Titel der Dissertation:

Sustainability transition of the electricity system: Levels, actors and mechanisms

Der Fakultät Wirtschaftswissenschaften
der Leuphana Universität Lüneburg
zur Erlangung des Grades
der Doktorin der Wirtschafts- und Sozialwissenschaften (Dr. rer. pol.)

genehmigte Dissertation von

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geboren am 13. September 1978 in Limanowa, Polen

Eingereicht am: 19. Januar 2021

Mündliche Verteidigung (Disputation): 07. Juli 2021

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Die einzelnen Beiträge des kumulativen Dissertationsvorhabens sind oder werden wie folgt veröffentlicht:

Paper 1

The underlying factors in the uptake of electricity demand response: The case of Poland

Author: Katarzyna Ewa Rollert

Published: Utilities Policy, Volume 54, October 2018, 11-21,

https://doi.org/10.1016/j.jup.2018.07.002

Paper 2

Gaining legitimacy for sustainability transition: A social mechanisms approach

Authors: Ursula Weisenfeld and Katarzyna Ewa Rollert

Review and re-submit: Environmental Innovation and Societal Transitions / August 2021

Paper 3

Demand response aggregators as institutional entrepreneurs in the European electricity market

Author: Katarzyna Ewa Rollert

Under review: Journal of Cleaner Production / August 2021

Veröffentlicht im Onlineangebot der Universitätsbibliothek unter der URL:

http://www.leuphana.de/ub

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Acknowledgements

Elaborating this dissertation has been a very important time of my life: While I have broadened my scientific perspectives, I have also grown as a human being, a mother and a wife. In particular, I revised the importance of patience, regularly questioning 'the taken for granted' and discussing things. This experience would not have been possible without the support of many people:

First of all, I am grateful to my supervisor, Prof. Dr. Ursula Weisenfeld, for her continuous inspiration and encouragement throughout the whole research and writing process.

I also thank Prof. Dr. Markus Reihlen and Prof. Dr. Paul Upham for being on the committee.

My dissertation would not have developed to such an interesting endeavour without the many electricity system practitioners and analysts who were kind enough to take time for an interview.

I am also unbelievably thankful to my family: my husband Florian and my sons Jan, Emil and Maximilian. Florian, you have been a source of motivation to me in particular in the phases when I doubted whether I was capable of completing this huge project. By taking on a significant part of our family duties, you enabled me to concentrate on the dissertation while providing me with the comforting awareness that our boys are in good hands.

Through your love and curious questions, Jan, Emil and Maximilian, you also unknowingly contributed to my completing this dissertation. Thanks to you, I remained focused, clear about my priorities, and learnt to continuously improve my organisational skills.

Synopsis: Key factors in enacting the sustainability transition of the electricity system

1 Introduction

Back in 2014, at the beginning of my dissertation, I intended to examine why electricity demand response (DR), a concept to make electricity demand more responsive to the constraints on the supply-side, is being utilized at such a low level in Europe compared to, for example, the USA and Australia (Bertoldi, Zancanella & Boza-Kiss, 2016; Gils, 2014; SDIA, 2020). Since DR helps to integrate volatile renewable energy sources (RES) and reduce the need for generation capacity (Eid et al., 2016; Müller & Möst, 2018; Stede, 2016), it facilitates a transition of the electricity system towards more sustainable modes of production and consumption. My interviews with key actors of the Polish electricity system for Paper 1 soon showed that investigating DR uptake involves a much deeper systemic analysis than I had originally assumed and that some parallels, but also key differences, between DR and the diffusion of other sustainable energy technologies can be drawn. In Poland, it astonished me that despite serious problems such as ageing power plants, supply security concerns and extreme air pollution this coal dependent country still sticks to its 'black gold' (Institute of Environmental Protection, 2019; Watts, 2018; Żuk & Szulecki, 2020) and largely ignores the necessity of phasing out coal and fostering sustainable energy technologies (CAN Europe, 2019; Kuchler & Bridge, 2018), a goal broadly acknowledged and legitimised by the Paris Agreement and EU directives. Paper 2 of my dissertation is motivated by this astonishment. Drawing on the multi-level perspective (MLP) as a practical framework to understand sustainability transitions (STs) of large societal systems within a broader context, my co-author Ursula Weisenfeld and I investigate the reasons for the non-transition of the Polish electricity system despite an evident window of opportunity. In Paper 3 I examine ST from the change agents' perspective and describe the challenges DR aggregators face as institutional entrepreneurs and their efforts to tackle them, thus trying to reform the European electricity market.

To sum up: The aim of my dissertation has evolved from addressing the diffusion of a single technology to the investigation of the mechanisms of ST of the electricity system including the examination of actors' challenges and behaviour when trying to induce institutional changes in this path-dependent and supply-oriented sector (IRENA, 2019). While the electricity system is well studied in ST research, it is still a highly important field of analysis due to its increasing relevance as an engine of our society with a daunting impact on climate change, its lock-ins, as well as its research bias towards Western Europe and transitions ‘in progress’ (Antal, 2019; Araújo, 2014; Geels et al., 2016; Loorbach, Avelino & Frantzeskaki, 2017), and renewable energy sources (RES) (Jacobsson & Bergek, 2004; Kuzemko et al., 2017). Despite a substantial body of literature on MLP, the explanatory power of this scientific framework still needs to be strengthened through the identification of key mechanisms of systemic change and more focus on individual actor-focused perspectives when transforming existing and establishing new institutions (Köhler et al., 2019; Sorrel, 2018; Upham, Bögel & Dütschke, 2020).

In MLP terminology, Paper 1 focuses on an innovative niche technology that struggles to anchor in the extant socio-technical regime, while Paper 2 deploys an overall systemic perspective and addresses mechanisms within and between all system levels, and Paper 3 focuses on niche actors that engage as institutional entrepreneurs to transform the existing supply-oriented socio-technical regime of the electricity system.

Drawing on MLP and inspired by the critical realist perspective (Sorrel, 2018), a philosophy of science that seeks to explain how, why and under what circumstances particular phenomena come about (or do not) (Bhaskar, 1975), this synopsis highlights the key factors for the realization of ST in the electricity system as a ‘common denominator’ of and in addition to the findings of the three papers.

The remainder of this synopsis is structured as follows: In section 2 I show the relevance of research on the ST of the electricity system using the example of Poland and DR as a niche technology. Section 2 provides an overview of the MLP framework and its limitations from the critical realist perspective. In Section 3 I identify and discuss the key factors in fostering ST. Section 4 concludes with a summary of the main contributions of my dissertation and recommendations for the direction of future research.

2 The relevance of my dissertation topic

2.1 The need for research in ST of the electricity system focusing on Poland and DR

The world is facing the challenge of climate change and its associated environmental and societal problems such as natural catastrophes, health hazards, poverty and migration. The past decade 2010-2019 was the warmest on record and the global emissions of greenhouse gases (GHG) continues to grow. Scientists and climate activists call for urgent actions to stop this trend (WMO, 2019). Limiting global warming to 1.5°C compared to pre-industrial levels requires rapid and far-reaching GHG reduction efforts in numerous industrial systems (IPCC, 2019). The European Environment Agency estimates that Europe has less than a decade to achieve this goal (EEA, 2019). There are, however, no simple solutions available and fundamental systemic changes, in other words sustainability transitions (STs), are needed. STs are radical shifts in large societal systems such as energy, mobility and agriculture towards more sustainable patterns of production and consumption to cope with grand societal challenges including climate change and its repercussions. Sustainability, defined here as seeking 'to meet the needs and aspirations of the present without compromising the ability to meet those of the future' (WCED, 1987), must be interpreted in relation to its socio-cultural context and so changes over time (Frantzeskaki, Loorbach, & Meadowcroft 2012). ST requires an interplay of developments on different system levels that overlap and reinforce each other, thus leading to institutional changes that enable more sustainable modes of production and consumption while ensuring the fulfilment of societal functions (Köhler et al., 2019).

The ST of the electricity system provides a highly interesting and relevant research topic: As a basis of light, power and heat, the electricity system is indispensable for the functioning of our society (Gielen et al., 2019). Like other large societal systems, the electricity system is characterised by sunk investments in centralised infrastructures (power plants, transformers and transmission lines) with high capital intensity and long utilisation periods as well as a broad range of actors including households, businesses, energy utilities, appliance manufacturers, policymakers and regulators. The elements of this system are interdependent and various kinds of institutions in form of technical standards, organisational and institutional procedures as well as informal practices have been established to ensure their smooth functioning. All this provides stability and reliability, but leads to path-dependence and lock-ins, thus hindering the entrance of newcomers and the uptake of innovations (Markard & Truffer, 2006; Verbong & Geels, 2010). Given its heterogeneity, the number of interconnections and the interdependency among its components, the electricity system is a complex system (Praetorius et al., 2009). Notwithstanding significant decreases, this system is still the largest source of GHG emissions. Electricity and heating account for 23% of the EU's (including Iceland) total GHG emissions (EEA, 2019) and due to the electrification of further economic sectors the demand for electricity is expected to grow (Agora & Sandbag, 2019). A cleaner electricity system can foster ST within other industrial sectors (EEA, 2019). Therefore, to achieve the goal of climate neutrality by 2050 the ST of the electricity system needs to accelerate in the EU. In the EU Parliament's European Green Deal, the term 'transition' appears 51 times (EU Parliament, 2019/2956).

In the context of Eastern Europe, ST is an under-researched topic, even though a better understanding of their lack of ambition regarding ST is crucial for the achievement of the EU's climate goals (Antal, 2019; CAN Europe, 2018; ESS, 2018). This is in particular true for Poland as the EU's fifth largest emitter of CO_2, behind Germany, the UK, France, and Italy. The ST of the Polish electricity system is, however, a particularly challenging task (Rybak & Rybak, 2019; Żulinski, 2018) with approximately 79% of electricity still generated from coal and lignite, which makes Poland one of the most coal-dependent countries in Europe (Institute of Environmental Protection, 2019). At the same time, despite dramatic levels of air pollution, this largest Eastern European country is the main opponent of EU climate ambitions (Dempsey & Khan, 2019; Kuchler & Bridge, 2018; Aljazeera, 2020).

Another research bias is the focus on the uptake of RES (Gielen et al., 2019; Kuzemko et al., 2017) although a mix of different technologies is needed to foster the ST of the electricity system. The growing share of weather dependent RES requires a higher flexibility of the whole system, to which DR can contribute (IRENA, 2019; SDIA, 2020). Nevertheless, DR, though complementary to RES (Geels et al., 2017), significantly differs, for example, regarding deeply rooted field level practices including an interplay between electricity customers and system operators, which influences its broader uptake.

In the recent two decades, the recognition of the necessity of ST as well as the amount of research and publications in this field have grown (Köhler et al., 2019; Loorbach et al., 2017). Numerous frameworks have been developed to explain and promote ST. Among the most popular approaches are the multi-level perspective on socio-technical transitions (MLP), strategic niche management, transition management and technological innovation systems (Geels, Hekkert & Jacobsson, 2008; Köhler et al., 2019; Lachman, 2013).

2.2 MLP and its limitations from the critical realist perspective

Combining concepts from disciplines such as evolutionary economics, science and technology studies and neo-institutional theory, MLP is a scientific framework that offers a 'big picture' on ST (Smith, Voß & Grin, 2010). Since its emergence in the early 2000s, MLP has stimulated a wide range of theoretical contributions and empirical applications to different societal systems including energy, transport and agriculture (El Bilali, 2019) in – though biased towards Western European countries – a number of geographical regions (Antal, 2019; Köhler et al., 2019; Markard, Raven, & Truffer, 2012; Sorrel, 2018). Some of the fruitful discussions and critiques that have advanced the development of MLP and that are addressed in my dissertation are referred to below.

MLP explains ST as a result of multi-dimensional interactions within and among three levels: niches, the socio-technical regime and the socio-technical landscape.

At the micro-level, niches are protected spaces where technical and social innovations can emerge while being shielded from mainstream market rules. Such protection – for example in form of R&D projects, actor networks or experimentation spaces – is necessary since innovations usually perform worse, in particular regarding cost efficiency, than incumbent technologies.

At the meso-level, the socio-technical regime involves dominant technologies and their material artefacts, such as, in the case of the electricity system, power plants and the grid, actors including policymakers, businesses and households, as well as the formal and informal 'rules of the game' that govern actors' behaviour, for example sectoral regulations, beliefs and cultural patterns. Vested interests, established practices and sunk investments lead to the path-dependence and lock-ins many existing socio-technical systems suffer from. While ensuring stability these mechanisms hinder the diffusion of niche innovations (Verbong & Geels, 2010).

The socio-technical landscape forms an external environment for the socio-technical regime and niches. It contains broader trends in demographics, public awareness, culture and geopolitics, supranational regulations and exogenous shocks such as wars and natural catastrophes. These macro-level developments change slowly and system actors have little or no influence on them (Foxon, Hammond & Pearson, 2010; Geels et al., 2017).

MLP conceptualises ST as a shift from one socio-technical regime[1] to another that is characterised by more sustainable patterns of supply and demand (Markard et al., 2012; Verbong & Geels, 2010). Niche innovations produce the momentum for change, while landscape pressures and systemic inefficiencies contribute to the destabilisation of the socio-technical regime, thus creating a window of opportunity for ST. As a result, mature niche innovations can anchor in the existing socio-technical regime (El Bilalai, 2019; Köhler et al., 2019).

Processes at the micro-level are described by Geels (2004) as socially embedded 'game playing,' with actions and counteractions of actors and social groups happening within the institutional setting that can be directed at either reproducing or adjusting the components of socio-technical regime. This game playing is based on differences between actors regarding power and available resources (including finance and know-how), which influences their possibilities to realize their interests and shape social rules. Such conditions open up a space for struggles. Geels and Schot (2010) conceptualize the enactment of transitions as a chain of events: 1) the existing rules of the game lead to the actors' conditioning; 2) actors interact with each other through searching, learning, collaborating, framing, and struggling in the form of actions and counteractions; 3) as a result, the institutional setting is reproduced and maintained or modified through institutional entrepreneurs; and 4) externalization and institutionalization take place (approval and retention of new institutions) (Geels et al., 2016).

The following features of ST make it a particularly distinctive and demanding field of research that requires an interdisciplinary approach: (1) multi-dimensional and co-evolutionary character, since STs involve many elements such as technologies, habits, policy, regulation and infrastructures that are interdependent and develop in parallel; (2) highly contested, since STs engage many actors from diverse fields including science, politics, industry and civil society with their different interests, resources, values and perceptions, usually leading to incumbent resistance and multiple struggles, for example over the most appropriate solutions and pathways; (3) long-term, since STs might unfold over decades due to usually long development and diffusion processes of radical innovations, path-dependence and incumbent resistance; (4) open-ended and uncertain, since it is difficult to predict which niche innovation will anchor in the socio-technical regime, which transition pathway will be followed, and setbacks, reversals

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[1] The term 'socio-technical regime' is commonly used in the MLP literature, although as Sorrel (2018) argues, it is not concisely defined and conflates with the term 'system'. In the synopsis I decided however to use the original term 'regime' to more clearly distinguish this meso-level from the overall system.

and accelerations are possible; (5) characterised by tensions between stability and change; and (6) highly dependent on public policies that are crucial to support it through appropriate regulation, standards and innovation policies (Köhler et al., 2019).

Though continuously developed and already widely applied, MLP has been criticized for several limitations (Geels, 2011; Smith, Voß & Grin, 2010; Schlaile & Urmetzer, 2019). Sorrel (2018) addresses the limitations from a critical realist perspective. Realism is an influential philosophy of science that claims that the existence of the external world does not depend on our sensory impressions, thinking, and volition, and that the world can be explored and understood. In other words, reality - that refers not only to physical artefacts, but also to cognitions and emotions - does not depend on our perceptions and actions. Since most of the world can be known, people are able to and should try to examine it. Realism implies scientists strive to create true accounts about the world within given limitations, including cognitive boundaries. While most realists acknowledge these key assumptions, three forms of realism can be differentiated: naïve, critical, and scientific realism. Positivism, which sees knowledge as a result of empirical data exploration, represents a form of naïve realism (Reihlen, Habersang & Nikolova, 2021).

In my dissertation I draw on critical realism, a perspective representing a kind of a bridge between positivism and constructionism. It evolved in the 1970s around two core arguments: 1) the separation of ontology (dealing with the nature of reality) from epistemology (addressing questions about the possibility of studying reality); 2) materialist ontology that perceives the world as made of material elements (and not of events) that have their own inner structure, inherent properties, and casual powers (in contrast to the flat ontology of visible events, which attributes causal connections between these events as achievable by human mind only and not as an integral characteristic of things) (Reihlen, et al., 2021).

Critical realism claims that the material elements of the world (entities) are composed of other parts and have causal properties as an effect of the relationships between their constituent parts (Bhaskar, 1975). When these causal properties are activated, they combine to act and generate events, some of which are observable. Science aims at revealing these entities through describing and explaining their causal properties and, based on this, grasping events as a contingent set of entities and their properties. In this way, inertia or change can be explained. For example, to explain a social event, it is necessary to analyse the people involved as entities with their capacity to think, their mutual relationships and dependencies. In other words, critical realism emphasizes mechanism-based explanations of events, which implies answering questions about how, why and under what conditions they happen (Sorrel, 2018). Bunge describes mechanisms as drivers in the process of change (1997). Yet, mechanisms can rarely be observed and scientists have to theorise to discover them (Reihlen et al., 2021). To sum up, in the light of critical realism the main goal of social scientific research is to seek explanations of why something came about or did not.

From a critical realist perspective, Sorrel argues that MLP possesses insufficient explanatory power. In particular, although MLP studies aim at explaining why transitions come about, they tend to show a large number of developments at different system levels without clarifying how and when they work. Instead of assuming an alignment of these developments, the focus of MLP should be to determine which of them have the highest priority for ST to happen. One possible approach to achieve this is to analyse counterfactuals. The Polish electricity system with an evident window of opportunity for ST should, according to MLP, unlock change. That this is not the case and change is still resisted which represents such a counterexample and is described in Paper 2. Another shortcoming in the light of critical realism is that many MLP studies have focused on socio-cultural factors, including values and user practices, and largely overlook the physical and economic components of the socio-technical regime (Sorrel, 2018). This gap has been addressed in this synopsis by highlighting the relevance of supply security concerns due to bottlenecks in the physical infrastructure and the emphasis on the short-term-oriented economic evaluation in the ST process.

A further limitation of many earlier MLP studies was too much emphasis on niches and insufficient attention to the processes on the level of the socio-technical regime (Geels, 2011; Köhler at al., 2019). Therefore, a recent agenda for ST research calls for improving our understanding of how unsustainable incumbent socio-technical regimes can be destabilized and phased out (Köhler at al., 2019). Paper 2 addresses this issue by indicating the relevance of legitimacy transition and highlights framing and interaction patterns as key mechanisms to delegitimize established power blocks. The synopsis also contributes to this point by highlighting the crucial role of policymaking in fostering ST.

Another suggestion to enhance MLP is to focus on individual actor-focused perspectives to bridge the macro-to-micro gap (Upham et al., 2020). Though without an explicit reference to MLP in Paper 3 I emphasise actors' angle and describe DR aggregators' challenges and efforts as institutional entrepreneurs.

3 Key factors in enacting ST

Inspired by Kurt Lewin's classification of forces that influence change processes (1947) Figure 1 depicts the key factors in enacting ST of the electricity system.

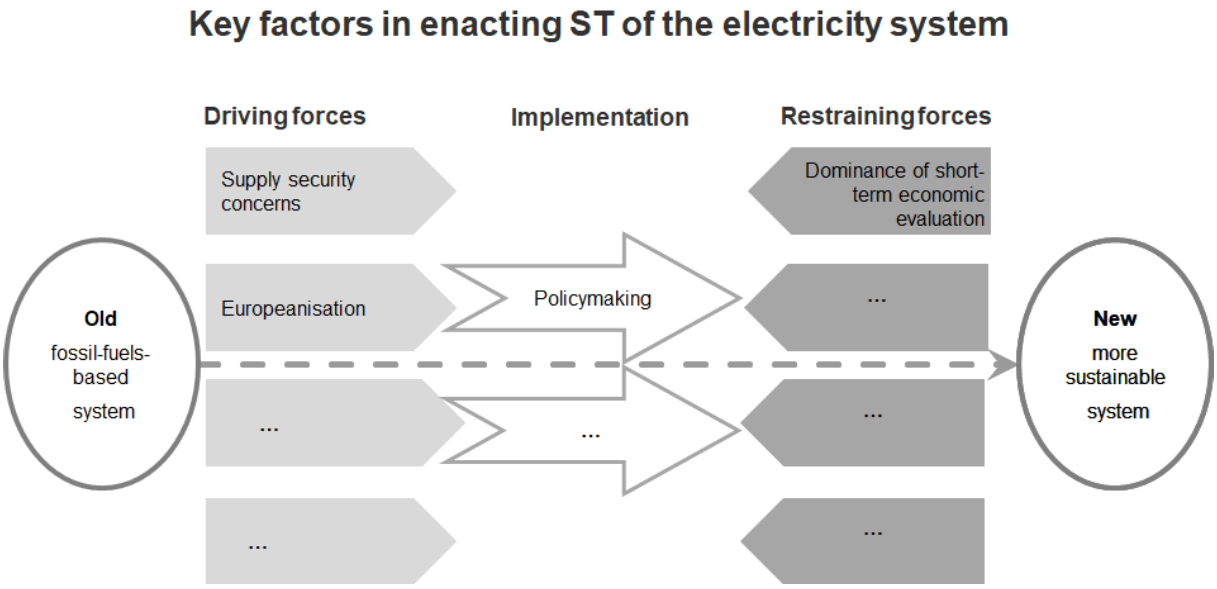

Figure 1 Overview of the key factors and their function in enacting ST

Despite the straight arrows in Figure 1 and as already highlighted in section 2.2 ST is a complex and iterative change process with largely unpredictable outcomes, in which multiple interdependent forces are involved (Burnes, 2004; Lewin, 1947). This synopsis highlights four of them: supply security concerns, Europeanisation, policymaking and the dominance of short-term-oriented economic evaluation as a 'common denominator' of the three papers of my dissertation.

3.1 Supply security concerns

My research stresses that a serious risk of electricity shortages can become an important driver of radical innovations in the electricity system if usual solutions are not available. Ensuring supply security at affordable prices is the core function of the electricity system as a large technical system and, accordingly, the key criterion to evaluate it. Large technical systems are characterised by a complex interplay of interdependent components: 1) physical infrastructure with high capital expenditures and long utilisation periods; 2) non-physical artefacts, including regulation, policies, standards and practices; and 3) divergent actors such as regulators, policymakers, consumers and utilities. The electricity system ensures the functioning of other technical systems like IT, health, industrial production, water supply, and transportation. Consequently, power blackouts might lead to a chain reaction that affects millions of people and large geographical areas. Like all large technical systems the electricity system tends to inertia and path-dependent incremental innovations (Geels et al., 2016; Markard & Truffer, 2006).

An urgent threat of shortages in electricity supply might provide a strong impetus to unblock lock-ins and to facilitate a diffusion of radical innovations. In MLP terminology, supply security concerns are a pressure on the level of the socio-technical regime, caused by, for example, outdated power plants, or landscape level developments such as instability in countries that are large exporters of fossil fuels (Verbong & Geels, 2010). Interviewees I spoke with for Paper 3 described the relatively progressive market design in terms of a level playing field for DR in the UK, Belgium and France as a result of the security of electricity supply being at risk and the unavailability of usual alternatives. In Germany, on the contrary, power blackouts were considered unlikely and despite a growing penetration of RES there was no sufficient driver to introduce consequent DR enabling policies (Kuzemko et al., 2017). Also the interviews I carried out with the key actors of the Polish electricity system (Paper 1) indicated that an urgent threat of power shortages could cause the transmission system operators (TSO) to induce institutional changes to enable DR. This has already taken place in part: After 1,600 of the largest industrial companies were taken off the grid to prevent a blackout in 2016, the Polish TSO introduced a payment for DR availability, and opened the capacity market to DR as an incentive for large electricity consumers to provide it (RAP, 2018).

The MLP literature does indicate risk to electricity supply security as a driver of radical shifts in the extant socio-technical regime (see, for example, Smith, 2012; Markard & Truffer, 2006; Smith & Hledik, 2011); however, the mechanism how and under which conditions it works still needs to be explained (Sorrel, 2018). Paper 2 tries to close this gap by emphasising that supply security concerns, like other systemic challenges, need to be adequately framed and legitimacy struggles over appropriate solutions are necessary as transformational mechanisms to unlock shifts in the socio-technical regime.

3.2 Europeanisation

My research highlights the Europeanisation of energy policy as a crucial driver for the adoption of sustainable energy technologies at a national level. This process of developing common structures of governance at the EU level (Risse, Green Cowles & Caporaso, 2001) implies a weakening of national sovereignty and an amendment of governance practices of the member states. In this sense, the Europeanisation of energy policy leads to a centralisation of the respective policy-making activities in Brussels, whilst remaining dependent on national policymakers and administration for their execution (Solorio, 2011). In MLP terminology, Europeanisation can be seen as an exogenous landscape pressure. However, Europeanisation also has a ‘bottom up’ dimension involving the communication of a country’s own interests in the EU arena to influence community law and an exchange among the countries (Pach-Gurgul, 2016). The MLP literature has so far paid little attention to the mechanisms of Europeanisation in the sense of how it evolves and its influence on ST (Nilsson, 2012).

Although energy matters had served as an early impulse for European integration, energy policy has long remained a domain of member states since they significantly differ in terms of available domestic energy resources and energy policies (Pach-Gurgul, 2016). With the acknowledgment that pressing challenges such as climate change and the security of energy supply can only be jointly tackled, a comprehensive energy policy was considered a top priority on the EU’s political agenda. The goal of the energy policy is to achieve a so-called ‘EU energy trinity’ that is, energy supply security and competitive European economies at affordable prices while fostering environmental sustainability. Important milestones were the EU Communication 20 20 20 by 2020: Europe's climate change opportunity in 2008 (Solorio, 2011) and the recently endorsed EU’s goal of climate neutrality by 2050, with a revision of relevant energy legislation by June 2021 as a key measure (EC, 2019a). The EU energy related documents consist both of acts that are legally binding for member states such as directives, regulations and decisions (EC, 2019b) and of those that can be described as ‘soft’ instruments to promote debates, raise awareness and stimulate learning (Solorio, 2011).

The EU declared an increase in the share of RES and electricity DR as crucial for ST of its electricity system and promotes their adoption by binding directives to be implemented in national legislation within a certain deadline. The revised Renewable Energy Directive raises the EU goal for RES consumption to 32% by 2030 and allows member states to contribute to its achievement ‘in the most cost-effective manner in accordance with their specific circumstances, energy mix and capacity to produce renewable energy.’ The national targets established for 2020 are, however, member states' minimum contributions to the new 2030 framework (EU RES 2018/2001). Regarding DR adoption, the Electricity Directive is pivotal: It requires member states to support DR in particular by enabling all customers to participate in it, fostering DR aggregation and eliminating market discrimination through the consideration of the technical capabilities of DR (EU ED 2019/944).

The European Commission monitors the proper implementation of EU law and if a potential infringement is discovered it can commence infringement procedures (European Parliament, 2018). Nevertheless, most EU member states have difficulties in the transposition of EU directives into their national law, thus, in the case of energy policy, hindering the expansion of sustainable energy technologies. Several factors can explain these difficulties: the complexity of the changes to be undertaken, the insufficient experience of the actors involved in the implementation process, conflict potential among them, and a mismatch between EU and national policy in the respective field (Steunenberg & Rhinard, 2010). While my research confirms these findings, it highlights in the case of Poland that both the prevailing public perception and national policymakers' framing of the EU energy legislation as externally imposed (see also Żuk & Szulecki 2020) contribute to downplaying the necessity of its proper transposition. The huge mismatch between the Poland's current coal-dominated energy policy and the EU's ambitious climate and energy goals requires much more effort to align these opposites than simply implementing the relevant EU directives. In terms of the DR, its high complexity seems to be particularly challenging to design appropriate institutional measures for its broader adoption.

Notwithstanding the difficulties in the transposition of EU energy law at a national level, my studies show that the proponents of DR perceive the Electricity Directive as a core legitimation of their reform efforts and Europeanisation as an important driver in enabling sustainable energy technologies (Antal, 2019; Ceglarz & Ancygier, 2015; Szulecki, 2017). A question in this context is how to accelerate the proper implementation of binding EU provisions in the field of energy and support the respective niche actors and the ST they are pursuing. Given the adversarial perception of EU energy and climate policies in Poland (Szulecki, 2017), it seems particularly important to strengthen consultations over planned EU legislation to ensure sufficient consideration of the core interests of each member state. Taking into account the complexity involved in the transposition process of energy-related EU legislation another suggestion is to provide more advisory support to the responsible bodies at a national level. Imposing more daunting financial consequences on regulatory noncompliance, as recently discussed in the context of the abuses of democratic standards in Poland and Hungary (Independent, 2020), could also be considered as a measure to accelerate the transposition process.

3.3 Policymaking

In line with the extant literature, my research confirms the central role of policymaking in removing institutional barriers hindering the diffusion of sustainable energy technologies such as DR and RES (see, for example, Geels et al., 2017; Jacobsson & Lauber, 2006; Markard & Truffler, 2006, Shen et al., 2014). As these technologies are largely incompatible with existing institutions in the sense of the formal and informal 'rules of the game' including regulations, market access, standards and customer practices, an institutional realignment or, in other words, a systemic shift is required. Accordingly, institutional changes are at the heart of ST, and policymaking is a process to design and to enact them.

Policymaking involves a range of actors that draw on shared interests and beliefs to form an advocacy coalition willing to change an existing hostile institutional framework in line with their needs. A core component of this process is the acquisition by proponents of a new technology of powerful advocates who will help them gain legitimacy and influence relevant institutions. Such powerful advocates might include universities, industry associations, the media, public administration, and politicians (Jacobsson & Bergek, 2004). Politicians play a crucial role in shaping field-level institutions through influencing regulation, taxation, subsidies and designing innovation policies, also jointly termed as 'policy mixes' (Kern, Rogge & Howlett, 2019). While economic policy instruments such as taxes and subsidies are important and currently dominate, innovation studies reveal that measures fostering network and community building, vision formulation, and experimentation/learning are crucial too (Geels, Hekkert & Jacobsson, 2008).

MLP research shows that politicians frequently work together with incumbent firms to resist institutional changes as threatening their mutual benefits. For this purpose an alliance of politicians and industrial players, also called in the literature as a 'fossil fuel historical block' in the context of fossil fuel-based energy systems, implements instrumental, discursive, material and institutional forms of power (Geels, 2014). Using the example of the Polish electricity system, Papers 1 and 2 of my dissertation show how effective this resistance is when defending the domestic coal industry and keeping support for RES and DR at a bare minimum. The alliance of policymakers and incumbent firms seems to be particularly strong in the case of state co-ownership of industrial firms. In Poland, the largest energy utilities (RAP, 2018) and coalmines are co-owned by the state and run by functionaries of the ruling party (Schwarzkopff & Schulz, 2017). In addition, Paper 3 shows the necessity of regulatory reforms to create a level playing field for DR and of lobbying efforts by DR aggregators to pressure politicians and network operators to enforce them. As small start-ups, newcomers need the support of larger actors including politicians, network operators and associations to pursue institutional reforms that enable their technologies to accommodate in the socio-technical regime.

Jacobsson and Bergek (2004) list the main mechanisms that prevent institutional changes enabling new technologies: high technical, economic and market uncertainty; lack of the legitimacy of the new technology; and weak connectivity in terms of learning and political networks. These mechanisms are analogous to factors hindering the implementation of EU law at a national level (listed in section 3.2) including the complexity of the reforms, the lack of experience of the actors involved, conflicts among them, and a mismatch between the new technology and the national policy in the respective field (Steunenberg & Rhinard, 2010). While my research confirms these barriers to institutional reforms, it emphasises the key role of legitimacy transition via framing struggles in overcoming them and stresses the relevance of a strong civil society and supportive media in facilitating disputes (see also Antal, 2019; Geels et al., 2017; Upham et al., 2015).

3.4 Dominance of a short-term-oriented economic evaluation

Although an urgent need of ST is broadly acknowledged, my research confirms findings from the extant literature that short-term-oriented economic and not sustainability-oriented criteria still play the key role in the implementation of energy technologies (Geels et al., 2008; Verbong & Geels, 2010) which hinders the adoption of sustainable innovations. This refers both to electricity consumers who primarily assess potential financial gains when deciding on the provision of DR (Paper 3) and policymakers and network operators who frequently justify favouring incumbent technologies with a high investment needed to enable sustainable alternatives while resisting required institutional reforms (Papers 1 and 2). In the so-called energy policy triangle sustainability is one of the three key priorities (besides supply security and economic rationale), but market-based considerations emphasising short-term profit, as a part of institutional market logics, still dominate (see also Weisenfeld & Hauerwaas, 2018).

Since the cost efficiency of early phase innovative energy technologies is often lower compared to established solutions, they need protection in niches to withstand mainstream market selection (Geels et al., 2008). The goal is however that niche technologies become competitive with established solutions and ‘survive’ on the market without subsidies (van der Loo &

Loorbach, 2012). This goal could be achieved by evaluating the externalities of all technologies that can be used to provide flexibility. Such an evaluation, also taking long-term effects into account, should serve as a basis to redesign the selection criteria of markets, a development that would benefit sustainable energy technologies such as DR.

However, carbon pricing defining GHG emissions as a negative externality has proved to be relatively inefficient in tackling climate change. Instead of driving real changes, translating GHG emissions into prices triggers actors to search for the lowest cost option within their specific conditions. This contributes to framing climate change as a market failure that can be solved by pricing, which fails to acknowledge its seriousness (Rosenbloom et al., 2020).

The analysis of the Polish electricity market (Papers 1 and 2) shows that despite an enhanced environmental awareness the majority of Polish people is unwilling to pay more for sustainable solutions (Płatkowska-Prokopczyk, 2017), a finding that policymakers eagerly instrumentalize to hinder RES expansion. Despite their improved cost efficiency (IRENA, 2019; Gielen et al., 2019), RES are still perceived in Poland as an option only rich Western European nations such as Germany can afford. How to overcome the primacy of a short-term economic thinking and introduce new more sustainability-oriented guiding principles into the decision making of consumers, firms and policymakers? Again, my dissertation highlights the key role of legitimacy transition and framing struggles in extending the portfolio of evaluation criteria by considering social, environmental and cultural aspects as part of the assessment of available technology options. Geels et al. speak in this context about ‘positive discourses’ (2017: 5), and Smith (2012) stresses the pressure civil society can exert in this regard.

4 Conclusions

Transition studies reveal numerous factors that impact ST in the energy system including landscape shocks such as the Fukushima disaster that accelerated the phasing out of nuclear power in Germany (Upham, Eberhardt & Klapper, 2020) and the resistance of incumbent actors hindering ST in the UK (Geels, 2014). This synopsis highlights the key factors influencing the enactment of ST in the electricity system as a ‘common denominator’ of the three papers of my dissertation, which are (1) supply security concerns, (2) Europeanisation, (3) policymaking, and (4) the dominance of short-term-oriented economic evaluation. Drawing on Kurt Lewin’s taxonomy of forces (1947) that shape change processes these factors can act as driving or retaining forces for ST. In terms of policymaking, I regard it as an implementation vehicle of ST provided that the driving forces manage to supersede the retaining forces.

First, serious supply security concerns lead to an emergency situation in the electricity system and, when familiar solutions are not at hand, they might open up a space for radical institutional reforms that pave the way for a broader diffusion of new energy technologies such as DR.

Second, although EU energy policy is jointly shaped by EU member states, in the context of ST it is a landscape pressure. In the case of the electricity system, this pressure has a clear sustainable focus that lends legitimacy to those advocating sustainable transition. In particular, binding EU provisions seem to play a crucial role in Eastern EU countries as a driver of pro-environmental changes, which probably would not be otherwise initiated because of insufficient societal awareness and a deeply rooted perception that only rich countries can afford them.

Third, policymaking is the core activity to ensure protection of innovative niches and to implement pro-ST institutional reforms. Nevertheless, in Poland an alliance of politicians and state-controlled energy utilities is particularly efficient in resisting the ST of the electricity system despite an evident window of opportunity. A real policy shift is unlikely without a strengthening of civil society and the facilitation by mass media of a broad discourse over the consequences of maintaining the status quo.

The dominance of a short-term-oriented economic evaluation of energy technologies restrains ST. Breaking this dominance would support a sustainable policy shift, particularly in the early phases of technology development and diffusion, when their economic performance is still lower than of incumbent technology options.

Pro-ST reforms can only be induced when supply security concerns and Europeanisation as their drivers are adequately framed and discussed. In other words, as presented in Paper 2, framing struggles between advocates of different solutions should lead to a legitimacy transition in which short-term economic performance is not the main criterion to assess them. Pro-ST policymaking is unlikely to be implemented as long as politicians and incumbent firms benefit from the status quo and institutional entrepreneurs pursuing sustainable technologies and civil society are too weak to exert pressure on them.

The MLP literature has dedicated little attention to the factors highlighted in this synopsis and further research is needed to better understand the mechanisms of their impact on ST.

In particular, the following research questions arise from my dissertation:

1. Which of the many factors that were identified in MLP studies are necessary and which are contingent to trigger ST of energy systems?
2. Why, how, and under which conditions do these factors work?
3. What are the key differences between Western and Eastern EU countries in terms of ST?
4. How can incumbent fossil fuel-based socio-technical systems be weakened and, in particular, how can politicians and established firms benefitting from the status quo be motivated to pursue sustainable reforms?
5. How can civil society and a discourse culture that facilitate framing struggles be strengthened in post-soviet societies?
6. Is ST a privilege only wealthy societies might want to strive for?
7. How can the process of Europeanisation be shaped so that new EU member states will also feel committed to agreed sustainability goals instead of arguing that they are externally imposed and harm their national interests?

Critical realism with its emphasis on mechanism-based explanations involving a careful specification of all entities involved in a phenomenon including their causal properties, relationships and interdependencies is a useful philosophical perspective to search for answers to these questions (see Reihlen et al., 2021). In particular, the deployment of methods and constructs of social psychology can improve the understanding of individual actor perspectives, thus helping to address the above questions (Upham et al., 2019).

In summary, my dissertation addresses the ST of the electricity system from different angles: Paper 1 focuses on a niche technology and sheds light on the underlying barriers and enablers of the rollout of DR as an energy technology that might support the ST of the Polish electricity system. Paper 2 deploys a systemic lens and introduces the notion of legitimacy transition via framing struggles into the MLP, explaining why the ST of the Polish electricity system is still lagging behind despite strong pressures on all system levels. In paper 3, I describe the challenges DR aggregators as institutional entrepreneurs face and how they cope with them, while trying to reform the European electricity system.

The main contributions of my dissertation to ST research are:

1. Extending the technology focus of ST studies through identifying DR as a further technology that supports the ST of the electricity system, which requires the development and diffusion of multiple low carbon innovations (see also Bergek, Hekkert & Jacobsson, 2008).
2. Extending the geographical focus of ST studies beyond Western European countries (that are largely committed to transforming their energy systems) to Poland as the largest Eastern European country and whose policymakers still defend the central role of coal in spite of evident problems such as dramatic air pollution levels and the threat of power shortages.
3. Complementing MLP by introducing the notion of legitimacy transition and highlighting the importance of legitimacy struggles and interaction patterns to explain the non-transition of the Polish electricity system despite an evident window of opportunity.
4. Uncovering so far under-researched processes on the level of the socio-technical system in the case of the Polish electricity system.
5. Identifying DR aggregators as institutional entrepreneurs and revealing the challenges they face and strategies they implement to reform the supply-side-oriented European electricity system.
6. Identifying DR aggregation as an architectural innovation based on known technologies that changes the interplay between the key actors of the electricity system and which, through its inherent complexity, is particularly challenging to implement.
7. Highlighting the relevance of the features of an innovation for its diffusion in the context of the institutional reforms required to enable it, which is largely overlooked in ST and institutional entrepreneurship literature.

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Paper 1: The underlying factors in the uptake of electricity demand response: The Case of Poland

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Published in: Utilities Policy, Volume 54, October 2018, 11-21, https://doi.org/10.1016/j.jup.2018.07.002

Abstract

Demand response (DR) is considered crucial for a more reliable, sustainable, and efficient electricity system. Nevertheless, DR's potential still remains largely untapped in Europe. This study sheds light on the roots of this problem in the context of Poland. It suggests that unfavorable regulation is symptomatic of the real, underlying barriers. In Poland, these barriers are coal dependence and political influence on energy enterprises. As main drivers, supply security concerns, EU regulatory pressure, and a positive cost-benefit profile of DR in comparison to alternatives, are revealed. A conceptual model of DR uptake in electricity systems is proposed.

Highlights

- Unfavorable regulation is symptomatic of underlying barriers to widespread DR adoption.
- In Poland, these are coal dependence and political influence on energy enterprises.
- Coal protection policy discourages determined DR advocacy by key actors of the Polish electricity system.
- The threat of supply outages, EU regulatory pressure & DR's positive cost-benefit profile drive DR.
- Awareness among policymakers regarding the threats of status quo and DR potential needs to be raised.

Keywords: Demand response; drivers; barriers; Poland

1 Introduction

There is a growing consensus that encouraging consumers to adjust their electricity demand in response to constraints of the electricity network, demand response (DR)[2], is crucial for a more reliable, sustainable and efficient electricity system. Shifting consumption to periods when electricity is relatively inexpensive or available in abundance allows for a more effective use of generation, transmission and distribution infrastructure, thus preventing blackouts, reducing operational costs and deferring investments. Greater flexibility of the demand side, which helps to decrease the use of peaking power plants and to integrate variable (intermittent) renewable energy sources (RES), might also, depending on the generation mix (Holland, Mansur, 2008), contribute to reducing CO2 emissions. Consumers are expected to benefit from participation in DR programs not only through enhanced reliability of the supply, but also through an increased awareness concerning electricity consumption and lower electricity costs (Capgemini, 2008; EC, 2013; Eid et al., 2016). Due to these potentials, the European Union (EU) considers DR important for attaining the 20-20-20 goals and requires Member States (MS) to enable a level playing field for it (Directive 2012/27/EU). However, although DR programs have begun to emerge across Europe in recent years, the flexibility of the demand side still remains largely untapped in most of the MS (EC, 2013; SEDC, 2015). Current real-life DR programs usually target energy-intensive industries and generally neglect the potential of smaller commercial or industrial consumers and households (IEA, 2011; SEDC, 2015; Torriti et. al., 2010).

Barriers to DR that are usually addressed in the literature can be clustered into three categories: consumer, producer, and structural barriers (Kim, Shcherbakova, 2011; cf. Costello, K., 2004). Among them, insufficient consumer awareness, the risk of process disruption in industrial enterprises (Olsthoorn et al., 2015) and DR cost (investment) recovery (Eid et al., 2016) play a significant role.

Nevertheless, one of the core and the most frequently discussed barrier to DR is unfavorable regulation (Benquey, Cesson, 2015; Chamoy, 2015; Greening, 2010; Grünewald, Torriti, 2013; IEA, 2011; SEDC, 2015). All other obstacles to DR cannot be effectively tackled without reforms at a regulatory level. Taking into account that the concept of DR is not new (Shen et al., 2014; Warren, 2014), it does offer numerous benefits and has been proven technologically

[2] In this paper, DR is understood as 'changes in electric usage by end use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized' (U.S. Department of Energy, 2006; Bertoldi, Zancanella, Boza-Kiss; 2016).

feasible, it is not clear why there is only moderate progress in removing the regulatory barriers in Europe. The reasons for this situation have yet to be understood.

In particular, little is known about the mechanisms, defined in this context as ‘a process in a concrete system such that it is capable of bringing about or preventing some change’ (Bunge, 1997), of uptake of DR in electricity systems. Despite the fact that this concept has been applied in e.g. the US (Eid et al., 2016) and the UK (Warren, 2014) on a significant scale for several years, major factors that impact DR uptake have not been sufficiently investigated. The DR-related behavior of key actors of the electricity system, including Transmission System Operators (TSOs), energy utilities and policymakers, also requires further research.

This study reveals the real factors in the uptake of DR, both drivers and barriers, in the context of the Polish electricity system. It suggests that the unfavorable regulation, which may appear as the main barrier to widespread DR adoption, is symptomatic of underlying systemic barriers. Further, this study investigates the DR-related behavior of key actors in the Polish electricity system. Based on the empirical results, a conceptual model of DR uptake in electricity systems is proposed and policy implications for Poland are provided.

Poland offers an interesting case study for the following reasons:

1) Poland urgently needs a short-term solution to cope with the threat of deficits in electricity supply (Maćkowiak-Pandera et al., 2015). Due to its relatively lower capital intensity compared to investments in electricity generation infrastructure (Green Alliance 2012), DR seems to be particularly suitable to prevent peak load shortages. Other challenges of the Polish system such as the need to reduce CO2 emissions could also drive DR adoption.
2) Numerous initiatives have been already undertaken in the context of DR; nevertheless, DR is still not on an equal footing with the supply side and only a small part of DR potential has been tapped (Bayer, Rączka, 2017; Pawłowicz, 2015; SIA Partners, 2015).

2 Methodology and data

As my goal was to investigate the factors which impact the uptake of DR and DR-related behavior of key actors involved in this process, I chose an explorative case study approach. The database consists of

1) Semi-structured qualitative interviews with 15 experts representing key actors of the

Polish electricity system (as listed below) as well as DR aggregators,[3] media, both mass media and media with a focus on the energy sector;

2) Secondary data, mainly media reports, publicly available policy documents and scientific papers.

The key actors of the Polish electricity system are:

- Polskie Sieci Elektroenergetyczne (PSE), the Transmission System Operator (TSO) that is responsible for the operation of the transmission network and the supply security across the country;
- The Distribution System Operators (DSOs) including approximately 169 companies, but only five of them (PGE, Tauron, Enea, Energa and RWE) are in charge of the grids that are directly connected to the transmission grid and are legally obliged to unbundle. PGE, Tauron, Enea, Energa are state-co-owned and belong to vertically integrated energy groups holding generation and distribution assets (below, they are referred to as energy utilities). They dominate the market and are so-called ‘default suppliers’ for households that did not switch to a new supplier. In 2014, PGE, Tauron, and Enea accounted for more than 50% of the installed generation capacities;
- Urząd Regulacji Energetyki (URE), the Regulatory Authority that is responsible for the regulation of the Polish electricity system and, in particular, for setting electricity tariffs for households and small enterprises that did not switch suppliers;
- Political decision-makers, in particular the Ministry of Energy that sets the strategic direction of the Polish energy policy; the state is the sole owner of the TSO ((PSE, 2016 (A), RAP, 2014) and the co-owner of the four largest energy utilities (URE, 2015).

For this study, the interviewed experts described their perceptions of the drivers of and barriers to DR in Poland, outlined and assessed activities undertaken to implement DR and provided policy recommendations. The interviews were carried out in the period April to September 2015. An interview lasted on average 0.5 to 1.5 hours. The majority were carried out by phone. The interview language was Polish; for the purposes of this study, all interviews were transcribed and translated into English.

[3] A ‘DR aggregator is a service provider who operates – directly or indirectly – a set of demand facilities in order to sell pools of electric loads as single units in electricity markets. The service is provided separately from any supply contract. The aggregator (a service provider who may or may not also be a retailer of electricity) represents a new role within European electricity markets, but is well established in the USA, Australia, South Korea and Japan’ (Bertoldi, Zancanella, Boza-Kiss; 2016).

Many of the interviewed experts work for state-controlled enterprises in senior positions and, for this reason, underlie a certain amount of political censorship. As the experts shared to some extent sensitive information and their private opinions, the collected primary data has to remain confidential. The table below provides an overview of the interviews in an anonymised form:

No.	**Interviewed experts/system actors**	**Interview date**	**Duration in minutes**
1	DR aggregator	24.04.2015	60
2	DR aggregator	28.05.2015	86
3	DR aggregator	29.05.2015	79
4	Energy utility (three employees within one interview)	21.05.2015	56
5	Energy utility (three employees within one interview)	21.05.2015	56
6	Energy utility (three employees within one interview)	21.05.2015	56
7	Energy utility	20.07.2015	60
8	Energy utility	12.08.2015	40
9	Energy utility	24.08.2015	52
10	TSO	10.04.2015	90
11	Mass-media	04.04.2015	56
12	Media – focus on energy	15.07.2015	40
13	Media – focus on energy	22.07.2015	34
14	Regulator	26.08.2015	92
15	Policymaker	28.05.2015	66

Table 1 Overview of the interviews

The analysis of the interviews followed the methodology proposed by Philipp Mayring (Mayring, 2015). A combined deductive-inductive coding procedure facilitated by the software MaxQda was implemented.

It involved a step-by-step thematic reading and re-reading of the interview transcripts to reduce the data volume and to identify core aspects relevant to the description of DR in the Polish context. Deductive codes were based on the categories addressed in the semi-structured questionnaire and they reflect researcher's assumptions on the topic in question. As deductive codes the following categories were used: definition of DR, status quo and activities of key actors in the context of DR uptake, barriers to and drivers of DR, recommended system amendments to accelerate DR uptake. Inductive codes rely on inductive reasoning in which key issues emerge from interview transcripts. The following inductive codes were derived (most importantly): coal mining, lobbying, politics, supply security, cross-border links, extension of generation capacity, nuclear power plant, cost-benefit profile of different technologies, renewables, EU, pilot projects, Polish mentality and history, DR in other countries, regulatory barriers, tariffs, tenders for negawatts, awareness, large enterprises, households, and environmental attitudes.

3 Results

The main aspects discussed in the expert interviews are used to structure the results below: DR-related behavior of the key actors of the Polish electricity system and of other relevant actors that are involved in DR adoption; key drivers of and underlying barriers to DR. Based on these results for Poland, a conceptual model of DR uptake in electricity systems is proposed in the discussion. The key drivers of and underlying barriers to DR uptake are depicted in Figure 2.

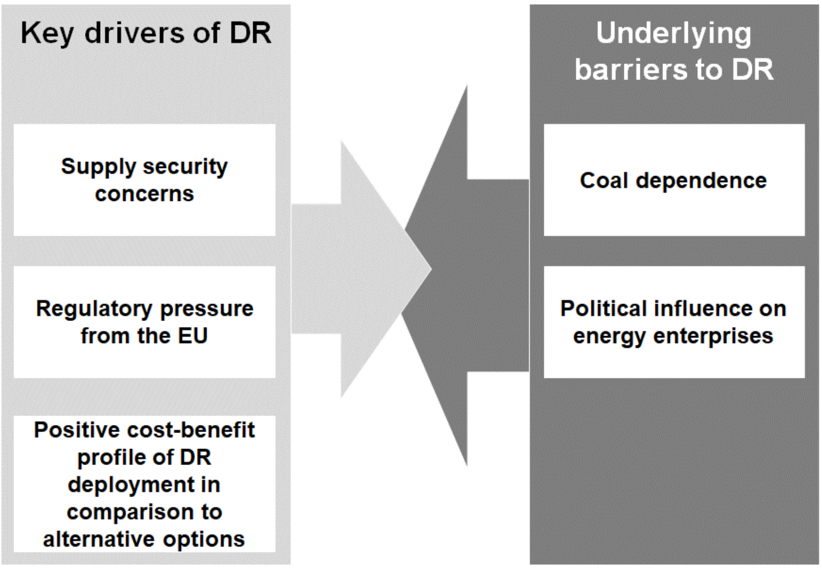

Figure 2 Key drivers of and underlying barriers to DR uptake in Poland

3.1 The DR-related behavior of the key actors of the Polish electricity system and of other relevant actors

Since 2015, when the expert interviews were carried out, the situation of DR in Poland has slightly improved. However, DR is still not treated on an equal footing with the generation side and its potential is not sufficiently seized. In 2016, the available demand reduction under control of the TSO amounted to approximately 200 MW in winter and 185 MW in the summer season, which was less than 0.8% of the peak load (SEDC, 2017). In 2017, the TSO acquired 361 negawatts in summer and 315 negawatts in the winter season (Energetyka, 2017). Estimations show that Poland could cover between 5%, approximately 1,200 MW (Bayer, Raczka, 2017) to even up to 14% (Raczka, 2016; Gils, 2014) of peak needs with DR, which further emphasizes the low utilization of this resource. It should also to be taken into account that the estimations are not based on empirical research comparable to, for example, the study on DR potential in Southern Germany (Klobasa et al., 2014).

Numerous regulatory policies hinder the utilization of DR. In particular, the TSO is actually the single buyer of DR based services; DR is used only as a last resort measure and activated rarely; there are no regulatory incentives to utilize DR at the distribution level; the role of a DR aggregator remains undefined in the regulation; most markets are still not accessible to DR; the TSO is allowed to curtail electricity power supply of large enterprises without compensation (SEDC, 2017; Bayer, Raczka; 2017; Raczka, 2016). The Emergency Reserve (ER) operated by the TSO is so far the only program DR can actually participate in. Due to low payments linked with strict participation rules, e.g. bid size of minimum 10 MW, the ER program was not successful on the market. In 2017, the TSO updated ER and introduced payments for availability. Theoretically, also balancing and wholesale markets are open to DR, but due to discriminatory participation rules and low price volatility, they do not have any practical relevance for DR providers (SEDC, 2017; Bertoldi, Zancanella, Boza-Kiss, 2016; Pawłowicz, L., 2015; SEDC, 2015).

In 2018, a capacity mechanism[4] is expected to be introduced in Poland and DR is envisaged to access it, but according to the original proposal by the Ministry of Energy, DR might not be treated equally with electricity generators, particularly regarding the significantly shorter contract length (Kukuła, Stoczkiewicz, 2016). The design of the capacity mechanism is subject to negotiations with the EC (EC, 2015).

Despite prevailing regulatory hurdles, numerous actors have already shown a substantial interest in DR. This interest is visible through diverse DR-related activities. The TSO has been the main driving force behind DR deployment in Poland (Olkuski, Ciesielka, Szurlej, 2015). Between 2012 and 2015, the TSO run six tenders for negawatts[5] (PSE, 2015). The key motivation of the TSO was to reduce the risk of shortages at lowest costs.

[4] Following the British example, Poland also intends to adopt capacity mechanisms to encourage investments in new power plants, thus preventing blackouts in the medium and long terms. The TSO will provide -via capacity mechanism - capacity providers with additional charges, on top of the income achieved by selling electricity on the market, for committing to maintain existing or build certain capacity that can be activated when needed.

[5] A negawatt/a negative megawatt is 'a theoretical unit of power saved; its name stems from a newspaper typo that Amory Lovins, the founder of the Rocky Mountain Institute and a dedicated energy efficiency supporter, decided to adopt for a 1989 keynote address at the Green Energy Conference in Montreal.' (IEA, 2013)

The state-controlled energy utilities have also been involved in DR activities: They implemented several pilot projects in which DR was tested (predominantly with households, as the utilities invest in residential smart metering to explore services that can be based on them). Energa, the energy utility operating in the north, established Enspirion, a DR aggregator. This was the first DR aggregator in Poland. Energa, the parent company of Enspirion, generated approximately 41% electricity from RES in 2015. With a 10% share in the generation, wind plays an important role in the portfolio of this state-controlled energy utility (Energa, 2016).

In parallel, internationally active aggregators such as Enernoc have been screening market entrance possibilities, which illustrates the expected potential of the Polish market. In 2015, PGE, another large state-controlled utility was about to establish a partnership with Energy Pool, a renowned French DR aggregator. Eventually, the partnership agreement was signed in 2017 (Energetyka, 2017 A). Parliamentary elections in September 2015 and the resulting governmental change postponed the deal as the right-conservative political decision-makers had to be convinced to approve it.

Polish energy utilities, their relatively good economic performance notwithstanding, seem to perceive DR primarily as a chance to lower operational costs and to improve market image. The so-called ‘first mover advantage’ is a strong motivator for them to pursue DR. The uncertainty about the future shape of electricity systems makes the high capital cost of traditional energy infrastructure seem especially risky. The losses of E.ON and RWE in Germany, which are struggling with write-offs on infrastructure as a consequence of the energy transition, Energiewende, (Balser, 2015) highlight the necessity of flexible and reversible solutions such as DR.

Large industrial enterprises with a significant share of electricity costs are also interested in seizing DR potential (FOEEiG, 2015), as they search for possibilities to improve cost efficiency to compete with western European counterparts.

The rollout of smart meters, considered a prerequisite for the mass uptake of DR, was initially driven by pilot projects implemented by the energy utilities. Approximately 1,000,000 smart meters had been installed by the end of 2015. 12.8 million meters need to be replaced in total until 2020 (80% of the Polish population) (Dobry Prąd, 2016). To achieve this, the rollout should be significantly accelerated. Interestingly, a certain inconsequence can be observed in the DR-related decisions of URE, the Regulatory Authority. URE first supported the rollout of smart meters through regulatory incentives for energy utilities, but then canceled them

(Piszczatowska, 2015), seemingly in alignment with political concerns about voter reactions to potential price increases.

Obviously, there are many influential market actors that seem to value DR and these are potential DR advocates. There is, however, no DR coalition. The potential DR advocates including the TSO, the energy utilities, large energy-intense enterprises and DR aggregators have not coordinated any DR-related activities with each other. The relevance or benefits of joint strategy when pursuing a level playing field for DR have either not been recognized or not perceived as outweighing the risks.

As there are no empirical studies available that would quantify DR effects for Poland, the arguments in favor of DR may also seem to lack persuasive power. So far, no awareness raising in general society has been undertaken (apart from information campaigns for local DR pilot projects). DR is still perceived as a niche topic that, due to its complexity, is difficult to communicate, particularly considering generalized low interest among Poles in energy-market issues (RWE, 2014). This seems to justify the fact why there has been no mass-media coverage on DR. Expert No. 11 summarized the prospective perception of DR as follows: 'We are a nation that is attached to a concrete evidence. If we have something big, material, constructed in a specific place, we can say that we have it, but if you say that you have some mechanisms that will control the demand, someone may say 'What are you talking about?''

The most influential actor on the Polish electricity market is the state. 'The Polish power industry has a specific character. In fact, we are talking about a state-run industry' said expert No. 15. As the owner of the TSO and co-owner of the largest energy utilities, the state has always impacted the decision-making of these enterprises via direct personnel policy. With the right-conservative government (since autumn 2015) even more state involvement can be observed in the energy sector (Szulecki, Ancygier, 2015). DR, or more exactly Demand Side Management, is mentioned in the 'Polish Energy Policy until 2030' as a means to improve energy efficiency (Ministry of Economy, 2009). Nevertheless, there are no other public governmental documents that indicate a strategy to tap its potential. Interestingly, the TSO had envisaged a package of activities that were to stimulate DR already in 2008 (Pawłowicz, 2015).

To conclude this subsection, numerous influential market actors, including the state-controlled TSO and the largest energy utilities, have shown a profound interest in DR. Nonetheless, there is no coalition of DR advocates and a governmental strategy for wider DR adoption is not available. Accordingly, DR is still not treated equally with supply-side technologies.

3.2 Drivers of DR uptake in Poland

The main drivers that motivate the key actors of the electricity system to actively pursue DR are supply security concerns and regulatory pressure from the EU. Both of them are decisive for actors' assessment of the urgency to reform the electricity system and perhaps to stimulate the uptake of DR. A further factor determining the possible choice of DR is a cost-benefit profile of DR deployment in comparison to alternative options.

3.2.1 Supply security concerns

The awareness that the supply security of electricity in Poland is endangered is growing. The majority of the interviewed experts admitted that this threat of supply deficits is one of the main factors that could drive DR uptake in Poland and it has, in particular, motivated the Polish TSO to start organizing tenders for negawatts (PSE, 2015). 'The topic of DR comes back whenever there is a threat of blackout in Poland' said expert No. 7. This threat became particularly evident after the heat wave in August 2015 (described below). Before the events in August 2015, some of the interviewed experts admitted to having difficulties assessing the probability of supply deficits. This perception is illustrated by statements such as 'At least in Poland it seems that this peak is not such an issue' (expert No. 6) or 'Blackouts are too unlikely to push significant system changes' (expert No. 2). Securing the long-term energy supply is nevertheless one of the main priorities of the Polish government (IEA, 2017).

The following features of the Polish electricity system have mainly been pointed out in the interviews when discussing the risk of the supply deficits:

Inadequate reserves to satisfy peak demand: The installed generation capacity of all Polish power plants amounts to approximately 39 GW, which seems to be sufficient to cover the annual peak load reaching 25–26 GW in winter (Rączka & Maćkowiak–Pandera, 2015), but many units are more than 30 years old and will be decommissioned in the upcoming years (IEA, 2017; WEC, 2014). Therefore, investments in new generation capacities are inevitable, but their finalization takes time and delays are nothing unusual. In 2015, approximately 2,500 MW generation capacities were under construction (URE, 2016). Although peak demand occurs in winter, the greatest system stress takes place in summer. On 10 August 2015, the net generating capacity amounted 38.7 GW, but only 65% of this capacity was available. As usual in the summer season, 40% of combined heat and power plants were offline and many units under planned maintenance. Due to shortages of cooling water (caused by high temperatures), the operation of several units was constrained. In addition, the largest plant was shut down due to emergency reasons. To avoid blackouts, the TSO imposed power restrictions on 1,600 of the biggest enterprises in the country. This was the most serious reliability event in 30 years in Poland which revealed the inadequacy of operational profile of the available reserves (Maćkowiak-Pandera et al. 2015).

Limited interconnector capacity: The interconnector capacity of Poland amounts to 6.5 GW. This capacity remains, however, largely unavailable because of delays in market coupling[6] with other European countries and unplanned power flows from Germany.[7] In 2014, only 2% of the total electricity demand was satisfied by imports, ranking Poland among the most isolated electricity systems in the EU (EC, 2016; Maćkowiak-Pandera et al. 2015). The Polish TSO has been working together with its counterparts to solve these problems (Mika-Bryska, 2015; Reuters, 2016). The importation of electricity, however, does not seem to be a favored option to improve supply security due to the preference for autarky that prevails across much of Polish society. This demands that the supply of strategic resources is ensured without any foreign dependency. In the interviews, the following comments were made in this regard: 'There is this political belief that we need to have our own energy sources and cannot count on EU's promises' (expert No. 11); 'The Poles like to be self-sufficient which means that we have to have it (generation infrastructure) here' (expert No. 15).

High electricity prices: High electricity prices can reflect supply security constraints and lead to voter discontentment. The concern of the impact of price surges on consumers is the reason why the Regulatory Authority still controls tariffs for the majority of the Polish households. In parallel, high prices can boost interest in DR both at supply- and demand-side. However, in the assessment of the interviewed experts, the price level on the wholesale and retail markets in Poland has not been sufficiently high to significantly increase DR attractiveness.

Increasing share of RES: Electricity generation in Poland is based on hard coal and lignite. RES still play a marginal role with the total share of approximately 14% in the electricity generation (IEA, 2017). Therefore, RES have not yet been perceived as a real threat to the stability of the Polish electricity network, especially because a significant share of RES stems from co-firing of biomass with coal (CEE Bankwatch Network, 2016; IEA, 2017; Olszewski, 2014), which does not cause balancing problems. The RES share is, however, projected to reach 15% of the

[6] Until the end of 2015, Poland coupled its day-ahead wholesale market only with one region, the Nord Pool.
[7] The unplanned power flows occur when the capacity of the German transmission lines is not sufficient to transport electricity generated from RES in northern Germany to the south. The flows overload the Polish transmission lines and, therefore, hinder planned transactions between Poland and its neighbors.

overall energy consumption in Poland by 2020 (EU, 2016). Particularly wind, which blows mainly at night when demand for electricity is low, is expected to play a more prominent role. The integration of the increasing share of wind generation into the Polish system, which is dominated by large thermal power plants with limited flexibility, will become a greater challenge in the future (Maćkowiak-Pandera et al. 2015). Accordingly, the demand for flexibility in the system will increase.

To conclude this subsection, the Polish electricity system has faced the threat of supply deficits because of inadequate reserves to satisfy peak demand and limited interconnector capacity. Supply security concerns have already motivated the TSO to pursue DR and could lead to a broader DR uptake. Increasing RES penetration, particularly wind generation, can additionally destabilize the Polish electricity system in the future, thus increasing the need for flexibility in the system.

3.2.2 Regulatory pressure from the EU

As an EU member, Poland is obliged to transpose binding EU regulations into national law in various areas. The Energy Efficiency Directive of the EU (EED) requires MS to enable a level playing field for DR in particular at the level of tariffs, regulatory incentives and market access (Directive 2012/27/EU). Therefore, the regulatory pressure of the EU has been perceived by many of the interviewed experts, particularly by those having a systemic view of the electricity market, as a potentially important driver of DR uptake in Poland. However, the provisions of the EED still have not been implemented into Polish national law, although the deadline passed in June 2014. Poland is not very unusual in this regard, as many MS had not yet met this goal by the end of 2015 (Crisp, 2015). Obviously, the consequences of non-compliance have not seemed sufficiently daunting. ‘We always implement those EU legislations into our own law with a significant delay and usually under the pressure of the approaching fine’ said expert No. 10 in this regard.

In general, the compliance with EU climate policy has been particularly challenging for Poland due to the country’s great coal dependence. For this reason, when negotiating with the EU on energy-related matters, Polish governments have usually requested special conditions pointing out the distinctiveness of the Polish situation and possible negative implications for economic growth in case of too radical decarbonisation measures (CEE Bankwatch Network, 2016; IEA, 2017).

To conclude this subsection, regulatory pressure from the EU boosts DR hopes, but it is not strong enough to drive immediate national-level reforms to enable a level playing field for DR.

3.2.3 Positive cost-benefit profile of DR uptake in comparison to alternatives

The security of electricity supply can be enhanced through a range of options that include the extension or upgrade of the generation capacity, importation of electricity, storage (still not sufficiently mature) and DR. Although complementary, these options can be deployed in different proportions and in different time horizons, and therefore compete with each other for financial resources. The majority of the interviewed experts spoke about perceived comparative advantages of different solutions to improve the security of electricity supply and indicated that a prerequisite for DR uptake is a positive cost-benefit profile of DR deployment in comparison to its alternatives. DR cannot supplant necessary investments in new generation and import capacities in Poland, but it can be implemented as a short-term solution that helps to prevent supply shortages in periods of peak demand.

When comparing DR with the alternatives that are available in Poland the following aspects were primarily addressed in the interviews: technical feasibility, economic benefits, contribution to uncertainty avoidance, and prestige.

Technical feasibility: DR with large industrial enterprises is generally considered feasible. In Poland, however, many enterprises associate DR with a disruption of internal enterprise processes and with a need for significant investment. Regarding DR in households and small commercial or industrial consumers, the interviewed experts do not consider it realistic in the short-term as it requires the installation of smart meters and intelligent appliances, which are still too expensive to be pursued on a mass scale.[8] In general, DR is still seen as rather exotic and unmatched for the traditional supply-oriented Polish system. Expert No. 3 commented on this in such a way: 'DR is not an easy subject, it is reversing the philosophy that has been present so far.'

Economic benefits: In macroeconomic terms, the experts are convinced that one negawatt achieved by DR is significantly cheaper than one megawatt of new conventional generation capacity (cf. Energa, 2014; Kancelaria Sejmu, 2015). Further, DR can be implemented in the short-term as it requires lower upfront investment than new conventional power plants. These seem to be the key reasons why the Polish TSO pursues DR. The interest in DR of commercial

[8] The mass roll-out of smart meters has so far progressed slowly, although Poland is obliged to complete it by 2020 (Bartczak, 2016; Ciepiela, 2013).

actors such as energy utilities, DR aggregators, and large enterprises is also driven by DR's economic potential. The considerable revenue streams that DR has generated in, e.g., the USA and the UK (Capgemini, 2008; SEDC, 2015), raise the possibility of comparable benefits in Poland. Economic perspectives of DR vary, according to the interviewed experts, depending on the time horizon. Under the current regulatory framework in Poland, DR, even with large enterprises, seems not profitable for commercial actors. It has been projected, nonetheless, that in the mid- to long-term DR will play a significant role. Therefore, both DR aggregators and energy utilities, have been trying to develop a business model based on DR. They are aware that in order to enable DR regulation needs to be adjusted in parallel.

Uncertainty avoidance: The perception of security specifically in terms of the supply of strategic resources is very important in Poland. This is particularly evident in the debates on the dependency on Russian gas imports and Polish political efforts to create a common European energy policy (Buras, 2015; Keay, Buchan, 2015). This striving for security has roots in the Polish history of loss of independence and Soviet rule. Poland's geographical location at the eastern border of the EU also justifies Polish determination in ensuring supply of strategic resources. DR programs were perceived by the interviewed experts as offering even greater reliability compared to physical generation assets. However, the experts assess that the Polish need for security demands material security guarantees that are 'visible'. Without an effective awareness-raising campaign, the real security provided by an 'invisible' mechanism such as DR, which is moreover quite complex to explain, is not perceived by the majority of the Poles as concrete. 'In our country, a large power station using coal coming from a mine somewhere near Katowice is still seen as the synonym of security and is considered to be somehow a guarantee' stated expert No. 12. Expert No. 13 added to it: 'The priority is to ensure sufficient demand for the power generated by conventional energy sources because this is safer… Technologically safer, because it involves the things that are known, that people are familiar with.' The responses to a quick questionnaire I distributed at an expert conference on smart grids in Warsaw in 2014 clearly illustrate this attitude: I asked the conference participants which measures they would recommend improving the security of electricity supply in Poland. Although some of the presentations and discussions at the conference were explicitly dedicated to the potential of DR, a great majority of the respondents indicated the enhancement of the physical infrastructure as the main prerequisite for supply security.

Prestige: Although DR has an innovative image among electricity sector insiders, for large parts of Polish society, physical infrastructure constitutes a real status symbol. In recent decades, the

Polish populace has been very active in extending organizational and personal 'physical infrastructure.' Perhaps because of Poland's experiences under communist rule, as Poles say, the 'economy of austerity', this desire for material goods is especially intense. This is reflected in the building of big houses, equipping them with modern appliances, and purchasing new cars in order to underline personal social status. This drive for prestige can also be identified in the investment-related decision-making of the boards of energy utilities. A new power plant generates more social prestige and lends itself to clear and easily understandable publicity than an 'invisible' and complex mechanism such as DR. The following comment of expert No. 11 clearly showcases this attitude: 'All those in charge of large energy utilities prefer to add such an investment as building a new generation unit in Opole to their CV rather than focus on the DR. If there is any information about improving the management of the demand side, it is usually written in small print somewhere at the back.'

To conclude this subsection, the cost-benefit profile of DR deployment is a complex category that is composed of several aspects including both 'hard facts' such as the economic benefits of DR compared to its alternatives and 'soft factors' such as the contribution of DR to uncertainty avoidance and prestige. The interviewed experts themselves perceive DR uptake as advantageous but assess that other key actors of the electricity system do not necessarily share this view yet. Accordingly, DR seems to be still associated with the distortion of internal enterprise processes and the necessity of significant investments. Further, DR's contribution to the demonstration of prestige and to uncertainty avoidance is insufficient compared to building new conventional power plants. Expert No. 4 summarized the current perception of DR by the key actors of the electricity system as follows: 'Today it seems that it is easier, for numerous reasons, to manage the system from the production side rather than from the demand side.'

3.3 The underlying barriers to DR in Poland

As mentioned above, one of the core and most frequently discussed barriers to DR is unfavorable regulation. Regulatory hurdles can be described as 'directly observable' and are common across many EU MS (SEDC, 2017; SEDC, 2015). These include in particular limited access of DR resources to electricity markets, undefined role of DR aggregators, and inadequate requirements imposed on the providers of DR based products. At their roots, however, are the 'underlying barriers' to DR that help explain why regulatory reforms have not been implemented to promote DR adoption. In this study, the following 'underlying barriers' to DR uptake in Poland are identified as most crucial:

a) Coal dependence of the electricity system
b) Political influence on the TSO and energy utilities.

These barriers lead to inertia of the overall system, thus forestalling reforms towards DR uptake.[9]

3.3.1 Coal dependence

Poland is one of the most coal-dependent economies in the world. Electricity generation is based up to 86% on hard coal and lignite, which are largely available domestically. RES account for approximately 14% in the electricity generation and nuclear power plants are currently not present in the Polish electricity system. A significant share of RES stems from biomass that is used for co-firing with coal in existing conventional power plants. This practice is aimed at complying with EU RES targets[10] without much additional investment (IEA, 2017). In the energy mix projected until 2030, coal is predicted to dominate in the Polish electricity generation with a share of 59%. 12% of the electricity will be generated by nuclear and 7% by gas-fired power plants; 17% will stem from RES (Ministry of Economy, 2015). These projections demonstrate the continuation of the traditional supply path in Poland, despite the related environmental and economic risks. Although the Polish Energy Policy until 2050 has not been issued yet (end of 2017), it has to be assumed that, according to the declarations by the government, coal will remain the main pillar of the supply security (IEA, 2017; Nasz Dziennik, 2016).

The achievement of the EU RES targets is uncertain due to the prohibitive regulatory adjustments regarding new wind installations which were issued in 2016. An increase of the interconnector capacity is also planned to fulfill European commitments (IEA, 2017), but one has to keep in mind that Poland is not keen on relying on external resources to ensure the security of electricity supply.

Coal resources are seen as a kind of national treasure (Dubrovnik, 2015; Goettig, 2015; Kamiński, Kudełko, 2010), despite the fact that the economic contribution of the coal sector to

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[9] In the expert interviews, as in many publications dealing with the barriers to DR, obstacles such as insufficient consumer awareness, risk of process disruption in industrial enterprises and DR costs have also been raised. However, this study focuses on the underlying barriers to DR that hinder regulatory reforms towards a widespread adoption of DR. Removing regulatory barriers is considered crucial for coping with other obstacles to DR.

[10] The Renewable Energy Directive of the EU establishes national RES targets for every EU MS, taking into account its starting point and overall RES potential. Poland is obliged to achieve 15% RES share in the gross final energy structure by 2020 (Ministry of Economy, 2010).

the GDP is marginal and significant parts of the coal demand are satisfied by cheaper imports (Bukowski et al., 2015; EC, 2016). Additionally, coal mining and surrounding sectors employ approximately 400 000 people, thus making coal a socially and politically sensitive issue (IEA, 2017).

According to the majority of the analyzed interviews, coal dependence, or as some have expressed this, coal lobby, is a crucial barrier to DR uptake. The following experts' statements clearly showcase this reasoning: 'In Poland, there is a very strong lobby of electricity producers. When you open the door to DR, then you need to cut somebody else's income' (expert No. 10); 'Everything that can threaten coal mining and the coal-based electricity generation is perceived as an enemy. The fact is that DR can only minimally reduce the need for the coal-based electricity generation; nevertheless, DR competes with them for financial resources' (expert No. 1). It has to be noted here that the experts representing state-controlled energy utilities were generally vaguer in addressing Polish coal resistance than other actors.

DR, similarly to RES (cf. Igliński et al., 2016), requires major changes to the existing supply-oriented system and it has been perceived as competition to coal. Although this perception is not based on evidence, especially as DR usually does not reduce electricity consumption, it prevails among many system actors. Accordingly, DR rollout seems to be expected to decrease the demand for domestic coal and consequently to further deteriorate the ongoing crisis in the mining sector, thus leading to loss of jobs and voter discontentment.

Theoretically, nuclear power can also be perceived as competition to coal, but policymakers remain committed to building it. The following aspects seem to explain this: The commissioning of the first nuclear power plant with 3,000 MW capacity is foreseen in 2022. To achieve this goal, many stakeholders need to work together to develop a necessary knowledge basis and create a cadre of employees capable of operating the nuclear power program (IEA, 2017). An overall skepticism towards the ultimate reality of such plans is apparent in Poland. This kind of skepticism regarding the implementation of large infrastructural projects is rooted in the Polish experience with unreliable schemes for new highways and other large infrastructural projects. Further, although nuclear power is a new technology in Poland, it does not require any radical changes to the supply-side oriented logics of the electricity system, even if the nuclear plans should surprisingly turn into reality.

The crisis in the Polish state-owned coal mines is driven by falling coal prices on the world markets and the decreasing efficiency of the domestic coal extraction. Primal restructuring plans involving reduction of the workforce and closure of the worst performing mines has been stopped by trade union protests, which traditionally have been very strong in this sector. Protests are their typical strategy and usually result in ad hoc bailout actions, thus preventing long-term structural reforms (EC, 2016; Szulecki, Ancygier, 2015; Wasilewski, Sobczyk, 2015). There is a widespread opinion that the coal sector has, via the trade unions, a significant influence on political decision making in Poland. This influence was particularly visible before parliamentary elections, when candidates visited regions dominated by coal mining and made declarations how they intend to protect the interests of this sector (Goettig, 2015). The right-conservative government (since autumn 2015) even promised to avoid the closure of the lossmaking coal mines at all cost (Szulecki, Ancygier, 2015). ‘When the miners protest on the streets, the government gives them what they want’ said expert No. 14. Expert No. 12 added to it: ‘Our government is claiming that the mining industry is one of the main pillars of the Polish economy.’

The enduring problems of coal mining seem to affect any attempts to reform the electricity system on two levels: Through the threat of its deterioration as an outcome of the implementation of alternative solutions such as DR or RES. Further, the crisis in coal mining seems to serve as a ready excuse for political decision-makers who, for various reasons, prefer not to have to consider new solutions. The utmost urgency of the coal mining problem is always given the main priority, leaving little capacity for other issues. A long-lasting process to establish an incentives system for RES generation in Poland (Ancygier, 2015; EC, 2016; Neslen, 2016) has showcased that solutions perceived as ‘alternatives to coal’ face strong resistance in the Polish energy landscape.

Decarbonisation of the Polish electricity system is additionally hampered by a lack of societal dialogue (FGiAP, 2015) on the available supply options in Poland. The building of new conventional power plants is simply assumed to be the most obvious solution to ensure supply security, almost unquestioned in public debate and therefore alternatives rarely receive political attention, let alone priority.

To conclude this subsection, coal dependence seems to be a major barrier to DR uptake, as DR is perceived as competition to coal and it requires significant changes to the supply-oriented electricity system. Coal mining lobby is very influential at a political level and political decision-makers are committed to defending the interests of this sector.

3.3.2 Political influence on the TSO and the energy utilities

As co-owner, the Polish state controls four large energy utilities and the TSO. The state has always used its influence on these enterprises to realize current political goals. Although the TSO and the state-controlled energy utilities value DR potential, which has been proven by their various activities in this regard, they have not managed to make DR a viable resource to address system challenges. The reason for this seems to be the politically-driven management whose direction is obviously influenced by the official coal protection policy of the state (Gazeta Polska, 2016; Goettig, 2015). The interviewed experts commented on the state's influence on the electricity industry as follows: 'The chairmen of all Polish energy groups are political figures' (expert No. 3); 'We can observe a short-sighted political thinking based on hypocrisy, … and a defense of the status quo at all costs for as long as possible because it is a source of certain profits both for decision-makers at energy utilities and for politicians' (expert No. 14); 'There is a group of people who are interested in maintaining the state's control over the companies and such ideas are best sold in the media and political sphere' (expert No. 11). When discussing the role of politics in the energy sector, the experts representing state-controlled energy utilities generally seemed to be more hesitant and avoided direct judgments, nevertheless even their cautious explanations in this regard showcase the relevance of politics for their firms. 'The election in Poland is a crucial element;' 'In the autumn we will have the elections and after the elections we will find out what happens next' said experts No. 8 and 9 when asked about the future positioning of DR in their firm's strategy.

A more consequent DR advocacy by these state-controlled enterprises could be seen as a threat to the domestic coal mining and, therefore, declared as noncompliance with the official coal protection policy. Board members of the TSO and the energy utilities who act independently and pursue decisions not compliant with the strategy of the ruling party usually lose their positions very quickly. Typically, every political election in Poland leads to a replacement of the boards of state-controlled enterprises by supporters of the current political winners (cf. Davies, 2016; Szulecki, Ancygier, 2015).

Interestingly, despite their instrumental treatment by the state, the TSO and the energy utilities have always been considered as very efficient in defending their own privileges at a political level. These enterprises have the image of experts who possess 'secret' expertise and if political decision-makers try to resist their recommendations, they can always deploy their core argument about negative impacts on supply security.

Compared to German energy utilities, which are struggling with the consequences of the Energiewende (Balser, 2015), their Polish state-co-owned counterparts are still in relatively good economic shape (Szulecki, Ancygier, 2015). The isolation of the Polish electricity system contributes to this situation and is defended by politicians. The relative economic prosperity of the energy utilities has certainly not motivated them to change their business models, which, in turn, are required to uptake DR.

To conclude this subsection, the TSO and the largest energy utilities as key actors of the Polish electricity system, value DR's potential. Their bargaining power, however, does not reach far enough to counter the official state policy that protects domestic coal mining. Additionally, in light of their positive economic performance, the utilities have not been strongly motivated to insist on reforms, particularly as DR adoption is expected to substantially change their supply-side oriented operational patterns.

4 Discussion

In Poland, we can observe a paradoxical situation: There is a 'window of opportunity' for a wider DR adoption and numerous influential actors have shown a profound interest in this concept. Nevertheless, DR still plays only a minor role in the electricity system.

Supply security concerns and regulatory pressures that were pointed out in the expert interviews as key drivers of DR seem to have driven DR adoption in the USA too. Smith and Hledik found out that, amongst others, low reserve margin[11] and high retail prices of electricity in some of the U.S. states which both imply supply security concerns motivated DR uptake. Further, they suggested that regulatory pressure and increasing RES penetration might strengthen the role of DR in the future. Other drivers identified by Smith and Hledik, including electricity market structure and presence of demand-side policy (Smith, Hledik 2011), showcase different categories than the ones used in this study – the 'chicken and egg dilemma' – but support the policy implications provided below.

Even if in one country there is favourable DR regulation in place, DR might not play a significant role because there is no need to implement it, e.g. supply security is not endangered and/or there is no regulatory pressure to create a level playing field for DR.

[11] Reserve margin is defined as 'degree to which the capacity of the system exceeds the expected peak demand.'

The perception of DR in comparison to available alternatives (in other words, the cost-benefit profile of DR deployment), was identified in this study as the third possible key driver of DR implementation. DR is not the only means to improve supply security and flexibility and therefore DR's positioning in the context of alternative options, such as the enhancement of generation infrastructure and the importation of electricity is crucial for the chosen mix of solutions. In Poland, rational arguments such as the short-term technical feasibility of DR and relatively low investment needed for its rollout do not seem to outbalance the fact that, in particular, DR does not appear as prestigious and secure as new conventional power plants. DR uptake cannot replace the enhancement of the generation capacity, which is inevitable to ensure reliable electricity supply in the future. DR can only become a complementary short-term solution that helps to prevent blackouts during peak demand periods (Pawłowicz, 2015). Interestingly, the potential environmental benefits of DR do not play a significant role in driving DR in Poland.

In terms of the underlying barriers to DR hypothesised in this study, two were identified: coal dependence and political influence on energy enterprises. Both of them cause inertia of the Polish electricity system and explain why the necessary regulatory reforms have not been undertaken to enable a sufficient level playing field for DR.

Coal dependence in Poland is a form of path-dependence and specifically in this context of what Gregory Unruh has referred to as 'carbon lock-in' (Unruh, 2000, 2002). In Poland, such a carbon lock-in is evident at all levels of the electricity system, and this study found few reasons to believe that it can be overcome in the near future. The Polish policymakers are committed to defending the national coal industry and, as DR is perceived as competition to coal, which could further deteriorate the enduring crisis in this sector, there has been opposition to reforms that would empower alternatives to coal.

It can be assumed that in other countries, other sorts of path-dependencies resulting from the prevailing energy mix might be responsible for hindering regulatory reforms towards DR and other new energy technologies.

The second underlying barrier is political influence on state-controlled energy enterprises, in particular on the TSO and the largest energy utilities. Political influence on these influential actors, who have shown interest in DR and therefore could become 'institutional entrepreneurs'[12] (DiMaggio, 1988), is the reason they are not becoming determined DR advocates. Presumably, a significant weakening of the economic performance and/or shifting managerial priorities away from compliance with political goals towards long-term-oriented economic rationality would motivate these powerful enterprises to take up new solutions.

In the scientific discourse about barriers to DR, such underlying barriers to DR as resource dependencies and political influence have been mostly neglected so far and therefore the question why DR-unfavourable regulation still persists in the majority of the EU member states has not been truly answered.

Further research is needed to understand how DR uptake has succeeded in the countries where DR has been applied on a larger scale. Bo Shen et al. stressed the role of regulatory reforms, market changes, and technology development to make DR a viable resource in meeting energy challenges in the UK, but did not address any background forces influencing systemic reforms towards DR (Shen et al., 2014). In this regard, it would be crucial to investigate barriers to regulatory reform that enabled demand-side resources and to analyse the strategies of key actors, institutional entrepreneurs, to overcome these barriers. More specifically, answers to the following questions are of utmost relevance to speed up DR uptake in Europe: Which actors were particularly interested in pursuing DR uptake in countries, in which DR has become a viable electricity system resource? How did these actors manage to convince other market players of the advantages of DR? What kinds of arguments and communication strategies did they use? Which role did political decision-makers play in pursuing regulatory changes towards DR?

Conceptual model of DR uptake in electricity systems

The results of the study can be generalized in a form of a conceptual model explaining the mechanisms of DR uptake in electricity systems.

[12] Institutional entrepreneurship refers to the 'activities of actors who have an interest in particular institutional arrangements and who leverage resources to create new institutions or to transform existing ones' (Maguire, Hardy and Lawrence, 2004).

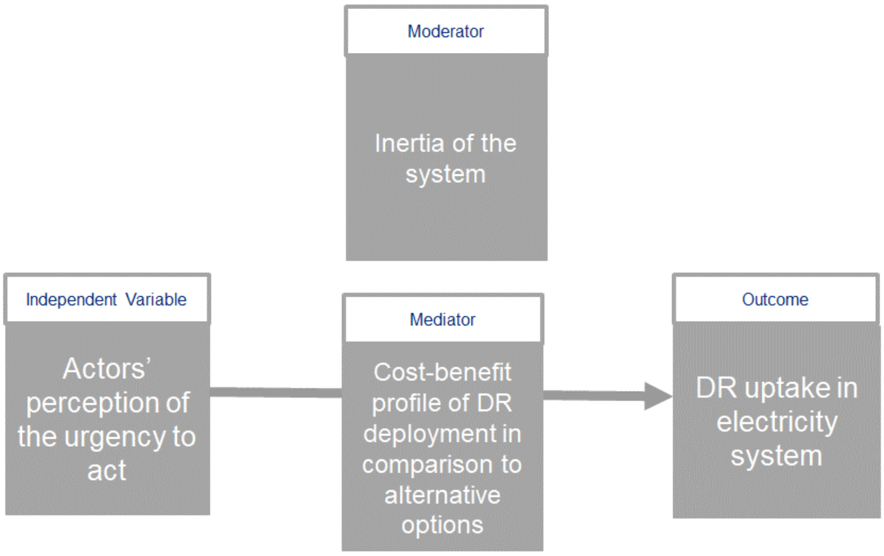

Figure 3 Conceptual model of DR uptake in electricity systems

The mechanisms of DR uptake can be described as follows: As long as key actors including policy decision- makers, energy utilities, TSO and large electricity consumers are satisfied with the status quo of the electricity system, there is no motivation to undertake any changes. The need to act arises when actors perceive their interest to be threatened and are therefore under pressure to act. In Figure 3, it is expressed as actors' perception of the urgency to act. This can be the result of projected supply deficits or regulatory pressure. Other drivers could be external shocks or increased awareness, which contributed to the uptake of RES in Germany (Jacobsson, Lauber, 2006). In Poland, actors' perception of the urgency to act seems to have increased after the blackout threat in August 2015 and it might be one of the motivating factors for the introduction of DR availability payments in 2017. Actors' perception of other options providing effects similar to DR is probably a mediating factor in DR uptake. The more advantageous or complementary DR is perceived in relation to its available alternatives, the more likely it is that actors who value DR's potential and have sufficient resources, institutional entrepreneurs, will actively pursue systemic changes enabling DR uptake. In Figure 3, it is expressed as a cost-benefit profile of DR deployment in comparison to alternative options. In Poland, the feasible alternatives to DR to ensure continuous electricity supply include in particular the extension/upgrade of the conventional generation capacity and electricity importation. Although complementary, these options can be deployed in different proportions and in different time horizons, and therefore compete with each other for financial resources. As the expert interviews and politicians' statements revealed, the building of new coal-fired power plants is still, for various reasons discussed above, the most preferred option in Poland. The pace of systemic reforms towards DR uptake depends on the characteristics of the system in question. The stronger the inertia, caused by path-dependence, the more challenging it is for potential institutional entrepreneurs to succeed in tackling the barriers to DR. Accordingly, the inertia of the system has been identified as a moderator of DR uptake. In Poland, coal dependence that is preserved by political decision-makers is responsible for the inertia. As some of the interviewed experts underlined it, maintaining the status quo is a source of benefits for many key actors of the electricity system.

DR uptake in electricity systems is to be evaluated at various levels of the electricity system: At a regulatory level, DR should not be put at a disadvantage compared to supply-side solutions. In terms of consumers, awareness of DR's value could be a further criterion to assess the degree of DR adoption. Quantitative indicators of DR uptake need to include the percentage of peak demand satisfied by DR, number of actors involved in commercial DR activities and revenues generated by DR.

It is likely that both drivers and underlying barriers to DR uptake are common for the adoption of other solutions, which, as DR, are in fact radical innovations and require deep changes at numerous levels of electricity systems.

5 Conclusions and policy implications

The key message of this qualitative study is that the slow DR uptake in Poland may be hindered by underlying barriers preventing systemic reforms needed for a wider adoption of DR. It can be assumed that such underlying barriers to DR also prevail in other European countries. Unfavorable regulation, often discussed as the main obstacle, is in fact symptomatic of these underlying barriers. In Poland, coal dependence and political influence on energy enterprises are identified as these underlying barriers. Both of them can explain the inertia of the Polish electricity system. Supply security concerns, regulatory pressure from the EU, and the positive cost-benefit profile of DR deployment in comparison to alternative options are revealed as main drivers of DR uptake. These drivers are likely to have led to various DR-oriented initiatives, such as tenders for negawatts (PSE, 2015), the opening of the balancing market to the demand side (SEDC, 2015), pilot projects and the establishment of DR aggregators. These drivers have, however, not turned DR into a valid resource to address the challenges of the Polish electricity system. It has been estimated that, so far, only a small part of DR potential has been tapped in Poland (SEDC, 2017; Pawłowicz, 2015; SIA Partners, 2015). Instead, building new conventional power plants has been chosen as the main solution to avoid potential blackouts. DR, as a primarily software-based solution without large physical infrastructures and which requires consumer involvement, is not seriously treated as a valid short-term solution to prevent blackouts during peak demand periods in Poland.

The state-controlled energy utilities and the TSO have shown a deep interest in DR. However, possibilities for meaningful actions by these actors, which have a dominant position in the Polish electricity system, but are subject to political influence, are limited by state policies designed to protect the domestic coal industry. As a result, these actors are prevented from consequent DR advocacy and adoption, since it could aggravate the crisis in coal mining, thus leading to voter discontentment.

Based on the empirical results discussed above, a conceptual model of DR uptake in electricity systems was proposed in this study. This model stipulates that DR uptake depends on key actors' perceptions of the status quo of the electricity system in the context of the realisation of their primary interests. If these interests are threatened and if DR is perceived as a potential means to protect them in light of the available alternatives, either more advantageous than or complementary to the alternatives, DR uptake could be pursued. The inertia of a system such as the one in Poland can, however, represent a major obstacle to DR uptake.

Since the pressure to implement reforms in the electricity system and, more specifically, to enable DR is linked with actors' perception of the necessity to do so in relation to their goals and priorities, one main policy implication for overcoming regulatory hurdles to DR can be derived out of the proposed conceptual model: Awareness among key actors concerning the threats of maintaining the status quo and DR potential to address challenges of the electricity system in question is a prerequisite for meaningful action.

What could this policy implication mean for the Polish electricity system? The state as the most influential actor in the Polish electricity system is still committed to protecting the interests of the domestic coal industry, thus, in fact, maintaining carbon lock-in in Poland. To overcome the lock-in, a new energy policy needs to be developed (cf. Foxon, 2002). Raising awareness among Polish political decision makers concerning the consequences of the coal dependence and concerning DR potential to address the challenges of the Polish system seems to be crucial in this respect. As seen in the context of the Energiewende in Germany, this kind of approach involves, among other dimensions, a long process and intense advocacy work of different societal groups (Jacobsson, Lauber, 2006). In the absence of a strong civil society in Poland (Makowski, 2014), state-controlled energy enterprises seem to be the only actors with a sufficient expertise and capacity to influence political decisions and to initiate changes with regard to energy policy. A prerequisite for involving these state-dependent actors as institutional entrepreneurs is, of course, the awareness that the status quo threatens their future business.

While this study cannot propose an effective strategy to raise awareness among political decision makers, it does highlight two aspects: First, it would be necessary to coordinate the efforts of different DR advocates and to develop a joint roadmap concerning DR uptake. Second, to effectively pursue systemic changes that enable a wider DR adoption, the complementary character of DR (especially in the context of conventional coal-fired electricity generation) could be emphasized rather than presenting DR as a competitor to coal. For this reason, independent studies will have to be commissioned to quantify the potential and to discuss the possible combinations of different options, including DR, that are likely to contribute to energy security in Poland. In these studies, the impact of DR on the domestic coal mining will have to be assessed. Obviously, positioning any energy technology as a coal alternative would immediately lead to resistance of political decision makers in Poland who, instead of creating enabling conditions for this solution, would block it. Due to the perception of coal as a national treasure and coal miners that play a key role in gaining political power, it seems to be advisable to avoid coal-antagonistic framings and, instead, to pursue a step-by-step shift in awareness.

In the context of the regulatory pressure of the EU as another driver of DR uptake in Poland, in particular the EED, which still has not been implemented into the national laws of many MS including Poland, the extent to which harsh penalties for non-compliance could lead to a quicker adoption of EU provisions at the national level should be examined

DR uptake is a complex process that requires changes to the electricity system. To tackle the underlying barriers preventing systemic reforms necessary to exploit the DR potential in Poland, it will be necessary to garner the support of political decision-makers. This might be a great challenge given the position of coal in Poland. Investigating DR uptake in countries in which this concept has been applied on a significant scale for many years, particularly regarding main drivers, underlying barriers, and related strategies of DR advocates, could provide valuable insights on how to manage this process more effectively. Further research could also be used to validate the model of DR uptake proposed in this study.

Acknowledgements

I would like to thank my advisor Ursula Weisenfeld for the continuous support and fruitful discussions during the elaboration this study.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Paper 2: Gaining legitimacy for sustainability transition: A social mechanisms approach

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Review and resubmit: Environmental Innovation and Societal Transitions / August 2021

Abstract

Applying a social mechanisms approach to the Multi-Level Perspective, we conceptualize mechanisms of socio-technical transitions and of gaining legitimacy for transitions as co-evolutionary drivers and outcomes. Situational, action-formational, and transformational mechanisms that operate as drivers of change in a socio-technical transition require corresponding framing and framing contests to achieve legitimacy for that transition. We illustrate our conceptual insight with the case of the coal dependent Polish electricity system.

Highlights

- We propose a conceptual model of mechanisms in socio-technical & legitimacy transition.
- We present framing and interaction patterns as key mechanisms of legitimacy transitions.
- We analyse a non-transition and identify a lack of legitimacy struggles.

Keywords: sustainability; legitimacy; transition; social mechanisms approach; multi-level perspective; energy system

1 Introduction

Innovations need legitimacy to be developed and supported (Geels and Verheers, 2011; Hargadon and Douglas, 2001; Markard et al., 2016). Legitimacy is related to the social acceptance of for example, a new industry (Aldrich and Fiol, 1994), new technologies (renewable energy: Bergek et al., 2008), or material elements (coal: Isoaho and Markard, 2020). Acceptance as a relational concept is in the eye of the beholder (Ashforth and Gibbs, 1990) and in the case of a socio-technical transition there are many such as citizens, companies, regulators, and national and supra-national policymakers. As actors differ regarding knowledge, norms, values and perceptions, are embedded in different 'systems' and thus, pursue different agendas, legitimacy struggles are highly likely. With increasing pressure for change, the need for new technologies and institutions including regulation and practices becomes apparent. Efforts to change are met with efforts to conserve: transitions are characterized by struggles (Geels et al., 2016). The struggles between proponents of the 'new' and defenders of the 'old' or among advocates of different technologies take place in public arenas.

The Multi-Level Perspective (MLP) is a useful framework to study these complex developments: linking three levels, and investigating processes, outcomes and depicting actors has furthered our understanding of how sustainability transitions (ST) evolve. Yet, transition failures are under-researched (Turnheim and Sovacool, 2020), and we can learn more about bottlenecks when investigating transition cases that exhibit a lack of progress (e.g., Hungary: Antal, 2019). We take the case of a (so far) transition failure as a starting point and explore conceptually the nexus of legitimacy and slow or even non-transition.

This reluctance to transition applies to the energy systems in Central-East EU member states that are characterized by out-dated infrastructure, supply security concerns and environmental problems, on the one hand, and EU climate commitments and decreasing prices of renewable alternatives on the other hand (Nabiyeva, 2018; Scott, 2018; World Bank Group, 2018). Still, policymakers in these countries largely stick to conventional bulk electricity generation (Ámon, 2018). The Sustainability Transitions Research Network has explicitly called for extending transition studies beyond Northern European countries (Köhler et al, 2019). This is particularly important for Central-East EU member states because their electricity systems are responsible for a significant part of CO_2 emissions (Eurostat, 2019), they actively attempt to block international decarbonisation efforts (Keating 2019; Strupczewski and Baczyńska, 2019) and without their active contribution the EU's climate targets will not be reached.

To explain the reluctance of pursuing a transition, we apply the social mechanisms-based framework of change (Hedstrøm and Swedberg, 1998) to the MLP, conceptualizing the MLP as a system of systems, each with its components and relationships (systemic view: Bunge, 2003). Opening the black box in the context of ST means asking why the transition of a particular socio-technical system does not take place (for the time being) in spite of multiple pressures. We depict situational, action-formational, and transformational mechanisms as drivers of change in a socio-technical transition and argue that framing and framing contests are key mechanisms to achieve legitimacy for that transition. This involves multiple objects of legitimacy judgements, from technologies and related artefacts to actors and their actions.
We investigate 'energy market' related policy documents, regulations, scientific papers, press articles and statements of various actors on the national and EU level to explore the reluctance to change of the coal-dependent electricity system in Poland. Poland is an interesting case because (a) being exposed to systemic pressures such as out-dated electricity generation infrastructure, EU decarbonisation commitments, and promising potential of renewable energy sources, there is an evident window of opportunity for a ST; (b) Poland represents a socio-technical system based on coal where state, coal mining industry and energy utilities are intertwined (RAP, 2018; Szulecki, 2020), which provides a power block that is difficult to enter (similar to Hungary: Antal, 2019) and (c) the 'block' uses framing as a mechanism to legitimize the preservation of the status quo and to squash emerging players (Żuk and Szulecki, 2020). Although the number of these emerging players is growing, they are still weak and without significant influence on policymaking.

Our conceptual study contributes to the understanding of ST: First, we introduce the notion of legitimacy transition into the MLP framework and highlight the role of framing and framing contests as key mechanisms. A socio-technical transition involves change regarding technologies, artefacts, agents, habits, and reasoning – gaining legitimacy for these 'new elements' is key for the *actual* transition to take place. Exploring this process we address the link between individual and social processes (Upham et al., 2020), and between structural elements and dynamic processes (Oliveira et al., 2020). Acknowledging the discussion of the role of legitimacy in the context of transitions (Bergek et al., 2008; Markard et al., 2016), we use the social mechanisms approach to explain conditioned action within the social system. Second, we illustrate our framework by applying it to a context that differs importantly from countries that initiated ST: Poland and other Central-East EU countries are rather interested in maintaining the status quo (Heinrich Böll Stiftung, 2018; Nabiyeva, 2018; Antal, 2019). These countries differ in their energy mixes, but are similar in their attachment to conventional electricity generation as a guarantee of supply security (Ámon, 2018; Mata Perez et al., 2019).

2 MLP and mechanisms of transition

The MLP (Rip and Kemp, 1998; Geels, 2010) conceptualises ST as a significant transformation of large societal systems towards more sustainable modes of production and consumption (Markard et al., 2012). The MLP differentiates between landscape, socio-technical regime, and niche levels: landscape represents an exogenous background including socio-technical developments (Coenen et al., 2011), supra-national regulation, and external shocks (Geels, 2018). The socio-technical regime consists of institutions such as regulation and established user practices, and relates in particular to intangible elements, whereas the socio-technical system refers to more readily measurable elements such as technical infrastructure (Geels, 2012). Niches are spaces of experimentation (Rip and Kemp, 1998). In the following we use the term "socio-technical system" implying both intangible and tangible elements of the MLP.

Transition pathways describe how developments on these different levels align over time as trajectories of transformation, substitution, reconfiguration or de-alignment & re-alignment (Geels and Schot, 2007). Geels et al (2016) further develop these typical pathways through differentiating between various kinds of enactment and technological & institutional change. Complexity, non-linearity and shifts between different types lead to many possible 'real' pathways, with different landscape structures (Geels et al, 2016) such as (path dependent) political and economic systems adding to the variety of possible paths. Common to all these pathways is that they depict developments from one system to another by investigating actors, technologies, institutions, and their interrelations on the different levels and across levels over time. What are the drivers of change?

Recently, Sorrell (2018) proposed a realist take on the MLP, which emphasizes the need to identify causal mechanisms to explain a particular (non) transition of a system. Our approach follows the realist philosophy, which holds that "the external world exists independently of our sense experience, ideation, and volition, and that it can be known", (Bunge, 1993: 229), if only partially and often indirectly. Identifying mechanisms is key to explaining change in and of systems (Bunge, 1997; Hedstrøm and Swedberg, 1998).
Bunge's scientific realist philosophy (Bunge, 1996, 1998, Reihlen et al, 2021) is particularly well suited to describe and explain (lack of) change:
Ontologically, seeing the world as a system of systems, with each sub-system incorporating its

own dynamics, the approach accounts for emergent properties, which in turn influence each (sub-) system. Accordingly, we refer to the socio-technical regime as a system, the niche as a system, and depict systems that stretch across the levels, such as the political system. Epistemologically, relational value judgements (such as legitimacy judgements) are acknowledged as real and the task of the researcher is to describe and explain these.

Mechanisms are drivers in processes of change (Bunge, 1997) and unveiling them means to explain the change process, which opens possibilities to influence it. The social mechanisms approach links behaviour on the micro level with systemic outcomes (Coleman, 1990), thereby delivering explanations of social phenomena (Hedstrøm and Swedberg, 1998; Edling and Rydgren, 2016). To open "the black box we need to specify the relevant types of actors, the type of activities they engage in, what propels them to behave the way they do, and how their behavior collectively brings about the macro outcome to be explained" (Hedstrøm and Wennberg, 2017: 92). It entails identifying causal relationships and exploring contextual conditions (Oliveira et al., 2020). Hedstrøm and Swedberg (1998) describe three types of social mechanisms: (1) *Situational mechanisms* (macro - the effect of structure and events - to micro - the effect on beliefs and desires), where being exposed to a specific situation affects actors in a certain way: belief-formation mechanisms, opportunity-generating mechanisms, and preference-formation mechanisms; (2) *Action-formation mechanisms*, where (micro-to-micro) psychological and social-psychological mechanisms, such as framing, mending or innovating, generate specific actions; (3) *Transformational mechanisms*, where interactions, such as framing contests, development of master frames and coalition building, lead to collective outcomes (micro-to-macro transformation).

In the case of ST, key macro-to-micro situational mechanisms are system problems and landscape events (such as capacity problems, a new technology, emerging cultural patterns, or catastrophes underlining the need for change) that influence actors' beliefs and preferences.

These potentially disruptive events need to be articulated to achieve social significance (Franco-Torres et al., 2020). Depending on the dominant framing used in this context aligned with actors' preferences and possibilities, action-formation mechanisms occur. For example, the meltdown of the nuclear fuel rods in Fukushima as a macro-to-micro situational mechanism led to the German chancellor Angela Merkel changing her position regarding nuclear energy, followed by action-formation mechanisms 'weighing the options' and 'deciding' that Germany will phase out nuclear power. This decision and respective framing in turn provided an impetus for pushing (as another action-formation mechanism) RES even more. Such events open opportunities for some entrepreneurs, but the same event as a macro-to-micro situational mechanism also leads to other reactions such as actors engaging in warnings regarding price increases or defending nuclear power as a means to halt carbon emissions (Blackmore, 2013). Generally, resulting actions vary and interact. These relational aspects are expressed in mechanisms of social norms (Kim et al., 2016) and social influence. In the case of the nuclear phase-out decision, the majority of the German population perceived nuclear power as dangerous (after years of struggles: Glaser, 2012; Paul, 2018) and welcomed the move towards pushing renewable energy sources. The action-formation mechanisms (phase-out decision, increased engagement in alternative energy sources) strengthened the anti-nuclear sentiment and became the social norm (Blackmore, 2013). This is a collective outcome based on interaction patterns of struggles and alliance building as a transformational mechanism (Hedstrøm and Ylikoski, 2010). The related institutional change was seen as legitimate, thereby alleviating people's worries concerning the consequences of energy transition (Ehlert et al., 2019). Figure 4 depicts types of social mechanisms in the context of ST.

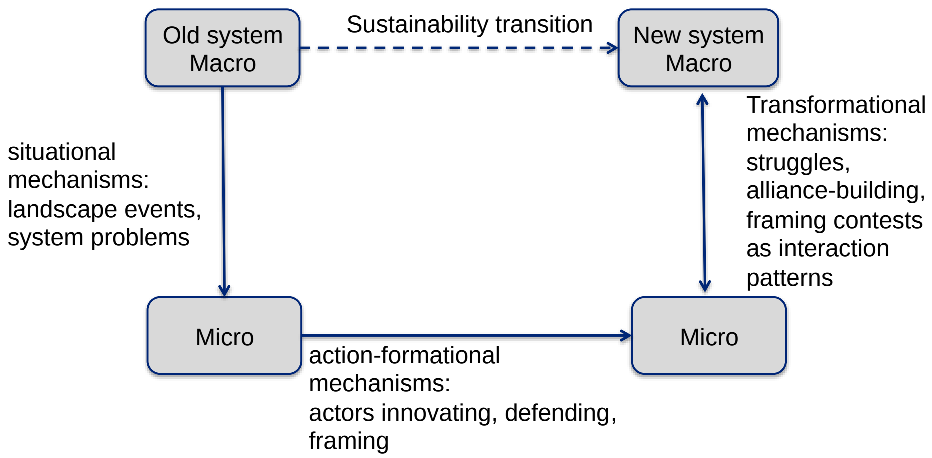

Figure 4 Social mechanisms in ST

To apply the social mechanisms approach to the MLP, it is useful to describe and to understand the socio-technical system, the niches, and the landscape in systemic terms (CESM, Bunge 2003): A concrete system has **C**omponents, an **E**nvironment, a **S**tructure (relationships between components), and **M**echanisms.

As a crude sketch, in a concrete socio-technical system we find actors (as individuals and groups) as 'social' components, technical artefacts such as built infrastructure as 'technical' components, and features such as emerging expectations and habits of actors regarding technical components as 'socio-technical' components. Relationships between these components make up the structure. The niches are depicted as systems with their own actors, artefacts and structure, as are various systems that stretch across the levels such as the natural, economic, and political system. While the levels of niche, socio-technical system, and landscape indicate increasing structuration, differentiating between several systems allows explaining the effects of a system's peculiarities (types of components and relationships) on the operation of social mechanisms and thus, on emergence and submergence. Figure 5 depicts the combination of the MLP's three levels with the systemic perspective and sketches a landscape event (for example, a natural disaster) as situational mechanism.

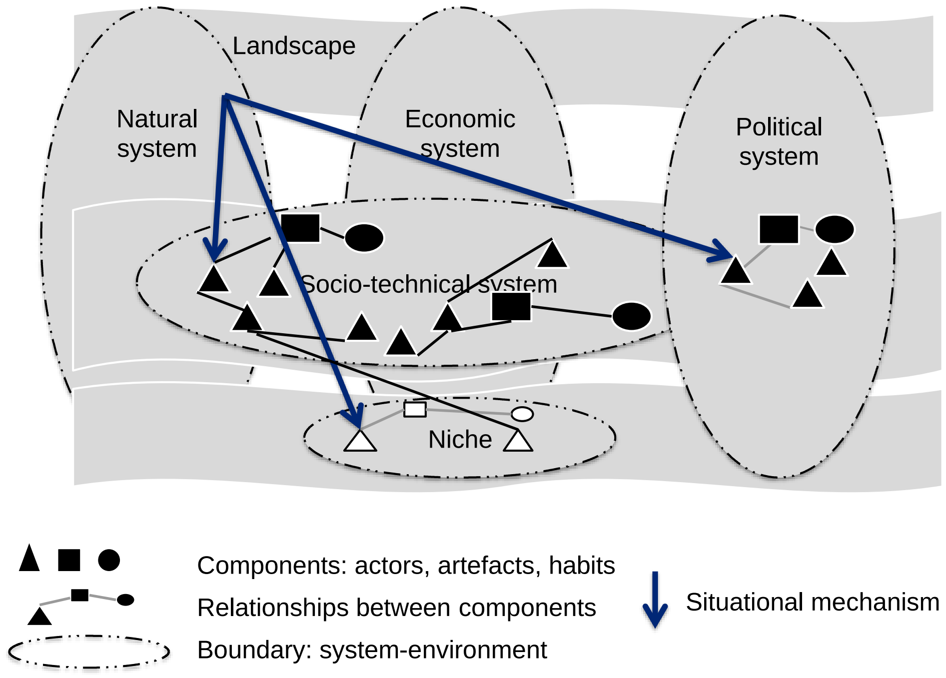

Figure 5 Systemic view on the MLP

Situational mechanisms then are events that influence actors, whether the actors are part of the socio-technical system or a niche, or any other system. The meltdown of the nuclear fuel rods in Fukushima as a macro-to-micro situational mechanism influenced actors in the political system (strengthening doubts about an established technology), in the niche as a system (bolstering up entrepreneurs engaged in renewable energy sources) and in the socio-technical system (established actors fearing technological disruption), initiating respective action–formational mechanisms. Likewise, a blackout caused by (socio-technical system-immanent) capacity problems as a situational mechanism could lead to actors in the socio-technical system calling for enlargement of the conventional generation capacity, actors in a niche being encouraged to propose alternative solutions, and actors in the political system defending the status quo or re-orientating their support.

The effect of a situational mechanism on an actor in the shape of initiating an action-formational mechanism thus depends on the actor's knowledge, beliefs and preferences, which are – crucially – also shaped by the peculiarities of the system(s) that the actor is part of.

The sequence of situational and action-formational mechanisms can take place in each of the different systems. Figure 6 depicts the sequence of a capacity problem as a situational mechanism and an action-formational mechanism in three systems.

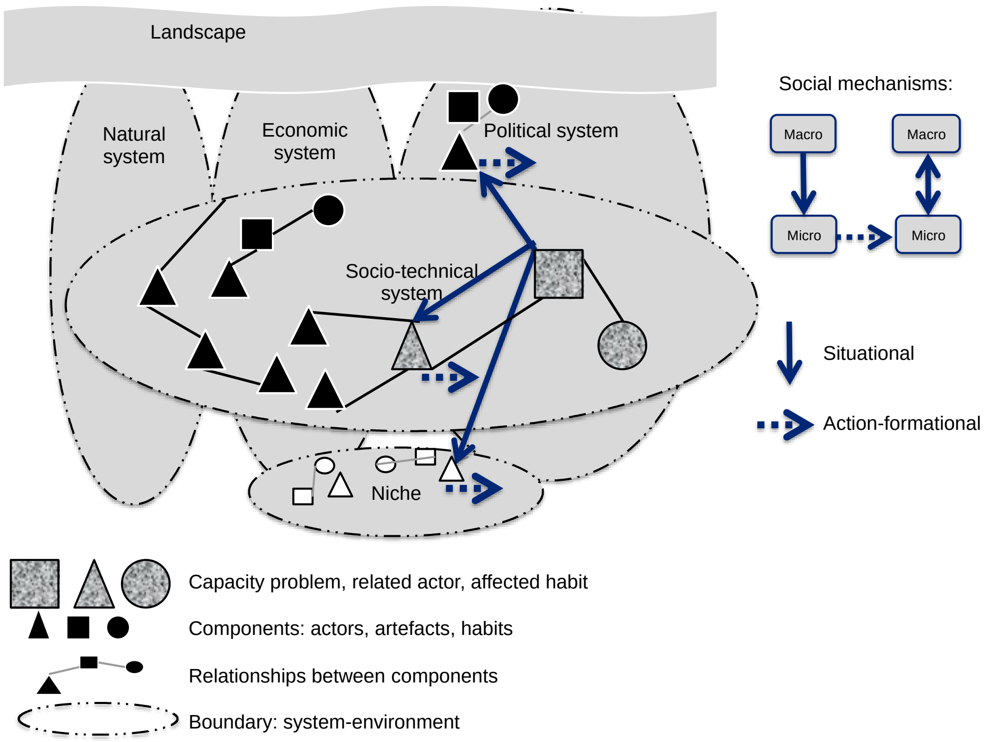

Figure 6 Capacity problem as a situational mechanism inducing action-formational mechanisms

Thus, for each system, the relevant socio-technical system, the niche, and the political system, this situational mechanism affects actors and leads to different action-formation mechanisms. Problems in the current socio-technical system such as out-dated technology may on the one hand facilitate change (Geels 2005), as depicted in the transition pathways 'transformation' (some incumbents pursue gradual or even radical change), 'substitution' (new actors overthrow incumbents) or ‘reconfiguration’ (niche actors and incumbents cooperate), (Geels et al., 2016). On the other hand, established actors of the system are likely to resist major change: Turnheim and Geels (2013) and Geels (2014) highlight this resistance and call for attention to destabilization of existing fossil fuel-based systems. Especially incumbent firms tend to defend the status quo and oppose radical change; they actively deploy instrumental, discursive, material and institutional forms of power (Geels, 2014). As Turnheim and Geels (2013) demonstrate with the example of the British coal industry, legitimacy crises caused by external pressures and performance problems repeatedly eroded support for the industry from the public and policymakers. Eventually, the UK electricity system is said to undergo a ST with an ambitious decarbonisation agenda (Barton et al., 2018). However, the recent UK government’s silence on a new deep coal mine in Cumbria, the resulting protests, and subsequent reconsideration (Harvey and Greene, 2021) are testament to the unfolding struggles in ST. In general, the political system plays a crucial role for transition: it sets some ‘rules of the game’ for the socio-technical system and the niche system and may provide or restrict resources; policies may support more sustainable technologies or destruct the established system (creative destruction: Kivimaa and Kern, 2016).

Finally, while systems’ components and relationships influence actors’ beliefs and preferences, it is important to consider heterogeneity of actors within systems regarding preferences, competences and their openness for ‘something new’.

To summarize: social mechanisms as drivers of change help to explain different transition pathways through specifying how actors respond differently to pressures. A systemic view on the MLP allows explaining the different impacts and conditions of social mechanisms in the socio-technical system, the niche and in other systems such as the political or economic systems. Applying the systemic view and analysing actors’ relationships with other system elements further the understanding of actors’ motivation for specific actions such as pursuing change or defending the status quo. Key mechanisms for transition are landscape developments and socio-technical system problems (situational mechanisms), and actors’ activities such as mending or innovating (action-formation mechanisms) and interaction patterns (transformational mechanisms).

Scholars have stressed the important role of legitimacy for transitions (Turnheim and Geels, 2013) and Bergek et al. (2008) identify the process of legitimation formation as crucial for the emergence of new Technological Innovation Systems (TIS). Yet, how does social acceptance of actors, technologies, artefacts and habits change; how is legitimacy eroded for the established system and how is legitimacy built for the new (legitimacy transition)? We pay particular attention to framing and framing contests as *social mechanisms* for legitimacy transition.

3 Framing and framing contests to achieve a legitimacy transition

Legitimacy is a widely applied concept in the management literature. It relates to the social acceptance of something, and Suchman's (1995) definition of legitimacy as "a generalized perception or assumption that the actions of an entity are desirable, proper or appropriate within *some socially constructed system* of norms, values, beliefs and definitions" (emphasis added) highlights the relevance of the respective system and the related 'frame of reference' for legitimacy assessments. Legitimacy involves knowing about the 'something' and taking it for granted, what Aldrich and Fiol (1994) call 'cognitive legitimacy', and the degree to which 'something' fits with recognized principles and rules, what Aldrich and Fiol's (1994) define as 'socio-political legitimacy'. This 'something' could be technologies (renewable energy: Bergek et al., 2008), artefacts (coal: Isoaho and Markard, 2020), new ventures (Fisher et al 2017), agents (entrepreneurs: DeClercq and Voronov, 2009), positions (cultivation bans on genetically modifies organisms: Tosum and Schaub, 2017), and whole systems (energy system: Stefes 2020). It is this legitimacy of a whole socio-technical system that is addressed when referring to a legitimacy transition. If technologies deliver cheap energy, artefacts are part of traditions, and actors and their decisions are not questioned, the system possesses legitimacy. Citizens are 'socialized' into the energy system, with self-reinforcing dynamics supporting the system's legitimacy (Stefes, 2020). Taken for grantedness' is the highest degree of cognitive legitimacy (Aldrich & Fiol, 1994): people are knowledgeable and don't question the appropriateness.

How then do cracks emerge? Here, social mechanisms affect change within and across systems: legitimacy plays a key role for the acceptance of actions and interactions, and discourse and framing struggles are key mechanisms for creating that legitimacy (Geels and Verhees, 2011). The systemic approach explains actors' relationships with components (such as assessment of legitimacy) and the emergence of new relationships and components as situated in each (sub-) system.

In our systemic view on the MLP we differentiate between legitimacy in and across three systems:

In an established *socio-technical system*, components and relationships between components have come to be taken for granted in society, that is, actors, their strategies and the technologies and artefacts they pursue, possess (cognitive) legitimacy (Markard et al, 2016). The actors' history provides them with roots and interpersonal relations. This implies firstly, favourable regulation, access to resources and media, as well as established user practices. Secondly, as legitimacy is strongly associated with expectations, these players, the infrastructure, and the institutions as rules and habits provide a well-oiled system that is seen as appropriate (socio-political legitimacy). When proposing change, actors can relate to the current – known - components and can make use of existing relationships within the socio-technical system. They can introduce the 'something new' by drawing on socio-political rules of the system.

In a *niche system*, actors experiment and develop inventions and relationships between components. Experimenting and inventing are perceived as appropriate (socio-political legitimacy) for the niche and the tentativeness of outcomes is known and accepted (cognitive legitimacy) as can be conjectured, for example, from grants provided for respective research projects or the endorsement from respective research communities. The components and relationships are protected from the socio-technical system's performance expectations and requirements. However, on trying to enter the socio-technical system, niche actors and their proposed innovations lack the 'taken for grantedness' and actors need to construct 'legitimating accounts' (Creed et al., 2002) for their ideas to generate acceptance in the socio-technical system.

In the *political system,* actors and groups of actors adhere to and create policies and institutions to address problems. The legitimacy of problems and solutions (what counts as relevant and appropriate) is also expressed in the media and in the general public's attention. Key components of the system are politicians, government posts, policies, institutions, public opinion, and processes such as bargaining; interrelations provide opportunities for purposeful agenda-setting (Kingdon, 2011; Normann, 2015). The components and interrelations impact the socio-technical system of interest as well as the respective niche systems. These impacts reside in policy content as well as policy procedures (Edmondson et al., 2019) and manifest themselves in the socio-technical system and in niche systems as regulations that are introduced, the resources that support certain objectives, and the extent to which actors from the niche or the socio-technical system are involved in negotiation and implementation. Thus, the political system by design shapes components of the other systems and relations might go as far as entanglements between actors, leading to vested interests (Edmondson et al., 2019). Cognitive and socio-political legitimacies of new policies and procedures are likely to differ between the three systems, as respective actors vary in their knowledge and in their perception of appropriateness of ‘the new’. An open policy window for pursuing change emerges as a result of situational mechanisms such as new problems to be solved, political events such as turnover of elected politicians, or swings of national mood. Open policy windows enable linking of problems, their possible solutions and politics, and place these three combined elements on decision agendas: it is crucial that proponents of particular solutions are able to link them with either an encountered problem or politics (Kingdon, 2014).

When introducing something new into the socio-technical system, actors try to legitimate their novelty and here, frames play an important role both as action formation and transformational mechanisms: Frames and framing encompass a broad range of cognitive, linguistic, and cultural processes within different contexts such as individual sensemaking, meaning creation, and mobilizing support (Cornelissen & Werner, 2014). On the one hand, frames provide an outlook on situations, they are means to see (”to organize experience”, Goffman, 1974). Established actors’ frame is based on their experiences from within the socio-technical system, whereas new actors’ frame is based on their experiences with their technological or institutional innovations. On the other hand, frames are a means to influence or steer the seeing of others (selecting information and making it more salient in communication, Entman, 1993) and in that capacity framing is an important social mechanism in the MLP, bridging individual perspectives and social processes (Upham et al., 2020). Thus, frames are both constraints and resources. Framing contests take place when coalitions of actors engage in disputes on public stages to influence relevant audiences’ perception of what is legitimate (Geels & Verhees, 2011). In this sense framing contests are dynamic processes of meaning construction (Kaplan, 2008) and might become transformational mechanisms that initiate change through influencing access to decisive resources such as finance and political support.

For legitimacy transition, both the frame as a lens to see and framing as a way to make others see are important. The seeing as a frame of reference relates to goals, perceived problems & challenges, and appropriateness of strategies & solutions (Smith, 2005). Through framing, actors position ‘their’ technology in its context (Markard et al., 2016).

Regarding the energy sector, decades-long developments have cemented the positions of incumbents (Bergek et al., 2008), leading to a frame that lends legitimacy to dominant ‘large-scale, centralised technologies, like coal power stations’ (Smith, 2005: 117). The frame might thus include national energy supply security as a goal, overly ambitious international decarbonisation efforts as a challenge, and investment in modern coal technologies as an appropriate solution.

Actors use framing as an important means to convince relevant audiences of 'their' components and relationships and to de-legitimize other components and relationships. Advocating new technologies might include drawing attention to different goals such as reducing pollution. When several technological options are available, actors use different performance dimensions to shape expectations: analysing the framing of competing solar photovoltaic technologies, Hoppmann et al. (2020) identify past achievements, present performance, concrete prospects, and hypothetical future performance as variants that organizations use to show their favoured technology in a good light. The choice of variant is thereby related to the maturity of the alternative technologies: lesser-known and -developed technologies are framed more in terms of future performance.

The framing and counter-framing take place within and across systems. For example within the political system, actors holding different government posts might disagree on a policy and try to win over fellow politicians in order to change policies. As Normann (2015) shows with the example of offshore wind in Norway, changes inside government may open or close a window of opportunity for the implementation of a new technology. Across the socio-technical and the niche systems, actors are likely to disagree regarding the worth of a particular innovation. Transformational mechanisms then are interactions such as alliance building that mobilize for or against significant change. To achieve legitimacy, 'coalitions' engage in framing contests with other actors. These framing contests have a performative role in producing legitimacy (Geels and Verhees, 2011), which may lead to a predominant collective frame as a productive outcome (Kaplan, 2008), initiating respective change.

Thus, the transition of a socio-technical system is interlinked with legitimacy transition: the impetus (situational mechanism) leads to different actions in the systems (action-formational mechanisms), each accompanied by respective framing. Interactions as mechanisms of socio-technical transition expose actors to alternative frames, and resulting framing contests may produce legitimacy for a transition. However, as Lee and Hess (2019) demonstrate with the example of distributed solar energy in the USA, when the framing contest goes beyond a struggle between incumbents and new entrants, it may evolve into partisan polarization, hardening existing frames and hampering a transition.

The following narrative illustrates how mechanisms of a socio-technical transition and of gaining legitimacy for that transition develop co-evolutionary: A major protest against poor air quality (situational mechanism) changes some actors' frame and leads to new legislation (action in the political system), enhanced end-of-pipe measures to curb emissions (action in the socio-technical system), and increased investment in RES use (action in the niche system). These actions are each justified by respective framing: lauding the new regulation as the right solution for the problem in the political system, defending end-of-pipe measures as the right economical choice in the socio-technical system, and praising RES use as the more sustainable option. With increasing pressure, possibly from a combination of situational mechanisms, more radical change is required and actors need to do 'more', seeking alliances and redlining opponents. In framing contests, coalitions draw on 'their' components and relations, which, however, are changing as a response to situational mechanisms and owing to the alliances built. These changes allow actors' frames to soften and develop accordingly, which broadens the space for solutions.

In terms of transition pathways, the systemic approach explains the emergence and submergence of components and relationships in the socio-technical system, and their contribution to change, based on social mechanisms. For example, the substitution pathway is characterized by new components (actors and technologies) that achieve legitimacy, while existing components' legitimacy is being eroded: A multitude of situational mechanisms puts high pressure on the socio-technical system; established actors in the socio-technical system do not take sufficient action and persist in their current frame; actors in the political system are pressured to act and turn to new actors, thereby being exposed to new frames; established actors of the socio-technical system do not engage in significant interactions with new entrants; established actors of the socio-technical system and their technology loose legitimacy with the public and with policymakers, thereby providing the opportunity for niche actors and their innovations to enter the socio-technical system and to gain legitimacy. The transformation pathway is characterized by existing components (actors and technologies) safeguarding their legitimacy by (often gradual) change, which is appreciated by actors in the political system. The pressure on the socio-technical system is thus countered by action, and the frame is adapted accordingly. Niche actors and their innovations lack legitimacy (liability of newness, associated with unproven solution propositions) and the pressure is not sufficiently high to facilitate their entering of the system.

Framing contests as a transformational mechanism do not guarantee a transition: while a lack of framing contest implies a lack of new meaning construction, an extensive framing contest, drawing on frames beyond the function of the socio-technical system, could lead to polarization. Thus, a limitation of the social mechanisms approach is its lack of predictive power: it *explains* developments, but, given the many possible constellations of social mechanisms unfolding, the approach does not provide a roadmap to achieve a transition.

To conclude, framing and framing contests are social mechanisms to achieve legitimacy: in framing, actors portray a way of seeing, thereby trying to (de-) legitimize components and relationships. In framing contests, frames may soften, initiating change, or harden, cementing positions. Legitimacy transition is achieved when the legitimacy judgements of various components of the new socio-technical system reinforce each other and the system by and large becomes accepted.

4 The case of the Polish electricity system

Based on a realist perspective (Bunge, 1997; Sorrell, 2018) we seek to explain why a transition has not happened by identifying mechanisms. We hereby use Figure 3 as a guide to organize our account.

4.1 The systemic view on Poland's MLP

Poland's electricity system is a mainly on coal based techno-institutional complex (Unruh, 2002): approximately 73% of electricity is generated from coal and lignite (Forum Energii, 2020; WNN, 2021). The majority of coal-fired power plants were constructed between 1960 and 1980 (International Trade Administration, 2020). Until 2035, approximately 60% of them, representing more than 50% of the currently installed generation capacity, need to be retired.

The main companies of the energy sector are owned by the state, in particular the transmission system operator, PSE (100%), and the four largest electricity distribution companies PGE, Energa, Innogy and Enea (majority-owned). Although legally unbundled, these companies are in fact parent companies possessing power plants and distribution assets (RAP, 2018). State-co-owned companies are responsible for 65% of the electricity generated and cumulatively account for more than 84% of the distribution sales in the country (Global Transmission, 2019). The companies and the tight relationships with the state represent a power block that protects coal as the core energy source (Szulecki, 2020). The state also owns most of the coal and lignite mines (Ministerstwo Energii, 2019). Coal miners enjoy a relatively high level of societal respect, are well organised in trade unions that play a significant role in political elections, and are able to hinder mine closures or any reduction of privileges (Ceglarz and Ancygier, 2015; Darby, 2018).

Poland underwent deep political and market reforms more than two decades ago, but its communist past left a mark on the political system: It is a young and fragmented parliamentary democracy and the many political parties seek popularity for lack of loyal membership. In the period of 1993-2016, seventeen parties were voted into the parliament (Szulecki, 2017). The Ministry of State Assets oversees state-co-owned energy companies including the largest energy utilities and coal and lignite mines (GOV, 2021). Environmental policy is supervised by the Ministry of Climate and Environment. Within the ruling right-wing government, different attitudes towards climate and energy policy can be observed. Older generation politicians including the former energy minister Krzysztof Tchórzewski and the former environment minister Jan Szyszko aimed at maintaining the coal dominance. A new generation of politicians headed by the Prime Minister (PM) Mateusz Morawiecki himself acknowledges the rise of environmental awareness in society and the popularity of photovoltaics among the middle class (Olszewski, 2019).

The Energy Regulatory Office, URE, is the authority responsible for the supervision of energy markets to ensure energy supply security, foster liberalisation & competition and protect consumers. The head of the URE is appointed by the PM. In particular, the authority approves electricity tariffs for households (regulated electricity tariffs) and decides on granting operating licences for energy companies. Additionally, the authority evaluates and consults strategies of energy companies to ensure their compliance with the national energy policy (Enerad, 2019; RAP, 2018). Economic hardship focuses the public's attention on energy costs, which is taken up by policymakers as a core argument in debates, so that any increase in the regulated tariffs for households is launched very carefully.

RES technologies as niche components become cheaper rapidly, yet, they are still widely considered as expensive and something only rich nations can afford (Mata Perez et al., 2019; Perzyński, 2019). Although Poland reveals a promising RES potential, only approximately 15% of overall electricity production stems from RES with wind power providing the majority of the installed capacity, followed by biomass, hydro, photovoltaics, and biogas (Forum Energii, 2020). According to the new energy policy, PEP 2040, RES share should increase to 23% of the total energy consumption in 2030. A closer look at wind power as an example for a niche system reveals that the political system favours off-shore wind capacity and hinders the development of on-shore capacity. Installed off-shore wind capacity is expected to grow significantly (Biznesalert, 2021) and state-controlled energy companies including PGE and

PKN Orlen (as members of the established socio-technical system) are foreseen to play a dominant role in its expansion (International Trade Administration, 2020). On-shore wind parks, on the other hand, were not considered to grow in the initial version of the energy policy and in the new PEP 2040 are predicted to expand only slightly (Forum Energii, 2019b; FEA, 2019a; Ministry of Energy, 2018 and 2019b; Świrski, 2019). The so-called Distance Act adopted in 2016 actually bans new on-shore wind turbines with a capacity exceeding 40 kW: They cannot be built closer than 10 times of turbine's height (including rotor and blades) from dwellings and forests, which rules out 99% of land (Barteczko, 2018; EP, 2017; Kukuła, 2018; Parliament, 2016; Zulinski, 2018; Wood and Broom, 2016; Skrzypczyk, 2020).

The development of RES is substantially hampered by the lack of a stable regulatory environment and insufficient support (NIK, 2018). Nevertheless, the number of actors involved with RES has been growing (Heinrich Böll Stiftung, 2018). While off-shore wind parks are rather a domain of large incumbent energy companies, small-scale RES installations run by consumers, local communities, and entrepreneurs outside the mainstream energy market ("citizens energy"), have been spreading. These niche actors are in effect not allowed to compete with the large state-co-owned energy companies: the existing regulation of feed-in-tariffs enables prosumer installations supplying electricity to the national grid, but excess generation is not remunerated. Renewable energy clusters have to balance production and consumption among its members. Clusters must not exceed five municipalities and citizens' involvement is limited. Nevertheless, predominantly photovoltaic installations have been growing. On the local level, conditions for RES development need to be improved, in particular in terms of allowing local authorities to get involved in the development of energy grids and better planning to consider RES requirements. The financial support for citizens' installations is mainly based on discounted credits supported by EU funds (Dyląg, Kassenberg, Szymański, 2019). Taking into account the potential and with reliable policy support, RES could constitute between 43% and 100 % of the Polish energy mix by 2030 (Forum Energii, 2020; Emerging Europe, 2018; World Bank Group, 2018; Czyżak and Hetmański, 2020).

In conclusion, we observe (a) a strong entanglement of the political system and the socio-technical system (the largest state-co-owned energy companies are controlled by the government), (b) a policy that favours incumbent actors in the socio-technical system through supporting 'their' new technologies and that hampers niche actors' progress regarding small-scale RES installations.

4.2 Situational mechanisms and unfolding actions

The Polish socio-technical electricity system is subject to multiple pressures that act as situational mechanisms, influencing actors on all levels and in all systems. In the following we depict situational mechanisms and actors' responses.

Main situational mechanisms arise from EU commitments, supply security concerns, crisis in the domestic coal mining and poor air quality:

As an EU member state, Poland is obliged to comply with the jointly agreed climate and energy policy. The recently endorsed EU's goal of climate neutrality by 2050 (EC, 2019a) represents a major pressure to the coal-dependent country, implying in particular the necessity to phase out coal-fired power plants and push carbon-free electricity generation.

Out-dated electricity generation infrastructure threatens electricity supply security, and the expected increase in electricity demand exacerbates the situation. By 2035, approximately half of the installed coal-fired capacity needs to be withdrawn (RAP, 2018; World Bank Group, 2018), which makes investments in new generation assets urgent. Their financing is, however, uncertain (WNN, 2019). In particular, summer demand peaks endanger the supply security. In August 2015, facing severe capacity shortage, the transition system operator had to impose temporary power restrictions on the 1,600 largest industrial firms to prevent a blackout (Rączka and Maćkowiak–Pandera, 2015).

The Polish coal mining industry is undergoing a crisis (EP, 2017; Ministry of State Assets, 2019; Ministry of Energy, 2019a; Shotter and Huber, 2019): Most of the mines struggle for survival because of inefficient production methods and sinking coal prices on markets (Szpor and Ziółkowska, 2018, Barteczko and Lewis, 2016).

Poor air quality is also increasingly seen as a problem: Poland ranks among the most polluted countries in the EU (EC, 2017). The World Health Organisation assessed that air pollution causes approximately 45,000 premature deaths yearly. Particulate matter emissions stem primarily from household heating based on poor quality coal and lignite, as well as wood biomass, and individual car mobility (Adamczyk et al., 2017; Polski Alarm Smogowy, 2019; World Bank Group, 2018). In 2016, the European Commission filed a complaint against Poland for not taking appropriate measures to address this problem (ClientEarth, 2018).

Actors in the *political system* respond to these pressures by delaying strategic change and opting for short-term fixes:

As co-owner of the largest coal-based energy companies, the government is reluctant to pursue renewable alternatives. In response to the EU's goal of boosting renewables, Poland transposed the Renewables Directive (after many renegotiations and financial penalties) six years after the deadline. Its original intention has not been achieved since new onshore wind installations are actually banned (Flanders, 2019; Kukuła, 2018; RAP, 2018; Barteczko, 2018; EP, 2017; Kukuła, 2018; Parliament, 2016; Zulinski, 2018; Wood and Broom, 2016).

Coal mines are kept alive thanks to financial help from the government (EP, 2017; Shotter and Huber, 2019): coal miners have recently negotiated with the government that some mines will be kept open until 2049 (Zasuń, 2021). In parallel, coal imports increase (Barteczko, 2018; Barteczko and Sobczak, 2017; EU, 2017). The state-controlled energy company PGE aims to extend its permit to explore the lignite mine in Turów until 2044, despite Czech neighbours' protest indicating that the mine destroys water resources and worsens environmental pollution. In this way PGE repeats the procedure from 2020 when the company silently managed to extend the operation of Turów until 2026 (Tabaka, 2021).

To prevent the risk of shortages in electricity supply, the capacity market was established in 2018. Its intention was to provide a stable financial perspective for electricity suppliers and stimulate investments in new generation blocks. Starting from 2021 onwards, not only generated electricity, but also the available capacity to provide it in the future, will be remunerated. Market actors including conventional power plants, RES, but also demand response[13] resources, can bid in auctions to be paid for standby capacity. Allowing the out-dated conventional power plants to access the capacity market is criticised as "backdoor subsidies" (Derobert & Flisowska, 2019) that drive up electricity cost (Forum Energii, 2019a). The unequal treatment of demand response (in comparison to the supply side actors) in the capacity market was brought to the European Court of Justice (Derobert & Flisowska, 2019). The capacity market has not, however, proven sufficiently efficient in stimulating investment in new generation capacities. Recently, a secret advisory meeting took place with the transmission system operator, the Minister of Climate and Environment, and the CEOs of the four largest energy utilities to discuss how to prevent blackouts after 2025 when the oldest power plants are to be disconnected from the grid. Unofficially it is known that the Ministry of Climate and Environment together with the transmission system operator have been negotiating

[13] Electricity demand response means that electricity customers adjust electricity consumption in accordance with the constraints on the supply side, in particular to avoid or shift demand peaks, thus leading to more efficient use of infrastructure and improving network integration of volatile renewable energy sources.

with the European Commission the extension of the capacity market access for these out-dated blocks also beyond 2025 (Zasuń, 2021).

In response to the mass protests by the anti-smog movement, the Clean Air Act was established, but it did not prove effective and has to be revised to maintain EU co-financing (Morgan, 2019; Polski Alarm Smogowy, 2019; Olszewski, 2018; Skowron, 2019).

The government reacts to the situational mechanisms with a new energy policy, PEP 2040. It took seven years to elaborate this long awaited strategic document. PEP 2040 announces a reduction of the coal share in the electricity generation mix to 56% in 2030, which is seen as progress compared to the current 73%. However, it is also criticised as insufficient in the light of the envisaged EU's climate neutrality by 2050 and the rules for the utilisation of EUs financial help for the transition of the energy system. PEP 2040 explicitly states that "domestic coal resources will remain an important element of Poland's energy security". To improve the air quality, PEP 2040 postulates the expansion of district heating and a ban on burning coal in households, but only by 2030 in cities and by 2040 in rural areas. To replace the retiring electricity generation assets, the government plans to launch nuclear power with the first unit of 1-1.6 GW becoming operational in 2033 and to expand off-shore wind and photovoltaic, however below available potential in Poland (Ministry of Climate and Environment, 2021; Biznesalert, 2021).

In the *socio-technical system*, actors as part of the techno-institutional complex turn to the government and pursue short term fixes. State-controlled energy companies reluctantly pursue some change and approach the expansion of large-scale off-shore wind power (International Trade Administration, 2020). Recently, the state-controlled energy utility Tauron announced its intention to reduce coal's share in its generation capacity from 90% today to one third in 2030, and to substitute it by an increase in RES to two-thirds of its capacity. Tauron justified this primarily by having to comply with EU air quality standards, deteriorating economics of coal, and a change in customer behaviour (Wynn & Coghe, 2019).

The response of the Polish *niche actors* to the situational mechanisms is to call for a more radical change in the electricity system than politicians and state-controlled energy companies are willing to launch. The niche actors highlight the legitimacy of their proposals, citing EU climate and energy policy. Although the number of niche actors has been growing, they are still relatively weak in comparison to the incumbent defenders of the established socio-technical system.

Proponents of "citizens' energy" (Instytut na Rzecz Ekorozwoju, 2019) stress in particular that RES have become the cheapest and the fastest-growing energy source,and the main driver to reduce greenhouse gas (GHG) emissions. In April 2018, the environmental movement "More than energy" (Więcej niż energia), an alliance of more than 150 actors including local communities, think tanks, green business associations, research institutes, and NGOs wrote to Jean Claude Junker, the then President of the European Commission. In this letter, the movement demands that at least 40% of EU funds is to be spent on tackling climate change, that receiving funds is tied to the removal of regulatory barriers that restrict RES, and to empower community-led energy projects (More than Energy, 2018). Similarly, the "Polish Green Network" (Polska Zielona Sieć) calls for the recently decided European Recovery Fund to be used for sustainability-oriented projects, and for reforms to unblock RES development ((Polska Zielona Sieć, 2021). "More than energy" also calls public attention to rising wholesale electricity prices owing to coal-based electricity generation and growing prices of CO2 allowances. Should decarbonisation be further hampered, Poland is envisaged to have the highest electricity prices in Europe. While households are still protected from this trend by the regulated electricity tariffs, the new head of the regulatory authority has announced that electricity price increases cannot be avoided (Wysokie Napięcie, 2020).

New climate activist groups like "Extinction Rebellion Poland" and the "Youth Climate Strike" managed to mobilize large protests in many Polish cities and towns (Broszkowski, 2019). The protesters demand the consideration of the reports of the UN's Intergovernmental Panel on Climate Change in policymaking, the introduction of climate change education in schools and an elaboration of a strategy to achieve climate neutrality by 2040 (TokFM 2019). Though new, these activists have already contributed to raising environmental awareness in society, where effects of climate change are increasingly felt, in particular in the form of rising food prices as a consequence of summer droughts. (Broszkowski, 2019).

A civil society grassroots movement "Development YES – Open-Pit Mines NO" aims at preventing new lignite open-pit mines and supports the sustainability transformation of the coal-dependent Polish economy. The movement succeeded amongst others in organising a referendum stopping an establishment of a new lignite mine near Legnica and Lubin (Rozwój tak- odkrywki nie, 2021).

To sum up: while situational mechanisms fuel niche actors' attempts to launch new technologies in the socio-technical system, actors from the political and the socio-technical system try to delay the abandonment of established technologies, and to secure established actors' influence through a focus on large-scale technologies.

4.3 Framing contests

As described above, the Polish electricity system is subject to multiple situational mechanisms that are expected to cause legitimacy crises, which in turn would erode support for the established technologies (Turnheim and Geels, 2013). Nevertheless, the legitimacy-constructing role of framing contests is not played out.

Actors of the RES niche and parts of civil society aim at decarbonisation. The government and large state-controlled energy companies avoid launching radical reforms, and instead pursue short-term-oriented small steps that by and large conserve the existing system. When transposing the EU climate and energy directives into national law, existing practices and policies are maintained as much as possible to avoid significant behavioural changes (Olgun, 2017).

Actors of the political and socio-technical systems are 'entangled' (Edmondson et al, 2019) and relations are marked by vested interests; the framings of these actors are largely aligned with each other: In their frames RES have been long portrayed as technologies promoted by foreign lobbies, too expensive and always requiring support by conventional power plants. The EU as the driving force behind decarbonisation has been criticized for too ambitious energy and climate goals that largely ignore the Polish national peculiarities. Coal, on the other hand, has been praised as "the national treasure" and a guarantee of the supply security at affordable prices

Government actors try to suppress challenging framings from niche actors or from civil society: Although the EU requires legal acts in particular in the field of environment to be publicly consulted, these consultations are cursorily conducted and take place usually at a late stage of policy development (Szulecki, 2017; Helsinki Foundation for Human Rights, 2019). Recently, for example, the Ministry of Climate and Environment invited public consultations for new rules regarding the requirements for RES micro-installations nine months *after* these actually came into power (More than Energy, 2020). Based on a broad study of the policy process in Poland, Dudzinska (2015) described it as an "operationally closed system, which … does not accept stimuli from the external environment."

In recent years there have been various mass protests in Poland against climate change, for independence of courts, against changes to the abortion law and pro independent media. A common governmental reaction is to largely ignore these protests and not to engage in an exchange of arguments with the protesters (Oleszyk, 2021).

The 'societal deep structures' (Geels et al, 2016) of Poland impede a constructive framing contest. The alignment of framings in the political and socio-technical systems, and the non-engagement with framing in the niche systems block the performative role of framing contests. This is facilitated by a culture of weak public deliberations in Poland (Heinrich Böll Stiftung, 2018; Szulecki, 2017). After 1989, broad deliberations were perceived as a threat to the stability needed to implement difficult and socioeconomically painful reforms. Therefore, the freshly elected government blocked strikes, demonstrations and societal consultations. This substantially affected the way legislation is elaborated, discussed, and enacted (Cianciara, 2015):

Polish policymakers still do not acknowledge the need for a broad citizen participation in political decision-making (Hess, A., 2013, Gliński, 2011). Since 2016, the situation of the civil society sector has even deteriorated: Freedom of assembly and access of NGOs to public funds have been restricted, thus further shrinking the space for a societal dialogue (Helsinki Foundation for Human Rights, 2019).

Public media do not support a broad deliberation either. They focus primarily on political and economic perspectives, and do not offer enough space for civil society and niche actors (Garpiel, 2016; Świątkiewicz-Mośny and Wagner, 2012; Świątkiewicz-Mośny, 2016). Hess, A. (2013) points out that Polish media value NGOs as information source, but do not consider topics promoted by them as sufficiently relevant and attractive. Additionally, since 2015 public media has become a mouthpiece of the ruling party PiS (Arak and Bobiński, 2017; Buras, 2017; Buras, 2019; Kalan, 2019) including public television that is the main information source regarding energy and climate issues (CBOS, 2016).

Although the environmental awareness in Poland does not seem to differ much from the European average, lower purchasing power compared to Western Europeans makes Polish citizens price sensitive and less willing to spend more for the sake of the environment (Deloitte, 2016; EU, 2019; PwC, 2016; Mata Perez et al., 2019). An opinion poll conducted in August 2019 revealed that more than 40 % of the respondents support decarbonisation, albeit without wanting to bear respective costs (Balcer, 2020).

Until recently, political parties' programmes paid little attention to energy and climate issues (Szulecki, 2017). This changed in 2019: All parties including the ruling PiS, Right and Justice, and PO, Civic Platform, addressed them in various ways (Barcikowska et al., 2019). This did not, however, impact the election debates in which sustainability was largely absent as a political issue (Wężyk, 2019). In the final presidential debate in 2020 neither climate change nor energy policy were among the official topics (Mikulski, 2020).

5 Discussion

Transition pathways emerge from alignments of pressure for change, innovation, and destabilization of the established system (Geels and Schot, 2007). A systemic social mechanisms approach (Bunge, 2003; Hedstrøm and Swedberg, 1998) explains these alignments in terms of (a) situational mechanisms such as landscape pressures and problems in the socio-technical system leading to (b) action-formational mechanisms, with actions influenced by the peculiarities of each system and (c) transformational mechanisms such as framing contests leading to a collective outcome. This systemic view on the MLP as a system of systems identifies and explains the embeddedness of agency within each system, and highlights the importance of framing across systems. Framing as an action-formational mechanism is used to mobilize for and against significant change, and the resulting framing contests as transformational mechanisms may produce legitimacy for the new (Geels and Verhees, 2011). Legitimacy for a new system requires legitimacy for different system components such as actors, technologies and artefacts.
Why is there only a weak framing contest in Poland? To address this question we consider the 'societal deep structures' (Geels et al, 2016) of Poland and describe the conditions that hinder the mechanism to unfold more significantly.

Firstly, the Polish electricity system is characterized by a strong relationship between the largest energy companies and the government. As Antal (2019) reveals for Hungary, such a power block prevents policies that threaten the established technology or promote new developments. For the most part, key actors in the socio-technical system are at the same time part of the political system, thereby reducing frame diversity. In that frame, coal is still strategically important for the supply security and energy independence at affordable prices. RES, on the other hand, are mainly framed as technologies pushed by the EU and foreign lobbies, uncontrollable and thus risky for the network as well as too expensive. RES development is only driven by the necessity to comply with EU regulation (Szulecki, 2020). In Hungary, we can observe a similar strategy of portraying RES as expensive and unsustainable by the power block of policymakers and energy utilities.

Secondly, mainstream media, being close to the power block, does not offer a sufficient space to discuss alternatives and to challenge established structures. The current frame is not challenged significantly: mass media in Poland do not support a broad societal debate on energy policy and tend to reproduce policymakers' perspectives.

Thirdly, similar to Antal's (2019) observation, there seems to be no broad deliberation in the public, thereby safeguarding dominant frames. Although there is a growing number of Polish climate activists and RES advocates including RES associations, prosumers, innovative enterprises, and local communities, these players do not possess sufficient means to engage in a framing struggle on a par with policymakers and incumbent energy companies. These incumbent actors build a powerful coalition defending the coal-based system.

Fourthly, the perceived high costs of RES coupled with price sensitivity of Polish customers support policymakers' framing of coal's high importance, thereby playing to citizens' socialization (Stefes, 2020) within the current energy system.

Considering the peculiarities of the Polish electricity system: the entanglement of the government with the largest state-controlled energy companies, the influence of the miners' trade unions on policymaking, the perceived high costs of RES, the relative weakness of civil society, and media not facilitating a broad discourse, we assume that a ST via substitution pathway is unlikely. There is neither a broad adoption of small-scale niche technologies that replace dominant incumbent solutions, nor are deep institutional reforms towards sustainability in sight. Niche actors still lack the means to overcome the discrimination by the government and to gain legitimacy. The new Polish energy policy envisages a moderate growth of off-shore wind installations and the introduction of nuclear power, both centralised large-scale technologies to be operated by incumbent companies. Accordingly, Poland seems to follow the transformation pathway, favouring slow gradual changes implemented by incumbents.

Yet, times are changing. Surveys show that citizens increasingly support decarbonisation: more than 90% of Poles believe in climate change and nearly 64% are in favour of giving up coal-fired electricity generation to cut emissions (Barteczko, 2020). The political system is pressured to act and might consider new actors, thereby being exposed to new frames. This might raise some hope for a new more sustainable energy policy to be pursued by the government. Accordingly, a shift in the governmental narrative on RES has already occurred: the PM

Mateusz Morawiecki stated in his exposé at the end of 2019: "In the past, we could not afford to develop RES. Today, we cannot afford not to develop them because they can provide a huge impetus for the Polish industry" (Globenergia, 2019). Surprisingly, in his speech Morawiecki mentioned neither coal, nor miners, terms that otherwise belong to a standard framing by a Polish PM. Another sign of change is the new strategy of the state-controlled energy utility Tauron that decided to reduce coal's share in its generation capacity from 90% today to one third in 2030, and to substitute it by an increase in RES (Wynn and Coghe, 2019). There is hope for change (Grzeszak, 2019).

6 Conclusion

In this conceptual study we propose that a window of opportunity, characterized by multiple systemic pressures and niche innovations ready to enter a socio-technical system, is not sufficient to trigger ST without a respective legitimacy transition. In particular, we identify framing and framing contests as key social mechanisms to achieve legitimacy for a ST. The systemic view thereby contributes to the conceptual development of the MLP as it explains the embeddedness of agency within each system.

We use the systemic social mechanisms approach to describe and explain ST: situational mechanisms trigger actions in the niche, the socio-technical, and the political system. These actions are accompanied by respective framing – making others see the rationale for the actions, trying to achieving legitimacy for new components and relationships. Subsequent interaction patterns are key for the transition; these interactions are accompanied by framing contests, which have a performative role in producing legitimacy. Legitimacy transition then involves de-legitimizing established components and relationships, and legitimizing new ones.

In the case of Poland, there are evident economic and ecological problems with the current system: coal becomes increasingly expensive both in financial terms and societal costs. There are evident gains expected from sustainable alternatives with the prospect of decreasing production costs and improving environmental conditions. Yet, these 'real' features get drowned in the dominant framing pursued by a power block of policymakers and state-controlled incumbent energy companies that sets and legitimizes an agenda of preserving the old system and of de-legitimizing emerging players. However, slight cracks can be observed in the existing system such as successful blocking of a new coal mine by an NGO's legal claim (Davies, 2019) or the introduction of anti-smog legislation. In spite of these developments, incumbent actors still avoid entering into discussion with change proponents, thus hampering the performative role of framing contests for legitimacy transition.

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Paper 3: Demand response aggregators as institutional entrepreneurs in the European electricity market

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Under review: Journal of Cleaner Production / August 2021

Abstract

Demand Response (DR) aggregators act as intermediaries between electricity customers and network operators to tap the potential of the demand-based flexibility. This qualitative study reveals DR aggregators as institutional entrepreneurs that struggle to reform the still largely supply-oriented European electricity market. Unfavourable regulation, low value of flexibility, resource constraints, complexity, and customer acquisition are the key challenges DR aggregators face. To overcome them they apply a combination of strategies: lobbying, market education, technological proficiency, and upscaling the business. The study highlights DR aggregation as an architectural innovation that alters the interplay between key actors of the electricity system and provides policy recommendations including the necessity to assess the real value of DR in comparison to other flexibility sources by taking all externalities into account, a technology-neutral approach to market design and the need for simplification of DR programmes, and common standards to reduce complexity and uncertainty for DR providers.

Highlights

- Demand Response (DR) aggregators help to unlock demand-side-based flexibility.
- They act as institutional entrepreneurs struggling for institutional reforms.
- The study reveals their key challenges and measures they apply to cope with them.
- DR aggregation is architectural innovation changing the interplay of the key actors.
- Policy recommendations are provided.

Keywords: DR aggregators, institutional entrepreneurship, reforms

1 Introduction

Demand response (DR) aggregators act as intermediaries between electricity end-customers as DR providers and network operators including transmission system operators and distribution system operators (TSOs and DSOs) as DR buyers. While well-established in other parts of the world, e.g. in the USA, Australia and Japan, they are relatively new in the European electricity market and have to struggle for a level playing field (Stede et al., 2020; De Clercq et al., 2018; Simon, 2018; SEDC, 2017; Gkatzikis et al., 2013; Bray & Woodman, 2019; Bertoldi et al., 2016).

DR is a change in a regular or current electricity load by electricity end-customers in reaction to market signals and system needs (EU ED 2019/944, ENTSO-E, 2019). When electricity supply security is jeopardised customers receive signals to reduce the load, e.g. through switching to an onsite backup generator or shifting some energy-intensive processes to an off-peak period. When electricity is cheap and available in abundance, customers might be requested to increase electricity consumption (Bray & Woodman, 2019; ENTSO-E, 2019; Ponds et al., 2018; Simon, 2018; Der Energieblog, 2018; Bertoldi et al., 2016).[14] In other words, DR is a source of flexibility.[15] Because of insufficient scale and high complexity, most electricity end-customers, including large businesses, do not trade their consumption flexibility themselves and need DR aggregators to enable them to do so (Garcia-Rundstadler, 2017).

DR offers numerous advantages: Through shifting electricity consumption away from peak times, DR allows for a more effective use of electricity generation, transmission, and distribution infrastructure. In this way, DR contributes to preventing supply shortages, lowering operational costs, and deferring investment. Further, DR can balance the volatility of weather-dependent renewable energy sources (RES), such as wind and solar, thus supporting their system integration. By boosting the RES share and diminishing the need for the mostly high pollution peaking power plants, DR reduces GHG emissions. Customers also benefit from DR through not only financial benefits and increased consumption awareness, but also in the form of improved reliability of electricity supply (Bertoldi et al., 2016; Eid et al., 2016; Kuzemko, et al., 2017; Ponds et al., 2018; Rollert, 2018; SEDC, 2017; Stede, et al., 2020). Accordingly, DR

[14] Implicit DR is customer response to price signals such as time-of-use tariffs. Explicit DR results from incentive payments. Explicit DR on the part of large industrial and commercial customers with high electricity bills allows for an economically viable scale of operation and can be traded on electricity markets.
[15] Flexibility is the ability of the electricity system to deal with an uncertainty and variability in supply-demand balance in a timescale of minutes to hours (IEA, 2017; Papaefthymiou et al., 2014).

supports the transition of the European electricity system towards more sustainable modes of production and consumption (Baker, 2017; Darby, 2020). Therefore, in the Electricity Directive the European Commission required EU member states to enable DR and, in particular, to create a level playing field for DR aggregation (Eid et al., 2016; EU ED 2019/944). However, there are currently numerous barriers to DR aggregation and only a small proportion of DR's potential in Europe has been tapped (Stede et al., 2020; Gils, 2014). It is estimated that Europe activates approximately 20GW of DR, while the potential is 100GW, rising to 160GW in 2030 (SEDC, 2017).

Can DR aggregators contribute to transforming the European electricity system? DR is an innovative customer-based service, yet if it is to expand beyond a market niche significant institutional reforms will be required (Simon, 2018). In the EU's traditionally supply-side oriented electricity system, demand passively follows supply. DR aggregators have the potential to become change agents. Some media have already acknowledged this by calling them 'the power cutters shaking up Britain's energy market' (Schaps & Twidale, 2016) or 'barbarians' pursuing negawatts[16] against megawatts (Moragues, 2015).

The aim of this study is to shed light on DR aggregators as institutional entrepreneurs struggling to reform the European electricity system. Institutional entrepreneurs are organised actors that engage in changing existing institutions or creating new ones in a field to realise interests they consider valuable and that are hindered by existing formal and informal 'rules of the game' (DiMaggio, 1988). While barriers to and drivers of DR, as well as the business models of DR aggregators, have already been studied (Good et al., 2017; Nolan & O'Malley, 2015; Kim & Shcherbakova, 2011; Torriti et al., 2009; De Clercq et al., 2019; Fang et al., 2017), little is known about DR aggregators as new market entrants that strive for institutional change.

Based on a rich qualitative dataset consisting of semi-structured interviews with market actors together with secondary sources, this study makes three main contributions to the literature:

(1) It identifies the key challenges DR aggregators face.

(2) It identifies the measures DR aggregators take in response to these challenges.

[16] Negawatts are negative megawatts. In 1989, Amory Lovins, an American physicist, discovered a misprint in a publication by a public utility company: 'negawatt' instead of megawatt. He borrowed the word to describe the energy saved through conservation or efficiency measures (The Economist, 2014).

These findings help explain why the uptake of DR in Europe is progressing slower than expected despite policy support at the EU level. Drawing on these findings policy recommendations are provided.

As a theoretical contribution (3) the study highlights characteristics of an innovation as a further category of factors that influence the execution of institutional changes needed to enable it and reveals DR aggregation as an architectural innovation (Henderson & Clark, 1990).

Because of the high relevance and great urgency of a transition towards more sustainable modes of production and consumption, the European electricity system offers an interesting case to examine attempts at institutional reforms: (a) As a highly complex system, including a capital-intensive infrastructure with a long utilization period, customers, energy utilities, and electricity service companies, the European electricity system shows a strong tendency to inertia and path-dependence (Praetorius et al., 2009); (b) in spite of ongoing liberalisation efforts, the European electricity system is still a highly regulated sector; (c) electricity and heat production is, despite substantial decreases, still the largest source of GHG emissions in the EU (EEA, 2019) and the pace of reforms in this sector needs to accelerate if the EU is to achieve climate neutrality by 2050 (EU Parliament, 2019/2956) (EEA, 2019); (d) with the rise of weather-dependent RES, the task of keeping electricity supply and demand in balance has become more challenging and the need for flexibility has significantly increased (BEE, 2015; Bertsch et al., 2012; Deloitte, 2019; Redl, 2018; IEA, 2017; Verzijlbergh et al., 2017).

This paper is structured as follows: In section 2, I provide a brief overview of DR aggregators as new market actors in Europe, and justify why they can be regarded as institutional entrepreneurs. In Section 3, I present the methodological approach used in this study and the dataset. The results are reported in Section 4, showing the challenges DR aggregators face and measures they implement to overcome them. In Section 5, I discuss the results and in Section 6 I conclude and offer policy recommendations.

2 Background

2.1 DR aggregators in Europe

DR aggregators enable electricity end-customers to trade their load flexibility. They do this by combining the loads of numerous customers to create a flexibility portfolio large enough to comply with the threshold criteria of flexibility markets, such as constraint management (e.g.

voltage control and congestion management), wholesale (e.g. day-ahead optimisation and intraday balancing) and balancing (e.g. frequency containment) (ESGTF, 2019).

DR aggregation consists of two main process streams: (a) interaction with end-customers to create and manage the DR pool and (b) trading of the DR pool understood as interaction with flexibility buyers including TSOs, DSOs, and Balance Responsible Parties (BRPs).[17] The first process stream includes customer acquisition, determination of the load baseline (regular consumption pattern), feasibility testing, monitoring and measurements, maintenance, and incentive payment. The second is made up of market monitoring, bidding, clearing, reporting, and remuneration (Ponds et al., 2018; Stromback, 2015). Crucial enablers of DR aggregation are advancements in information and communication technology (ICT) and progress in 'smart-grid' implementation (Good et al., 2017).

DR aggregators can operate as independent service providers, so-called independent or third party DR aggregators. For customers, this means that flexibility provision is not part of their electricity supply contract (ESTF, 2019; Wimmer & Pause, 2019). DR aggregators can also be electricity suppliers; in other words they are integrated or combined DR aggregators (Bray & Woodman, 2019; De Clercq et al., 2019; Elering, 2017; SEDC, 2015). Integrated DR aggregators do not need substantial regulatory changes to operate in the existing institutional setting. Their supplier licence grants them access to flexibility markets, which together with their current customers and brand recognition, makes it easier for them to create a DR pool (De Clercq et al., 2019; Desmyter, 2018). Independent aggregators, as newcomers unrelated to electricity suppliers and BRPs, require deeper institutional changes in order to access flexibility markets and acquire customers (De Clercq et al., 2019).

At customer premises, DR aggregators aggregate either (a) generation assets including backup generators or (b) customer load, e.g., heating, cooling, pumps, or lighting (Stromback, 2015) or, as in the majority of cases, (c) provide both services (ENTSO-E, 2019).

In Europe, there are approximately 41 independent and 22 integrated DR aggregators (ENTSO-E, 2019). Due to the effects of scale, the majority of them work with industrial and commercial customers that have high electricity costs (ENTSO-E, 2019; Respond, 2018; smartEN, 2019). Some commercially active DR aggregators, however, collaborate with households, e.g. Swiss

[17] A Balance Responsible Party in the electricity market is a market participant or its chosen representative responsible for its imbalances in that market (ESTF, 2019; EU Regulation 2019/943).

start-up company tiko Energy Solutions (Leroy, 2019). European DR pioneers were founded at the beginning of the 21st century, e.g., Flexitricity/UK in 2004 (Flexitricity, 2020) and Energy Pool/France in 2009 (Energy Pool, 2020). While they began as small technology-based enterprises, many of them have since been acquired by a larger market actor (Desmyter, 2018).

Despite the goal of a single European electricity market, the respective policies and regulation, also in the field of DR aggregation, vary across EU member states (Bray & Woodman, 2019; Pollitt, 2019; Torriti et al., 2009). The EU Electricity Directive requires in particular the opening of all relevant markets to DR, including wholesale, balancing, and ancillary services markets, as well as the non-discriminatory treatment of DR aggregators (EU ED 2019/944). Nevertheless, EU member states are at different stages in the implementation of these rules. France, the UK, Ireland and Belgium are considered to have the most mature markets, with numerous DR aggregators operating in their electricity markets (smartEN, 2019; Bertoldi et al., 2016).

2.2 DR aggregators as institutional entrepreneurs

Institutional entrepreneurs are actors – whether organisations, individuals, or groups – that work to change established institutions or create new ones (Pacheco et al., 2010). 'New institutions arise when organized actors (institutional entrepreneurs) with sufficient resources see in them an opportunity to realize interests that they value highly' (DiMaggio 1988: 14). Accordingly, institutional entrepreneurs initiate efforts to change existing field conditions as a means of advancing projects they consider valuable, yet are hindered by existing institutions. Institutions are taken for granted and commonly shared 'rules of the game' that 'shape human interactions' (North, 1990: 3). These include formal rules such as laws, regulations and policies as well as informal prescriptions including values, traditions, codes of conduct, and practices (Klein Woolthuis et al., 2013; Pacheco et al., 2010). Institutions guide und influence actor behaviour, but systemic actors may also impact and change institutions. The paradox of embedded agency illustrates well the tension between institutional determinism and actors' efforts to overcome it, thus fostering institutional changes (Battilana, 2006; Garud et al., 2012; Greenwood & Suddaby, 2006).

Battilana et al. (2009) stress that not all change agents are institutional entrepreneurs, as only actors that initiate divergent changes and that actively contribute to their implementation should be regarded as such. Changes are divergent when they substantially differ from the existing institutions in a field. Active contribution to the change process as another criterion of institutional entrepreneur means that they mobilize resources to enact the institutional change. To be considered an institutional entrepreneur, it is not necessary for actors to initially intend to reform institutions or to be successful.

The literature on institutional entrepreneurship points out two categories of factors that influence the enforcement of institutional change: the characteristics of the field and the actors' social position (Pacheco et al., 2010).

Field characteristics include the degree of heterogeneity and of institutionalisation as well as exogenous shocks and crises. Heterogeneity describes the extent to which different institutional arrangements co-exist in a field. High heterogeneity can create incompatibilities that result in tensions providing impulses for change. Institutionalisation influences actor agency. It is assumed that a low level of institutionalisation, which is typical for emerging fields, leads to higher uncertainty, which in turn might spur entrepreneurial activities. Highly institutionalised sectors seem, on the other hand, to be a more challenging space for initiating divergent institutional changes. Shocks and crises such as catastrophes, social changes, and technological disruption might shake the existing field-level consensus and create fertile ground for new ideas.

The actors' social position in a field defines their sectoral relationships and influences their perception of the status quo as well as their access to resources that can be mobilized to initiate changes (Battilana, 2006; Battilana et al., 2009). Many studies have found that new entrants or peripheral actors are likely to become institutional entrepreneurs because of their low field embeddedness, in other words low connection to sectoral actors and processes and high interest dissatisfaction through the existing institutional setting (Hockerts & Wüstenhagen, 2010; Pacheco et al., 2010), but established incumbents might engage as institutional entrepreneurs too (Smets & Reihlen, 2012; Smink et al., 2015).

To implement institutional changes, institutional entrepreneurs typically make use of cooperation, framing, theorization, and political strategies. Through cooperation, actors develop a collective identity and coordinate the pursuit of shared interests in creating legitimacy. Framing involves elaborating a common narrative to articulate problems and propose solutions. Theorization is the use of scientific explanations to justify new institutions (Klein Woolthuis et al., 2013; Pacheco et al., 2010). Political strategies, in case of formal institutions such as industrial regulation, might concentrate on lobbying to convey frames to pivotal actors such as policymakers and influence a wider public (Smink et al., 2015).

DR aggregators can be regarded as institutional entrepreneurs in the European electricity market because: (a) as new entrants they are motivated to change the existing institutions that largely hinder demand-side based flexibility provision, and (b) the required institutional changes diverge from prevailing regulation and field practices. The existing system is based on the needs of the supply side and, in particular, of large conventional electricity generators, which leads to a discriminatory treatment of electricity customers as active players; (c) DR aggregators actively mobilize resources to enact institutional changes, e.g. through lobbying and the creation of alliances.

3 Methodology

Due to the exploratory nature of the research question, I chose a qualitative methodology to collect rich and nuanced data from multiple primary and secondary sources (Gehman et al., 2018; Gioia et al., 2012; Graebner et al., 2012), thus revealing a broad spectrum of DR aggregator' challenges and behaviours in the European electricity market.

The database consists of:

1) Primary data obtained from 18 semi-structured qualitative interviews with actors that have in-depth insights into the DR aggregation business, so-called 'knowledgeable agents' (Gioia et al., 2012), including representatives of both independent and integrated DR aggregators from Germany, the UK, France, Poland, Belgium and Switzerland; energy market associations at national and EU level; EC, an energy market think thank; and media.
2) Secondary data in form of press articles, company Internet websites, policy documents, industrial analyses, reports, and scientific papers.

The interviews were conducted in the period from May 2015 to January 2020 until data saturation was reached. An interview lasted on average 30-60 minutes. Ten interviews were carried out face-to-face; eight were on the phone. All interviews were recorded, transcribed, and (if conducted in German or Polish) translated into English. As some of the information obtained is sensitive, the primary data has to remain confidential. These interviews are listed in Table 2.

No.	Actor type	Interviewee position in the organisation	Interview date	Duration in min.	Mode/ language
1	DR aggregator	Marketing Director	28.05.2015	86	Face-to-face / PL
2	DR aggregator	Former Technology Manager, Researcher	03.11.2015	74	Face-to-face / EN
3	DR aggregator	Director Global Services	04.11.2015	60	Face-to-face / GER
4	DR aggregator and electricity supplier	Strategy Officer	04.11.2015	49	Face-to-face / EN
5	DR aggregator	Regulatory Affairs Manager	05.11.2015	106	Face-to-face / GER
6	DR aggregator	Regulatory Affairs Manager	13.11.2015	84	Phone / EN
7	DR aggregator, digital utility	Communication Manager	23.09.2016	80	Face-to-face / GER
8	DR aggregator	Marketing Director	27.10.2016	40	Phone / PL
9	Media	Energy journalist	28.10.2016	49	Phone / EN
10	Energy market association	Policy Officer	31.10.2016	65	Face-to-face / EN
11	Energy market association	Officer responsible for network and regulation	14.11.2016	70	Face-to-face / GER
12	Energy market think tank	DR expert	18.11.2016	78	Face-to-face / GER
13	Energy market association / EU level & energy consultancy	Member of the Board, Managing Director	21.11.2016	50	Phone / EN
14	DR aggregator	Regulatory Affairs Manager	25.09.2019	30	Phone / GER
15	DR aggregator and technology provider	Sales Manager	26.09.2019	37	Phone / EN
16	Energy market association	Policy Officer	27.09.2019	39	Phone / EN
17	Energy market association	Policy Officer	13.12.2019	41	Face-to-face / GER
18	EU Commission	DR expert, researcher	21.01.2020	50	Phone / EN
			Total	**18hr 13min**	

Table 2 Overview of the interviews

The interviewees were asked to describe the key challenges DR aggregators face and how they cope with them. In addition to the challenges resulting from the existing institutional setting, other issues such as possible resource constraints were also addressed. The analysis of the interviews was based on the methodology proposed by Gioia et al. (2012). Interview transcripts were read and re-read to identify key categories relating to the DR aggregators' market settings and behaviours. First-order codes reflect terms used by the interviewees and second-order codes the researcher's concepts. Codes that arose from the interviews include complexity, technological proficiency, low economic value, scale of the business, and supply security concerns. To mitigate informant biases, I triangulated individual responses with those of other informants and with further sources including press articles, sectoral analyses and scientific papers.

4 Results

This section is structured according to the two main categories discussed within the interviews: the key challenges DR aggregators face and the measures DR aggregators take to cope with them (see Figure 7).

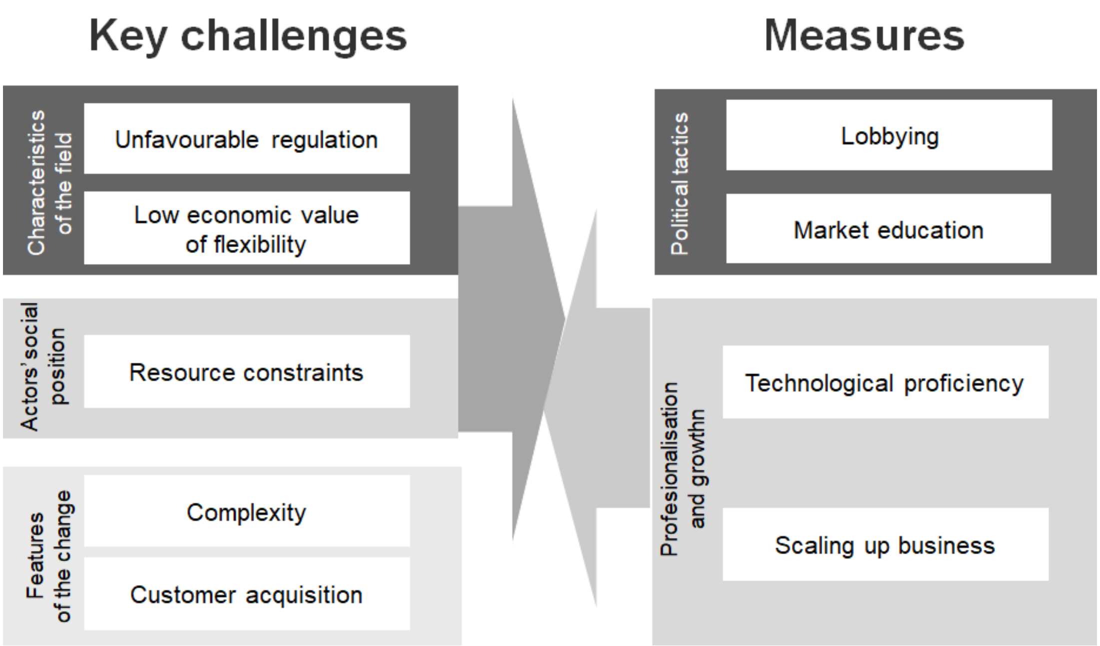

Figure 7 Key challenges DR aggregators face and measures they take to cope with them

4.1 Key challenges

4.1.1 Unfavourable regulation

Current regulation of the electricity system is perceived as one of the key challenges to the DR aggregation business (Bray & Woodmann, 2019; Vallés et al., 2016; Wohlfarth et al., 2020). Creating a level playing field for DR aggregators as representatives of the demand side requires significant regulatory changes regarding, in particular, market access, data exchange, and management of balancing circles.[18] Implementing these changes is a long and highly contested process. For many of the incumbents these reforms would mean a deterioration of their competitive position. E.g., when independent DR aggregators ramp up and down customer loads this leads to disturbances in the balancing circles managed by BRPs. For electricity producers that have traditionally provided flexibility, DR aggregators are new competitors. As Interviewee 5 expressed it, 'If DR aggregators get more space, someone has to give up some space. Incumbents do not want to share the cake.'

Regulatory barriers to DR are country-specific and higher in electricity systems where supply security is not at risk. Interviewee 11 said, 'In Germany, our system is working well and there are numerous flexibility options that do not need regulatory reforms. Why should we pursue DR?' In the UK, France, and Belgium, on the other hand, DR has quite early received more freedom to operate, which is interpreted as a response to supply security concerns. Interviewee 5 concluded, 'The urge to act was evident and traditional solutions were not at hand'.

Further regulatory changes are hindered by the fact that the systemic advantages of DR are still not well acknowledged among policymakers. Interviewee 7 observed, 'Policymakers declare they want new technologies such as RES and DR, but … no one wants to risk that the lights go off.'

With its Electricity Directive, the EU is an important driving force behind regulatory changes paving the way for DR. Nevertheless, the enactment of the directive lags behind in numerous member states (smartEN, 2019; Bertoldi et al., 2016). Interviewee 18 stated, 'In some countries, formal regulations seem to support DR aggregation at a first glance, but detailed arrangements such as bid size for certain markets are still discriminating.' It is unclear whether national regulators do not know how or do not want to implement the EU directive.

[18] Balancing circles refer to a system that balances supply and demand among electricity producers and consumers in a particular area.

At the beginning of the study (end of 2015), the interviewees primarily complained about the undefined market role of DR aggregators and the lack of market access. Later on (in 2019-2020), the focus shifted more towards regulatory uncertainty, complexity, and the lack of standards (ESTF, 2019). The frequently altering of DR programs and the unforeseeable direction of their further development were described as regulatory uncertainty (see also Baes & Carlot, 2018). In terms of complexity, interviewees mentioned the large number of DR programs in some countries (e.g. in the UK) and complicated participation rules that do not reflect the specific characteristics of DR. Some interviewees called for a less prescriptive regulatory approach and one that is based on outcomes. Another dimension of complexity are the regulatory differences among national electricity systems that hinder international expansion (Bray & Woodmann, 2019; Thies, 2018). DR aggregation across borders today requires following country-specific rules and adjusting technical tools. Regulatory complexity, on the other hand, might be advantageous for DR aggregators, since it discourages customers from trading their flexibility without an intermediary.

The lack of standards refers to numerous aspects such as contracts between aggregators and customers, comparability of DR aggregation services, baseline calculations, remuneration, feasibility and reliability testing, and communication with other market actors.

Independent DR aggregators are more affected by regulatory barriers than integrated ones. Being electricity suppliers the integrated DR aggregators have the supplier licence, which grants them numerous privileges, including the right to participate in certain markets, e.g. in the balancing markets in the UK (Bray & Woodman, 2019) and access to certain technical codes, which goes along with the possibility to participate in the process of reforming them.

4.1.2 Low economic value of flexibility

Given the systemic advantages of the DR aggregation, one would expect that the price of DR services would reflect them accordingly. The interviews revealed this was not the case. Many DR aggregators struggle for economic survival (Desmyter, 2018). Low prices of flexibility combined with limitations in market access are consequently another key challenge DR aggregators have to cope with (ESGTF, 2019; Wohlfarth et al., 2020). This is surprising as policymakers stress the increasing need for flexibility to enable the efficient integration of weather-dependent RES (Papaefthymiou et al., 2014).

Many interviewees blamed incumbent electricity generators for this situation because they contribute to overcapacity in electricity supply, thus lowering flexibility prices (BEE, 2015). According to Interviewee 6, this could be countered if positive externalities such as CO_2 savings and investment deferral were considered in DR pricing (Respond, 2018).

Significant investments in technology development and in customer acquisition are necessary to enter the DR aggregation business. DR aggregators need to incentivise electricity customers to build a tradable DR portfolio they refuse to collaborate otherwise. Interviewee 3 underlined, 'the social corporate responsibility value of DR is not a primary driver for customers to join our DR pool. DR provision is most attractive for businesses with low profit margins since DR, although it does not generate high incomes, can impact the bottom line.'

Interviewee 11 was particularly negative, 'Facing low flexibility prices and high investments, also for the establishment of metering infrastructure, today there is no business case behind DR aggregation.' A further problem is that TSOs in some countries treat DR as a last resort measure and rarely activate it. DR aggregators prefer instead that DR would become a regular service used in everyday system management, thus providing a regular income. DR-based services that require a very fast reaction time seem to be more profitable than those demanding a slow response.

4.1.3 Resource constraints

As start-ups offering a highly innovative service that requires continuous technology updates, time-intensive customer acquisition, and substantial regulatory adjustments, DR aggregators face resource constraints to cope with these multiple challenges. These constraints refer to both finance and manpower, since a highly skilled workforce is needed to implement this business. Interviewee 7 stated, 'We have had to cope with numerous issues at the same time. The majority of our employees are fresh out of the university.' Interviewee 5 added, 'Growth is more important to us than profit.'

In particular, end-customer acquisition is very resource-intensive. Incumbent electricity suppliers that engage in DR aggregation benefit from their established end-customers relationships. This places independent DR aggregators under increasing pressure.

4.1.4 Complex business model

The high complexity of the DR aggregation business model is another key challenge DR aggregators face (Parrish et al., 2020). This complexity can be seen at all stages of the DR aggregation process, including customer acquisition (see the next sub-section), integration within the existing balancing circles, and DR trading. It results in lengthy sales cycles and high operational costs, which are especially challenging for the many small independent DR aggregators.

When it comes to trading an established DR portfolio, multiple issues need to be addressed, such as which markets are open to DR and when more than one is accessible, how to optimize the value of the DR portfolio. DR aggregators must prove that the portfolio meets the required technical criteria of the buyer. These criteria, originally designed for generators, refer in particular to dispatch time and bid size and vary depending on countries and markets. In general, ancillary services require faster reaction times than participation in capacity markets (Ponds et al., 2018).[19]

Another complexity driver is potential imbalances caused by independent aggregators in existing balancing circles. Some argue that when an aggregator trades energy obtained from ramping down a customer's load, this energy has already been sourced by the customer's electricity supplier and the costs incurred need to be compensated by the aggregator (Baker, 2017; BNV GL, 2017). There are various calculation methods for this purpose and they have to be approved by a national regulatory authority (Wimmer & Pause, 2019).

The complexity of the DR aggregation business model affects communication among all parties including end-customers, DR aggregators, regulators, DSOs, and TSOs. A simple and standardised language would be important in facilitating DR.

4.1.5 Customer acquisition

End-customer acquisition is vital to DR business, but – also due to DR's complexity and an insufficient customer awareness – it poses a significant challenge in terms of time and the financial resources needed.

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[19] System operators purchase ancillary services in real-time to ensure grid stability and reliability when it comes to unexpected outages and supply–demand variations, e.g. through an intermittent character of RES. Capacity markets are to procure reserve capacity for future demand forecast or in response to an emergency event (Ponds et. al., 2018).

To build a tradable DR-based flexibility pool, a DR aggregator needs to persuade electricity customers to steer and trade their electricity load flexibility through manipulating such processes like pumping, ventilation and cooling (Ponds et al., 2018) and/or their on-site generators including backup generators. A first hurdle to customer acquisition is to identify who is responsible for DR, as energy management is frequently not reflected in the organisational structure of enterprises (Stede et al., 2020). Moreover, for any of these businesses (e.g. steel factories, breweries, or supermarkets), DR provision belongs to their core business. Frequently, they need to be convinced of having any flexibility at all.[20] Many still believe that flexibility provision might endanger crucial processes and lead to a loss of control (Stede et al., 2020; The Energyst, 2019). The complexity of DR and the lack of standardisation (ESGTF, 2019; Parrish et al., 2020) increase the effort to be invested in the acquisition too. Interviewee 5 concluded, ‘Normally you need to overcome a certain inhibition threshold of a customer: ‘It is not something for me. Very complex. I may have disadvantages. I will lose control over my production, and so on.’ Our main challenge is to cope with these stereotypes.’ Earning money from assets is the main driver of customer engagement, but many customers have higher financial expectations than DR aggregators are able to fulfil (The Energyst, 2019). To offer their customers a reasonable remuneration, a DR aggregator must calculate a so-called baseline, the normal demand for electricity without DR, which is a basis to determine the change in response to a DR event initiated by an aggregator. Different methodologies can be applied for this purpose, thus leading to uncertainty on both sides of the DR contract. An underestimation of the baseline implies that the DR will be undervalued (Elering, 2017).

Solid industry knowhow is needed by DR aggregators for successful customer acquisition, but it drives complexity too. Every new industry an aggregator intends to include in its DR portfolio requires resource-intensive software updates. In general, the technical requirements are extremely high in this business.

4.2 Measures

Facing these multiple challenges, DR aggregators implement a combination of the following measures: lobbying, market education, technological proficiency, and scaling up business.

[20] In most cases, customers’ load flexibility is based on a backup generator. This means that they do not in fact decrease electricity consumption, but go off grid and switch to a backup generator. Some DR aggregators supply electricity customers with backup generators.

4.2.1 Lobbying

To cope with regulatory barriers, most DR aggregators carry out lobbying activities as an integral but resource-intensive part of their business. Lobbying involves communication with decision makers including politicians, regulators, and network operators both at the European and at the national level with the aim of pointing out key barriers and proposing solutions. Many DR aggregators, despite being small companies, have their own employees responsible for lobbying or even teams for regulatory affairs. Some collaborate for this purpose under the umbrella of associations such as the Association for Decentralised Energy in the UK, Association of Energy Market Innovators in Germany, or smartEN, formerly Smart Energy Demand Coalition (SEDC), at the EU level. These associations represent the interests of diverse actors, including incumbents, and coordinate the development of a reform consensus. In particular, SEDC's efforts in supporting DR at the EU level are broadly recognized. Nevertheless, many DR aggregators find the level of collaboration in the industry insufficient and complain about 'free riders' benefiting from their efforts without contributing to them.

Apart from lobbying through their associations, many DR aggregators participate in public consultations of regulatory proposals and directly approach politicians to use them as a 'mouthpiece' to articulate their positions (e.g. EnerNOC, 2015). Communication with TSOs seems to be fruitful. Interviewee 6 said in this regard, 'TSOs listen to our advice because we, as an internationally active aggregator, have a good overview of relevant regulatory benchmarks.' In particular, countries that have already faced the risk of electricity supply shortages managed to implement regulatory changes that favour DR. Interviewee 13 recalled, however, DR's high conflict potential. 'DR makes the life of TSOs more difficult and through their established relationships with conventional generators there is a conflict of interests.' Germany was described in this context as a country with 'subsidized coal-fired power plants and overcapacity in electricity supply,' which addressed DR relatively late compared to other EU member states (see also Eid et al., 2016; Kuzemko et al., 2017).

To create a level playing field for DR, a technology-neutral and an outcome-based approach to reforming regulation is needed (Pause & Wimmer, 2018; Thies, 2018). The inclusion of environmental externalities arising from all flexibility sources – including also conventional generation and electricity imports – would be crucial to calculating fair payments (Barbero et al., 2020). DR aggregators' revenue streams could be further broadened by allowing DSOs to buy DR for network management at the distribution level (Simon, 2018). A simplification of

DR programs would be helpful too. The implementation of these reforms requires patience since institutional changes in the highly regulated and supply-side oriented electricity system are highly contested. Overcoming the resistance of incumbents and policymakers is particularly challenging for new entrants to the market.

4.2.2 Market education

To cope with the novelty and complexity of DR, all DR aggregators are involved in awareness-raising activities. Interviewee 5 said, 'Most people have never heard about DR,' but the interviewees acknowledged that the awareness of industrial customers has substantially improved in recent years thanks to the 'legwork' by DR aggregators (Desmyter, 2018).

Awareness-raising activities take place in numerous ways. Customer acquisition frequently involves improving their understanding of DR. Many DR aggregators give talks and presentations at industrial events, conferences, and trade fairs. Some of them see pilot projects with other market actors as a contribution to market education too, as they not only show the feasibility of DR, but also raise awareness regarding DR processes and benefits and establish useful networks.

DR aggregators use similar key messages to frame DR. Based on the analysis of the interviews and of the Internet homepages of DR aggregators, four key frames were identified: (a) DR as a source of an additional income, (b) the role of DR as a facilitator of a system integrating volatile RES, (c) its contribution to CO_2 reduction and (d) to the enhancement of reliable electricity supply. Interviewee 7 confirmed a certain degree of success DR aggregators have achieved in this regard: 'Policymakers associate DR with sustainability.' Sustainability plays, however, a minor role when acquiring end-customers. DR aggregators, well aware of the concerns businesses have, focus on advertising DR's financial benefits and on ensuring it does not disturb core business processes, which is particularly valid when DR is achieved through switching to diesel-fuelled backup generators.

4.2.3 Technological proficiency

Asked about their main USPs, all the representatives of DR aggregators interviewed mentioned the proprietary technology that lends them a competitive advantage both in customer acquisition and in DR trading. The following capacities were the most important: (a) the ability to deliver a quick load dispatch that enables service provision with the highest profit margins, (b) a 24/7 control room to monitor energy markets and customer sites, (c) software customisation reflecting the specifics of markets and industries, (d) big data analytics, and (e) in-house energy trading capacity.

As high-tech companies, DR aggregators invest a significant part of their resources in technology development. Software modifications are needed to acquire customers in new industries or to enter new markets and countries. Interviewee 15 summarised it like this, ‘To offer DR-based flexibility means you have to be flexible’ and this requires a highly qualified workforce including software developers and a sales force possessing industrial knowhow.

Only one interviewee admitted that his company carries out ‘manual’ demand reductions ‘because our national TSO does not procure fast services.’ Other interviewees confirmed that a ‘real’ DR business requires a high grade of automation.

4.2.4 Scaling up business

The key to survive in the steadily evolving DR aggregation business involves an appropriate scale of operations. The scale can be defined by the number of negawatts under control, the scope of services provided, the geographical range and number of markets served. Interviewee 9 put it like this, ‘Once you look at the aggregators you can see that the ones that seem to be doing well have much more than a handful of megawatts under control, are either multi-national or at least multi-regional in their operation, or have significant backing from some big players.’

Building a sizable negawatt portfolio requires a significant effort, which is a considerable challenge for small start-ups. Large energy-intensive businesses with a substantial flexibility potential - as ‘lower hanging fruits’ - have already been collaborating with aggregators. Established electricity suppliers that also offer DR aggregation have a clear advantage when developing their DR pool since they can tap their existing supply customers’ demand flexibility (Baes & Carlot, 2018).

Many originally independent DR aggregators have acquired a supplier licence, which involves a substantial investment. This licence grants them access to flexibility markets otherwise closed to them (Bray & Woodman, 2019) and enables participation in regulatory processes they would be excluded from.

To scale-up operations, DR aggregators collaborate with or are acquired by a larger partner (Desmyter, 2018; Hardy, 2018). E.g., Energy Pool, a French DR aggregator, is in a long-term strategic partnership with Schneider Electric, a global expert in energy management (Energy

Pool, 2020); the British energy supplier Centrica bought Restore, a DR aggregator from Belgium (Reuters, 2017), and Enel, Italian energy utility, bought EnerNOC, a global player in DR (John, 2017). Interviewee 13 described these mergers and acquisitions as typical for high-tech companies, 'They develop technology, gain a certain market share and deliver a proof of concept, then they try to attract a larger player to buy them.'

Many DR aggregators expand to other geographical locations and enter new markets to broaden revenue streams and diversify the risk of frequently changing regulations. Some decided to extend the scope of their activities through: (a) aggregation of generation, including RES, although it requires the development of new algorithms, (b) DR technology provision to other market players, although it might create additional market competition, (c) provision of energy, (4) adding storage to the portfolio (see also Baes & Carlot, 2018; Hardy, 2018).

In 2015-2016, several of the interviewed DR aggregators stressed that they focus on the core DR business and are not interested in collaborating with incumbents, because they are inflexible and therefore unable to successfully provide DR aggregation. Interviewee 6 stated, 'Adding new services or a merger with a utility are more of a plan B.' Later on, however, many independent DR aggregators implemented the plan B.

5 Discussion

As institutional entrepreneurs working to establish demand-side based flexibility in the European electricity market, DR aggregators face unfavourable regulation, the low economic value of flexibility, resource constraints, the complexity of the business model, and the difficulties of customer acquisition as the key challenges. Regulatory hurdles and the low value of flexibility result from the prevailing field level conditions, and resource constraints have their roots in the social position of DR aggregators as new market entrants (Battilana et al., 2009). Complexity and customer acquisition are related to the characteristics of DR. Finally, the characteristics of an innovation is a further category of factors that affect the uptake of the entrepreneurial changes required to enable it.

The existing conditions of the electricity system prioritise the electricity supply security (see e.g. BMWi, 2015), which results in a system architecture that is still highly regulated and largely favours incumbent conventional power plants as reliable flexibility providers. This translates into high market entrance barriers for new entrants and might temporarily lead to overcapacity in electricity supply and low prices for flexibility (BEE, 2015; BMWi, 2015;

Kuzemko et al., 2017), thus deteriorating the economic situation of DR aggregators. Additionally, although the EU is striving for a common electricity market, the EU member states differ significantly in their regulation of this area. This high institutional heterogeneity might drive entrepreneurial activities, but it is also a significant barrier to the international expansion of the DR aggregation business.

The resource limitations many DR aggregators, and in particular those that are independent, have to work with are a consequence of the 'liability of smallness' (Schaltegger & Wagner, 2011). This increases their motivation to strive for reforms, but also reduces their chances of being successful.

Involving multiple interdependent elements - actors, technologies, markets - that interact with each other, DR aggregation is a complex phenomenon (Good et al., 2017; Frenken, 2006; Poutanen et al., 2016). Inspired by Henderson and Clark (1990) that introduced the category of architectural innovations (in addition to the distinction between incremental and radical innovations), I propose to characterise DR aggregation as such. Based on known technologies, architectural innovations alter the relationships among system components, thus creating a novel system architecture. DR aggregation can be characterised in this way too: Drawing on ICT and 'smart grid' as well-established technologies DR aggregators change the way electricity customers interact with supply-side actors, which represents a paradigm shift in the electricity system. The characteristics of the innovation in question as a further key factor influencing the process of institutional entrepreneurship to foster it have received little attention in the literature.

To cope with these multiple and interlinked challenges, DR aggregators implement a combination of measures such as lobbying, market education, striving for technological proficiency and scaling up business.

Political tactics in form of lobbying and market education seem to be particularly successful in countries that faced the risk of electricity supply shortages and therefore provided a fertile ground for reforms to enable DR as a measure preventing it. This study reveals, however, that collaboration among DR actors, which is crucial for bringing about institutional change (Garud et al., 2002), does not play a central role in their strategies and is still relatively underdeveloped. This might be one of the reasons why in numerous EU member states there is still no level playing field for DR even though the EU Electricity Directive requires it (smartEN, 2019).

Although framing is identified in the institutional entrepreneurship literature as another key activity and despite commonalities in the narrative on DR advantages, it also did not emerge as key strategy in the interviews. Instead, increasing technological proficiency and scaling up business were seen as pivotal to creating legitimacy and overcoming the ‘liability of smallness’, and pursuing institutional change. Professionalization and growth have not been described in the literature as an institutional entrepreneur strategy for new market entrants.

Buying a supplier licence is an interesting strategy to scale up business as it allows independent DR aggregators to access markets and processes that would otherwise be closed to them. This may be perceived as the result of institutional pressures on organisations to appear as homogeneous entities in the field they are acting in (Marquis & Raynard, 2015). Possessing a supplier licence or becoming part of a larger entity with multiple competing offerings may, however, prevent DR aggregators from acting as institutional entrepreneurs.

DR aggregators are not only subject to institutional pressures but also exert pressure themselves, leading many incumbents to incorporate DR aggregation into their own service portfolios. These Goliaths mimicking new entrants increase market competition on the one hand, but, on the other hand, they contribute to expanding DR beyond a market niche (Hockerts & Wüstenhagen, 2010; Smink et al., 2015).

6 Conclusion and policy implications

This study identifies DR aggregators as institutional entrepreneurs working to reform the European electricity market and identifies the key challenges they face and the measures they apply to cope with them. Since DR contributes to an efficient integration of RES, CO_2 savings, improved reliability of electricity supply, and financial gains for customers (Bertoldi et al., 2016; Nolan & O’Malley, 2015), DR aggregators support the sustainability transition of the European electricity system (Darby, 2020). Nevertheless, in spite of the EU Electricity Directive requiring EU member states to create a level playing field for DR aggregators (EU ED 2019/944), in many of them there is still much to be done to achieve this goal (Bray & Woodman, 2019; smartEN, 2019; Bertoldi et al., 2016).

The key challenges DR aggregators face are unfavourable regulation and the low economic value of flexibility that result from the characteristics of the supply-side oriented electricity market, resource constraints aligned with the DR aggregators’ social position as new entrants, as well as complexity and customer acquisition, both resulting from the specifics of DR aggregation, which is described in this study as an architectural innovation that alters the interplay of the demand- and supply-side actors in the electricity system (Henderson & Clark, 1990), making it particularly challenging to implement. The literature on institutional entrepreneurship to date has not adequately addressed the role of the characteristics of the innovation as an influencing factor in the implementation of institutional reforms to enable it and future research should investigate this gap.

To overcome these key challenges, DR aggregators apply a combination of lobbying, market education (which can be considered as political strategies) and striving for technological proficiency and scaling up business (which reflect their efforts to increase professionalization and growth). The latter has so far not been highlighted as an integral part of an institutional entrepreneur strategy. The study also reveals that collaboration among DR aggregators and with other actors could be enhanced to more efficiently pursue market reforms.

Given the positive effects of DR in achieving EU climate and energy goals and the active role DR aggregators play as institutional entrepreneurs in pursuing reforms in the European electricity market, the following policy recommendations to promote this goal can be derived from this study: (a) It is urgent to assess the real value of DR in comparison to other flexibility sources by taking all externalities into account and reflecting them in flexibility payment mechanisms. (b) A technology-neutral and outcome-based approach is required when designing rules of market access and participation. (c) Simplification and unification of DR programs across countries as well as common standards would help reduce complexity and uncertainty for DR providers. (d) DSOs should be allowed to purchase DR for network management at the local level, thus broadening revenue streams for DR aggregators. (e) Educational work in terms of making electricity customers aware of DR processes and benefits should be more intensively supported by public institutions.

Acknowledgements

I would like to thank my advisor Ursula Weisenfeld for the continuous support and fruitful discussions during the elaboration this study.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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