section 5.2) [171,172] and similarly by developers to outline the challenges of wind-generation schemes [173]. It is possibly one of the most attractive mental shortcuts for decision-makers—a pejorative shorthand that dismisses any resistance as obstruction, as irrational, and selfish, thereby legitimizing all efforts to escape from considering the real issues of the complicated acceptance process [174].

The "backyard" frame is continuously reinforced in case studies in areas with predominant technocratic (Abstract) and hierarchic decision-making regimes. It starts with the attribution of community acceptance as the prime barrier to projects, with the knee-jerk reaction that this must obviously be "nimby" (Not in My Backyard). "The nimby effect is a natural reaction of a person to the unknown, in particular, to unfamiliar technologies" [98] (p. 12) is a recent example in a CCS (Section 5.3) study from Russia. The frame is pre-eminently related to dominant discourses because dominant actors use strategic resources to frame the content of the dispute. Therein lies another strength of the nimby frame: it fits two different ideological mainstreams. With the roots in market-oriented (Section 5.12) views and outright neoliberal thinking [175,176], it is also attractive for centralist (Section 5.4), hierarchical and technocratic (Abstract) policies emphasizing the general public interest [177]. These ideological views relate to dominant characterizations of renewables as either private or public (Section 5.12) goods, neglecting the emerging character of a common good (Section 5.12).

Although debunked since decades as an invalid explanation of problematic community acceptance—see the last paragraph of this entry—researchers keep looking for traces of nimby. When they do, they sometimes seem surprised: "people living in the vicinity of WTs paradoxically perceive them more positively than do people living further away from them" [178] (p. 2). Calling this observation as a "paradox" also reveals the base assumption about the visual impact of infrastructures associated with technocratic and centralized decision-making. "Visual impact" is conceptually highly complex, but in policy frames it usually becomes extremely distorted. First, infrastructures like wind turbines or solar arrays are often only associated with negative visual attitudes ("visual pollution"). A second simplification, also leading to the use of viewshed-calculations in decision-support systems (Section 5.5) [179,180], is the equalization of visual impact with mere visibility. However, in real decision-making processes visual impact is not an assessment of per se negative aesthetic quality of the structures, but the change in the landscape's perceived quality, invoked by the siting of the infrastructure. This is primarily guided by the individual's assessment of the landscape at the site [48,181], so visual impact cannot be covered by visibility. It is not a unique characteristic of the installation but rather an individual, socio-cultural valuation of landscape at the site. The facility itself is generally assessed in terms of infrastructure looking "in place" or "out of place" [182]. This contestation can be found in the juxtaposition of the concept of "energy landscapes" [183] and the outright rejection of any reference to wind and solar plants as "farms", which would mean "hijacking the rural environment" [184] (p. 192).

Although strong as a frame, as an explanation of community acceptance processes nimby is an empty concept. The literature has criticized nimby as invalid and pejorative soon after studies on wind deployment had started [173], but the frame persists although currently it is one of the most frequently debunked false claims [174,176]. “Nimbyism may be an easy to use and beguilingly simple way of thinking about objections to technology proposals, but social science reveals how inadequate it is as a means of capturing the dynamic interplay between the multiple actors involved in renewable energy deployment.” [185] (p. 321).

5.12. Public, Private, or Common Good

Since the integration of the early local grids in larger centralized monopolistic grids in the early 20th century [74], electricity provision was considered a “public good”. With the ongoing centralization and the wave of neoliberalism and privatization of power production in the 1990s, the generated power became defined as a commodity, a “private good” produced in competition by mostly private companies [186]. Electricity is provided by privatized actors (generators), while the service of distribution is provided by trading companies (utilities), which engage in wholesale purchasing and retail sales. For the distribution they are using the public grid, a monopolistic infrastructure, and connection to it is a “public good” provided by the DSO, a grid operator controlled or owned the state.

The centralized STS is a regime of which the elements of either public and private goods are firmly defined and laid down in legal regulations. This is a crucial element of the regime that supports the system’s lock-in [69]. The “rules of the game—institutions [47,132,136,151]—are challenged by the emergence of prosumers and distributed energy systems (Section 5.7). Prosumers do primarily produce a self-service [105,106] and could co-produce the infrastructure of distributed systems and exchange energy (Section 5.14) peer-to-peer in microgrids (Section 5.13) under a sharing economy model [187]. Their product must be classified as a “common good” instead of the dominant framing as a private commodity. Policy is yet to recognize this potential, showing how the power supply lock-in is not only embedded in sunk costs and vested interests, but also in paradigmatic views. Currently, grid managers are legally obliged to connect consumers and to deliver electricity regardless of consumption by others, a typical public service. Most legislation and operational procedures of power supply are also enforcing that prosumers are delivering a market-commodity. For example, the EU directive: “Support schemes for electricity from renewable sources shall provide incentives for the integration of electricity from renewable sources in the electricity market in a market-based and market-responsive way” [152] (art. 4:2). Although several countries still have some sort of support for excess power delivered by prosumers, their excess power is legally defined as private production, which must be fed into the public grid and cannot be shared directly via physical peer-to-peer (Section 5.14) connections with prosumers who contribute to their distributed energy system.

For common goods (Table 2), the concept of co-production [138,188] is essential and, therefore, also relevant for renewable energy. The first recognition of this was that co-provision would emerge as a new phenomenon in power supply [189]. The concept of common goods particularly applies to sustainable harvesting and use of natural resources (i.e., renewable energy flows) [48,190]. Co-production of infrastructure to provide the common good in social-ecological systems [137] finds its counterpart in the STS of distributed energy systems (Section 5.7) [50]. Within independently operating microgrids (Section 5.13), the common infrastructure also requires co-production in terms of cooperation in investments of finances, of space for siting, and of knowledge about how to install and operate such infrastructures [47].

Table 2. Typology of goods and services; adapted from Ostrom [188] (p. 24).

		Substractability of Use	
		High (Exclusive Substraction)	*Low (Non-excludable)*
Difficulty of excluding potential beneficiaries	*High: Rivalrous consumption*	Private good/service	Common good/service
	Low: No rivalry inconsumption	Club/toll good/service	Public good/service

Co-production by prosumers is based on the concept of the shared economy [187], with common distributed infrastructure (Section 5.7) being shared in the microgrid: the energy, the installed storage capacity, and the space for infrastructure. Most of the devices, such as generation units or storage capacities, as well as the space allocated can either be individually owned (e.g., rooftop PV panels, batteries or electric vehicles) or they may be commonly constructed and owned (e.g., ground-mounted PV, arrays on rooftops of apartments or community buildings). Both can be used in the common energy management and control system [191].

Electricity is rivalrous: a kW provided to one household cannot be used by another (Table 2). Any prosumer capturing the power of the sun with rooftop panels does so without interference by others—if it is not interrupted by tall buildings or high trees: the issue of 'resource rights' [192]—so no one can be excluded once the 'right to prosume' is settled. The exclusiveness only concerns the available space, as it is scarce and there are competitive functional claims [48], and it is beneficial to cooperate in order to acquire the area for the infrastructures. This co-production in distributed energy systems (Section 5.7) concerns the creation of common value, so it becomes a common good [190,193], and the capacity of generation, transmission, storage, is intelligently managed in a common system of operation and control, the "smart (Section 5.13) microgrid".

5.13. Smart Grid

Policymakers often imply that their policy spurs innovation, but the terminology that is used to frame this claim usually is restricted to replacing old technologies by new ones, or "architectural innovation" (Section 2.2; [194]). A notable example is the popular buzzword "smart grid". The term "smart" has a wider popularity as a frame to claim sustainability achievements. For the "smart city", for example, but here claims that smart leads to better sustainability do not seem to be fulfilled due to strongly one-sided technocentric interpretations of the term [195].

Policy definitions of smart grids still reveal a rather technocratic (Abstract) view as they tend to focus upon a set of technical innovations. The US Environmental Protection Agency states that "the digital technology that allows for two-way communication between the utility and its customers, and the sensing along the transmission lines is what makes the grid smart." [129]. The EU: "Smart electricity systems, or smart grids, are electricity networks set up to continuously process and respond to the behaviour and actions of producers and consumers in order to efficiently deliver electricity supplies" [196]. Climate change mitigation policies proclaim "transition" as a key aspect to limit the effect of climate change. The smart grid should become a cornerstone of this transition, although the relation between smart grid development and climate change remains rather undefined [197]. Moreover, architectural innovation is at odds with the transition concept, because a transition is not a synonym for a set of incremental changes. On the contrary, all perspectives on innovation and transitions emphasize the STS character [29] of power supply systems [198].

A comprehensive definition of the future smart grid is not simply the combination of power supply with information and communication technology [129]. Beyond changing the hardware, it should be a system that is organized and operating in an entirely different way: "a network of integrated microgrids that can monitor and heal itself" [199] (p. 570). In this definition the microgrid, with its internal control system for balancing various renewables with demand (Section 5.6)—a distributed energy system (Section 5.7)—comes to the fore as a fundamentally different structure. "Smart grids as well as microgrids are expected to continue to become a new energy paradigm, with microgrids allowing for higher shares of local renewable energy, prosumers trading within communities, and increased resilience" [200] (p. 201). This rapidly unfolding paradigm of distributed systems with multiple energy sources in integrated microgrids is seen as key for decarbonizing the power supply [201–203].

The centralized (Abstract) grid with its large-scale inflexible hardware is also an organizational structure, a package of business models, institutionalized knowledge and practices, which are strongly entangled with state hierarchy. It is run by "big unwieldy corporate machines" [31] who enact unfavorable policies towards distributed generation systems and microgrids, seen as threats to their business model [204,205]. To establish innovative systems, we must overcome the inertia and lock-ins in the existing systems and the regimes that support them [46,206]. Prosumers in microgrids reduce consumer demand, which increases power market prices, and thereby further sink demand, which could lead to a "utility death spiral" [205,207]. Framing is a strategy to prevent this disruption of the current system. If the smart grid is only defined by introducing technology (ICT) that is adapted to the hierarchically oriented centralized paradigm, microgrids could be centrally controlled (Abstract) with it [208]. The question would be whether prosumer communities would accept this.

The typical example of this is the framing of advanced metering devices. Remotely readable digital meters, framed as "smart meters", are replacing the mostly analogue older types. This is heavy framing, as the smartness is only a strong policy claim. The meters certainly do not offer prosumers significant new opportunities to manage their consumption in relation to their supply, particularly not if they want to share common benefits (Section 5.12) with other prosumers by exploitation of renewable sources. The prime objective of the meters is demand side management (Section 5.6), whereas in the distributed energy system (Section 5.7) frame intelligent sensors and processors would be part of an automated management and control system serving the optimal utilization of distributed renewables, storage and demand response (Section 5.6) in microgrids [209].

As the microgrids integrate distributed sources and aggregate individual consumers, prosumers and storage, to the public grid a microgrid can appear as one single prosumer [210]. This substantially decreases the challenges of integrating distributed resources into the public grid [200]. The power exchange with the public grid is minimized, hence reducing the dependency of the microgrid on the relatively expensive power from the public grid [84]. This also contributes to solving transmission capacity issues in the distribution grid, as it reduces peak demand from as well as peak feed-in into the public grid. The reduction of the overvoltage issue in the distribution grid would be an extra benefit as well [84].

5.14. *Peer-to-Peer*

Anyone producing power within the centralized grid can feed electricity into the public grid, but institutional conditions determine whether this really happens. The institutional changes linked to the introduction of feed-in tariffs (FIT) in Denmark and Germany around 1990 were so successful because they dealt with the establishment of the fundamental right to deliver to the grid combined with risk reducing long-term, stable and reasonable remuneration [211]. Today most FITs have been abolished and typically replaced by competitive market (Section 5.12) instruments, particularly auctions for renewables feed-in options. Substantial problems have risen as these new regulations tend to counteract acceptance [212], are crowding out community energy, slowing down renewables' deployment [144,212]. However, simultaneously the interest in distributed generation (Section 5.7) is shifting from feeding into the grid to possibilities of direct mutual energy exchange among consumers and prosumers—peer-to-peer (P2P) energy delivery [213].

Official EU policy attributes certain value to the general notion of community energy (Section 5.8): "Renewable energy communities must be able to exchange energy produced in the facilities owned by the communities concerned" [152] (art. 71). Legally, in all member states direct exchange of electricity is prohibited—with some exceptions to experiment. Now prosumers are forced to exchange via the existing, public grid. Consequently, the current always passes two meters, and even more when stored in a common storage (Section 5.12) facility. Both are not controlled by the prosumers, and the distributed generated power places an extra burden on the capacity of the distribution network. This can largely be avoided by balancing supplies and demand with shared distributed energy systems. These require sophisticated monitoring and information-processing capacities beyond the current remotely readable metering devices.

Equally important, all models used for studying the performance of these systems assume P2P energy exchange among prosumers [209,214]. P2P delivery "is able to reduce the energy exchange between the microgrid and the utility grid" [215]. Laboratory studies on the performance of these distributed energy systems in microgrids (Section 5.13) show that the free P2P flow of electricity within the system—between generation units, individual or common storage (Section 5.12), and (pro-)consumers—is an essential characteristic determining the performance of such microgrids [215].

A substantial part of P2P electricity will not be directly distributed among the members but stored in common storage and delivered to others in the microgrid later [216]. Balancing all flows, capacities and demand response (Section 5.6) requires full control by the distributed energy system's (Section 5.7) monitoring system within the microgrid. Interference by the public grid manager would disturb this with consequences for optimal utilization by the prosumer's community. Hence, P2P becomes a key condition for the establishment and utilization of jointly installed and managed generation and storage infrastructures [50,131,217,218].

Internal microgrid (Section 5.13) P2P interaction creates the fundamental condition for implementing reciprocity and trust among the users of the microgrid and for sharing the efforts and benefits of co-production [48,138]. This is characterizing renewables in distributed energy systems as a common good (Section 5.12) [50]. This also distinguishes it from the market-driven framing of renewables' power as a commodity (Section 5.12). The current legal and institutional frames obstruct P2P also because the metering associated with centralized (Abstract) tariffs creates transaction costs. Blockchain technology is a recent option that challenges the institutional frame of the current design of power supply [85,219,220]. Much research is still needed, but distributed ledgers seem a strong enhancement of the distributed energy systems' frame [200,217,221], as they provide an opportunity to create mutual trust and to avoid most of the extra transaction costs for prosumers found in control by the centralized grid.

6. Conclusions

6.1. Related Frames

After the first selection of frames found in the literature (Table 1), the glossary of Section 5 provides an overview and a discussion of all frames. The choice was made not to present and define them one by one, but to discuss them directly in relation to other frameworks and alternative perspectives in the literature. Overviewing the discussion in Section 5, some general trends can be observed. Most entries discussed several related frames and, moreover, on several occasions they overlap in conceptual or practical meaning. The most significant relations are mapped in Figure 2.

As a general trend, the first image that emerges as defining the most prominent frames is that many are about who is controlling the new infrastructure and the spatial configuration of the infrastructure. This control is about the sheer economic value of power generated with renewables, in particular by whom, for whom, and who is defining the conditions. At the right wing of Figure 2 we see frames that characterize and appreciate this economic value within the existing, fixed STS of the centralized and hierarchically organized electricity supply. The frames here reflect partly the idea of power supply as a public value—in economic terms: a public service—and these frames are strongly related to centralist decision-making with a strong element of 'government' instead of 'governance'. The centralist perspective concerns energy provision, but also the attribution of space to the new infrastructure. On the other side of Figure 2 we see several prominent or recently emerging frames that fundamentally challenge this characterization and valuation.

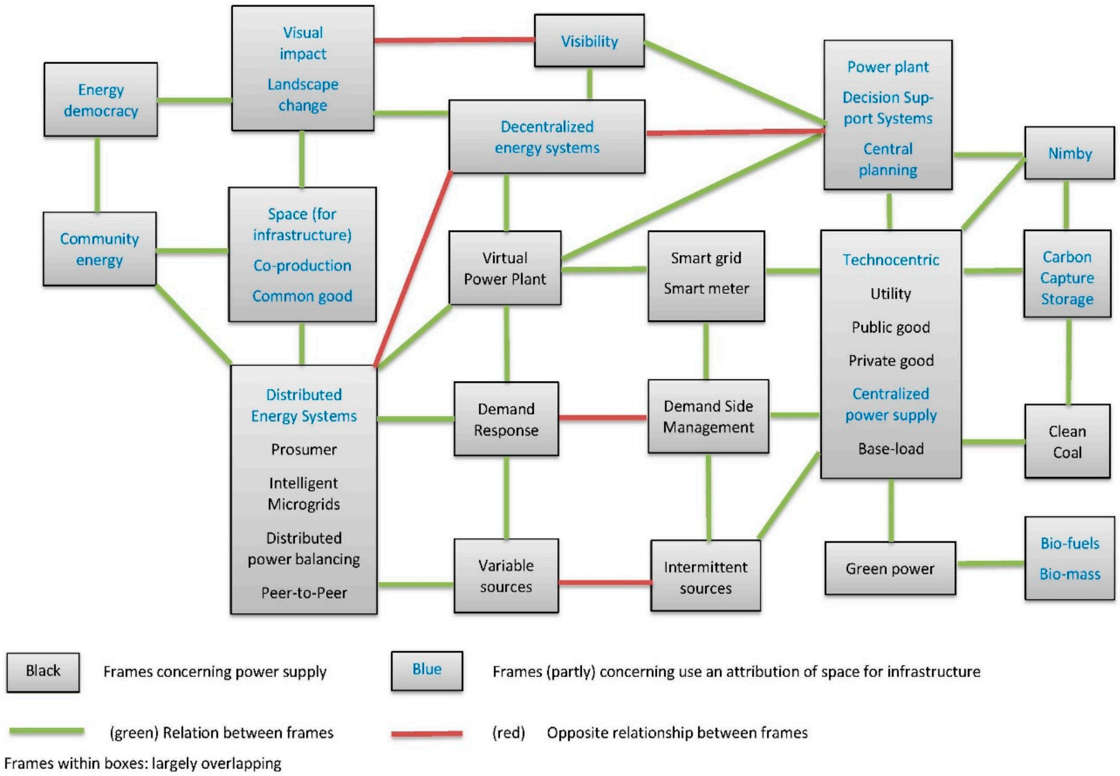


Figure 2. Overview of overlap and relations between frames as discussed in Section 5.

Several frames tend to be part of similar narratives in the literature. Possibly they may be pushed by different actors in policymaking, but their content appears to be in line. Those frames are listed within one box. Others are strongly related, which is indicated by connecting them. The overlapping and related frames are not always used in a consistent way. For example, "distributed" (Section 5.7) and "decentralized" (Section 5.4) are often presented as synonyms, but particularly the use of the term decentralized remains fuzzy. Mostly, it is simply used as an undefined opposite for centralized (Section 5.4).

6.2. Interpreting the Bias

Framing aims at setting the agenda, mainly by issue framing [52] for defining issues as well as for pushing certain solutions. Because of the lock-in of STS of current power supply [30,47,69], most frames representing the technocratic paradigm are connected to "centralized (Section 5.4) power supply" continue to dominate. This applies clearly to the frames concerning power generation, management and distribution, but it also concerns centralized thinking in adjacent policy realms. Several frames in Figure 2 have been marked as relevant for decision-making about the space that needs to be attributed to all the infrastructures related to renewables. The ones at the right side tend to reflect hierarchical and/or centralized thinking and emphasize centralist control over attribution of space to energy infrastructure. Even in this policy domain that is distinguished from energy planning, some are clearly related to the central power supply paradigm. An important question arises, as the main trend in research on community acceptance clearly is that any top-down planning generates problematic acceptance processes, and that participatory decision-making and distributional as well as procedural justice are crucial, even in cases of renewables' power plant siting [4,7,48,177,185]. In this investigation we focused upon the frames, and an important question for further research could be why centralist frames about power supply are so easily associated with centralist and hierarchic perspective in spatial planning.

As a manifestation of the lock-in, the dominance of centralized (Section 5.4) power supply persists despite the clear counter-frames in the academic literature that fundamentally challenge their position. Some frames may be even more dominant, as they are hardly questioned and tend to be followed without questioning them even in mainstream academic literature. Possibly the most fundamental expression of this is that many studies only describe goods and services produced and delivered in the STS of power supply as either "public" services (associated with state regulation) or "private" commodities (associated with markets). Even for researchers the juxtaposition of public and private in power supply is so self-evident that when they are investigating local distributed energy system (Section 5.7) communities, they often do so under the umbrella of "local energy markets" [85,217–220]. So even if the basic activity to jointly create such a distributed energy system is co-production (Section 5.12), the system remains described in market terms. The mutual distribution of investments and returns is indeed an essential part of the 'self-governance' [50,137] in such systems, but the most important feature really is that it is not about competition but about cooperation. Even in cases of relatively simple forms of community energy (Section 5.8), for example single source community owned renewable generation, investigations focus on how this activity originated from social capita, but still the final models are usually not named after the method of co-production from which they originate, but are referred to as 'business cases' [222].

Clearly, one could say that if alternative perspectives of renewables as a natural resource and establishing common infrastructures (Section 5.12) as outcomes of cooperation instead of competition or state regulation are not recognized in academic studies, the agenda setting by framing is obviously still effective. Nevertheless, whereas the counter-frame of renewable energy as a common good is hardly existent in policy realms, and after its introduction in 2002 [189] it remained almost unnoticed for a long time, recently this concept has been rapidly gaining ground in the literature [50,150,190,193].

6.3. Agenda Setting

Since Schattschneider [223], interest group scholars have explored the arguments and issue definitions that interest groups promote, and their effect on the groups' policy influence. This has led to the recognition and formulation of the concept of "non-decisions" [224]. "All forms of political organization have a bias in favor of the exploitation of some kinds of conflicts and the suppression of others because organization is the mobilization of bias. Some issues are organized into politics while other are organized out" [223] (p. 71). Framing is one strategy—among others—to mobilize this bias by trying to avoid that conflicting issues are set on the agenda. Several of the frames discussed in this paper highlight the efforts to amplify certain issues and solutions on the agenda, while stifling others.

For example, in the EU RED II directive [152] considerable attention has been paid to community energy (Section 5.8) and to the right of prosumers "to generate electricity for their own consumption, store it, share it, consume it or sell it back to the market" [225] (p. 5). At first glance, this reads like support for decentralized (Section 5.4) cooperating prosumers, but in fact they are still framed as prosumers producing a private commodity (Section 5.12) to sell on a market, not to each other, their cooperatives. The character of renewables as a natural resource and a common good that is co-produced (Section 5.12) is not mentioned. The rapidly emerging fundamental precondition for P2P (Section 5.14) for cooperation in distributed energy microgrids delivery is frequently mentioned in the literature, but in policies it has hardly (yet?) been recognized. It is not present in mainstream policy, but also only a few times has it been clearly phrased as part of the narratives of community energy (Section 5.8) or energy democracy [139,190]. It rapidly becomes prominent in studies on the future power grid, but it is not a policy issue, so it remains a "non-decision".

From the perspective of policy changes, transitions can be approached from different political theories. For example, the advocacy coalition framework (ACF) has been used to study the policy changes needed for an effective transition of the energy system [226,227]. An essential element in the advocacy coalition framework is the concept of policy belief systems. The frames in the glossary are part of such structural belief systems—not free-floating ideas. They are grounded in institutions, patterns of behavior that tend to replicate themselves and that are structured by social norms and rules. The cognitive component of these patterns are the beliefs, perceptions and appreciations that serve as the foundation of the frames that actors try to push [16]. Within the ACF, the belief systems consist of three categories: deep core, policy core, and secondary aspects [228] (p. 31). The theory describes how hard it is to change core and policy core beliefs. It explains why new concepts in science are hardly picked up in policy when they question core and policy core beliefs. However, it does not explain why these core beliefs, once they are framed, affect the thinking in the academic literature. This should be an important domain of further investigation: why and how do the core beliefs in policy have such an impact on mainstream research in the domain of energy?

6.4. Structural Differences

The clear connections between several frames indicate that they are part of more or less coherent visions, even concerning policy domains beyond energy, such as spatial planning. This finding is in line with other studies that identified groups of related "imaginaries". For example, one dominant imaginary that is characterized by market mechanisms and represents a technology fix (Abstract), is framed around energy costs, security, and climate change. Another one is motivated by a broader set of ethical, equity-related and environmental issues [229] (p. 986). In the glossary, we can recognize a similar juxtaposition, as the relationships that are opposed (Figure 1, red) can be found mainly between the right- and left-hand sides. However, there are explicitly some structural differences within such imaginaries, and some of these contrasts are possibly caused by sustained framing originating from successful dominant centralized power supply frame. The prime example is the distinction between "decentralization" (Section 5.4) as the label for systems that deviate from the centralized model, and "distributed energy systems" (Section 5.7). An example at the other side is the "community energy" (Section 5.8) concept, which covers several socially defined characteristics and normative objectives—democracy, inclusion, justice—without representing a clear coherent view on the design of the power supply system. For some concepts, it is extremely important to recognize whether they are analyzed, defined, or even pushed from strongly framed starting points. The prime example here is virtual power plants (Section 5.2). Studies reveal that this is basically a concept describing variants of distributed energy (Section 5.7) systems [230], but the danger of the label 'plant' is that the internal dynamics of the STS as a distributed system remains unnoticed.

Studies now show that differences in community acceptance of technologies have major consequences for the entire power supply system. Unrealized projects affect the entire system and the potential to reduce carbon, as well as the costs [231]. Almost any frame is justified with legitimizing concepts such as 'green' (Section 5.9) and 'sustainable' and being part of climate change mitigation strategies. During the last decade in most countries the claim to further an energy transition has been added to this. The consequence of that should be the inclusion of the notion that this concerns a transformation of a social-technical system. That is clearly not yet a done deal, policies still seem to be based on transition pathway scenarios based on techno-economic variables alone, and this technology fix is a receipt for severe acceptance issues.

Clearly, several frames at both sides do not do justice to either side of the STS—society and technology—or ignore it outright. Obviously, 'frames' do not rule the world, and neither do they determine the course of any transition. The fundamental issue is the recognition of structures—institutional frameworks—that offer actors the power to define the agenda. How do these actors operate when they try to set the agenda, and what strategies and tactics do they use? One way to find these is to recognize the content of the frames in which the issues around the deployment of renewables are described by powerful actors. Once these are recognized, it can be investigated where they come from, when and how they are used, and most important, why they are used and how the bias they generate, also in academic work, can be avoided.

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