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# Challenges for electricity network governance in Energy transitions: Insights from Norway

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## **Abstract**

Once transitions progress beyond the startup phase, niche technologies diffuse more widely to generate important knock-on effects in the focal sector. With this comes a need for moving beyond nurturing niches to embracing a 'whole system perspective'. In the case of the power sector, a whole systems view puts the role of electricity networks more central. This paper analyses how the governance of power networks is challenged by the pending renewable energy transitions. We integrate insights from network regulation studies and transition studies to propose a framework for understanding how energy transition challenges current regulatory thinking and practice. We use the framework for assessing recent attempts at regulatory innovation by the Norwegian network regulator. The paper shows how the established toolbox of network regulation can be amended to tackle innovation and transition. The Norwegian case shows that the network regulator does take up the challenges resulting from the energy transition. Yet it also shows the difficulties of making these new instruments effective. A key issue is the tension between a strong focus on cost-efficiency in the existing regulatory framework, on the one hand, and transformative change on the other.

**Keywords:** Energy transitions; Network regulation; Whole system change; Transition governance; Acceleration.

# 1 Introduction

Studies in the field of sustainability transitions are concerned with fundamental, socio-technical transformations in sectors such as energy, transport or food that are associated with sustainability issues (Markard et al., 2012). Transitions are typically seen as a process where one socio-technical configuration is replaced by or integrated with a new, emerging one (Geels, 2002; Geels & Schot, 2007). This process unfolds over three phases: start-up, acceleration, and stabilization. Central to the first phase is the formation of new niche technologies, while the second phase is characterized by large-scale diffusion of those technologies. The last phase sees a new configuration of technologies stabilize (Rotmans et al., 2001; Schot et al., 2016). Hitherto research on sustainability transitions has focussed on the first of these phases (Geels, 2018; Schot & Kanger, 2018). Therefore there is a need for developing more insights into how to govern later phases of transitions (Köhler et al., 2019; Markard, 2018).

In the ongoing transition in the power sector, for example, integration of new, rapidly diffusing low-carbon technologies such as wind and solar power into the existing power system and adapting that system accordingly are needed as part of the acceleration phase (Bird et al., 2013). A key challenge is to provide an infrastructure that can accommodate rising shares of decentralised and fluctuating generation (IEA, 2018; Sinsel et al., 2020). As the focus shifts from power plant development to whole system design, this also entails a new governance perspective (Martinot, 2016; Mitchell, 2016).

The shift from analysing emerging niche technologies towards a ‘whole system perspective’ puts the role of electricity grids or networks more central than previously because these constitute the (physical) architecture of the power sector. The grid connects millions of power-producing and -using components and influences how these interact. Therefore, the grid architecture and how it is regulated put important boundary conditions on which types of change can take place in power generation and consumption (Lindberg et al., 2019). As a consequence, changes in power grids as well as the interface with the other subsystems play a major role in the energy transition especially in the acceleration phase (Andersen, 2014; McMeekin et al., 2019). However, as power grids are not much affected by new niche technologies in the start-up phase of energy transition, there are only few studies on the transformation in power grids and its interfaces with other subsystems to provide a whole systems view (Andersen and Markard, 2019; Bauknecht, 2012; McMeekin et al., 2019).

Against this background, this paper aims at improving our understanding of how power networks and especially their governance are challenged and transform. We look at the specific governance arrangements for the power network, namely network regulation, and discuss how these can facilitate energy transition. While electricity markets have been liberalized, the electricity grid is still dealt with as a natural monopoly that needs to be regulated. With market liberalisation independent regulatory bodies have been set up to facilitate the provision of given network functions at least costs. However, with the energy transition, the overall objective shifts from investing in and operating a given system at least cost towards adapting the grid so as to accommodate the fundamental changes in generation and use. This leads to the question of how the established regulatory framework can address these new objectives.

To analyse these questions, we integrate insights from network regulation studies and from transition studies to propose a framework for assessing governance of networks in energy transitions which we apply to a case study. We do so in three steps. First, in section 2.1 we describe key governance challenges associated with transitions or ‘system innovations’ and how these differ from other governance rationales (Weber & Rohrer, 2012). Second, in section

2.2, we translate these governance challenges into the domain of network regulation thereby proposing a synthesis between transition studies and network regulation. We ask which new tasks network regulation should embrace to strategically support energy transition rather than involuntarily hinder it. We identify tasks related to promoting both technological and institutional innovations but also to influencing the direction of innovation such as developing joint future visions of the power system and the role of the grid. Third, in the empirical part, we analyse changes in power network regulation in Norway in response to changes in generation and consumption of power related to energy transition. We ask how the new requirements that are described in the conceptual part of our paper are addressed in this case, what practical challenges can be observed, and what can be learned from this experience.

We find that conceptually the general governance challenges related to innovations are reflected in recent developments in the realm of network regulation. As for the challenges related to transition, there is a mismatch between the regulatory objective to increase the efficiency of existing network functions, on the one hand, and the need to govern the transition towards a new energy system, on the other hand. Empirically, the Norwegian case shows that the network regulator does take up the challenges resulting from the energy transition. However, it also shows the practical implementation challenges and how they result from the tension between the current regulatory framework and transition governance requirements.

## 2 Energy system transition and regulation

### 2.1 Governing energy transitions

Socio-technical transitions describe a process of fundamental change or ‘system innovation’ which typically goes beyond incremental and radical innovations in individual products and processes. Instead it refers to a reconfiguration of multiple interlinked technologies, institutions, and actors involving clusters of incremental and radical innovations that affect large parts of the economy (Freeman & Perez, 1988; Geels, 2002). While historically, transitions evolved driven by technological progress or changing natural resource constraints, sustainability transitions aim at addressing grand societal challenges such as climate change, biodiversity loss, and pollution. This implies that they are purposeful with a crucial role for public governance. Within innovation and transition studies, governance of transitions refers to the policy challenges related to facilitating the technological and institutional change needed to address grand challenges. This perspective coincides with a ‘broad’ understanding of innovation policy as those policies that influence innovation in a “non-trivial manner” covering the process from creation of new ideas to implementation and diffusion of novelties (Fagerberg et al., 2005).

Governance of system innovations for sustainability challenges existing ways of thinking about policies for technological change (Weber and Rohracher, 2012). Traditionally, the main rationale for public policy was to correct *market failures* in the production of new knowledge and technology by providing firms with appropriability mechanisms such as patents to support science production (Arrow, 1962). More recently it was shown that there are several additional policy rationales related to *structural system failures* (Klein Woolthuis et al., 2005). These include (a) *infrastructural failure* refers to shortcoming in existing tangible infrastructures to support innovation such as science and research labs or training infrastructure. (b) *Institutional failure* refers to rules and practices that hinder innovation such as regulation and standards (formal) or social norms, routines and values (informal) (Edquist & Johnson, 1997). (c) *Interaction failure* refers to situations where too loose or too strong actor networks inhibit

innovation. The former occurs when there is very limited information sharing and interactive learning among actors in an innovation system. The latter occurs when social networks are overly dense with no inclusion of new actors which can lead to cognitive lock-in and rigidity. (d) *Capabilities failure* refers to lacking ability in organizations to innovate and to adapt to changing circumstances in the form of both transformation pressures and new technological opportunities. System failures inhibit the overall efficiency and effectiveness of an innovation system.

Both perspectives (market failures and structural system failures) are however insufficient for dealing with sustainability transitions. While previous thinking implicitly targeted innovation for economic growth, what is needed now is innovation directed towards solving societal problems. The resulting governance challenges can be articulated as four types of '*transition failures*', see table 1. These failures help identify important challenges to succeed with 'collective action' for system innovation (Weber & Rohracher, 2012).

(i) *Directionality failure* refers to a need for strong political goals to overcome systemic lock-in in existing socio-technical systems amidst profound uncertainty (Unruh, 2000). In this context, individual companies typically avoid taking major risks and cannot be expected to lead transitions. This insight creates a novel rationale for public policy in setting direction for innovation (Mazzucato, 2018; Schot & Steinmueller, 2018). Setting direction typically refers to strategic selection of collective priorities and the creation of shared visions (Weber and Rohracher 2012). Normative priority setting however inevitably brings politics and contestations into the discussion (Normann, 2015; Schlaile et al., 2017). This implies that the effectiveness of setting direction depends on alignment of interests and decision-making by a set of distributed actors (Andersen & Dannemand Andersen, 2017; Garud & Karnøe, 2001; Kemp et al., 1998). To achieve such collective action, wide social inclusion in goal setting, strategy design and outcome is crucial (Andersen & Johnson, 2015; Weber & Rohracher, 2012).

Overcoming directionality failure is closely related to (ii) *demand articulation failure*. In its broadest sense, this refers to lacking inclusion of new innovation stakeholders predominantly based in the user domain (e.g. prosumers, energy communities, citizens broadly) in innovation and processes of policy development (Kuhlmann & Rip, 2018). Wide stakeholder inclusion in the process of formulating societal goals and mechanisms of achieving them is important for building sufficient legitimacy to actually implement policies (Andersen & Dannemand Andersen, 2017; Boon & Edler, 2018). Moreover, linking science and technology policy to directionality (i.e. policy goals) is important but arguably insufficient for breaking system lock-ins. Indeed, it is widely recognized that demand-side policies are needed to create protective niche spaces—a market pull mechanism—for new technologies to improve performance via learning by doing (Mazzucato, 2016). Lastly, classical innovation actors should engage with new user types to explicate their latent demand for sustainable solutions. These issues further point to the need for broad social inclusion in transition strategy development.

(iii) *Policy coordination failure* refers to increased complexity for policy makers in coordinating an evolving policy mix (Rogge & Reichardt, 2016). Innovation policy cuts across many different policy domains (e.g. specific sectors, education, trade, environment) and a key issue is to align policies across domains to best support transitions (Fagerberg, 2018). This logic also covers alignment between private and public sectors (e.g. standards), multi-level policy alignment (e.g. local, national & international) and temporal alignment (Weber and Rohracher, 2012). (iv) *Reflexivity failure* refers to the need for continuous 'policy learning' to navigate in a context characterized by complexity, uncertainty and contestation. This has been referred to as reflexive governance (Voß et al., 2006). Weber and Rohracher (2012) mention three interrelated aspects

of this. First, the policy system must be able to self-reflexively monitor, evaluate and anticipate (e.g. via horizon scanning) change. This implies questioning and experimenting with not just technology but also established institutions e.g. regulatory and policy innovations. Second, the organization of the latter must take into account that change processes require coordination among widely distributed actors (cf. above). Third, due to uncertainty, policymakers must keep options open and operate with a portfolio of transition pathway options in parallel rather than single options. A key issue is to be able to adjust direction in the course of transition as context conditions change.

**Table 1: Overview of public policy rationales to support innovation**

| <b><i>Core focus</i></b> | <b><i>Market failures</i></b> | <b><i>Structural system failures</i></b>                                              | <b><i>Transition failures</i></b>                                        |
|--------------------------|-------------------------------|---------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Theoretical foundation   | Mainstream economics          | Innovation system theories (innovation within system)                                 | Socio-technical transitions (system innovation)                          |
| Goal / rationale         | Economic growth               | Efficiency and effectiveness of innovation systems for growth; the rate of innovation | Addressing grand challenges; the rate <u>and</u> direction of innovation |
| Types of failures        | Market failures               | Infrastructural failures                                                              | Directionality failure                                                   |
|                          |                               | Institutional failures                                                                | Demand articulation failure                                              |
|                          |                               | Network failures                                                                      | Policy coordination failure                                              |
|                          |                               | Capability failures                                                                   | Reflexivity failure                                                      |

These transition policy challenges imply that there is a widespread need for enhancement of capabilities in the public sector. Also note that the extension of innovation policy rationales is cumulative. Transitions require policies addressing market and system failures but these should be linked to and deduced from transition objectives. Moreover, the governance challenges are important across all transition phases although their particular form may differ across phases, i.e. directionality issues differ between start-up and acceleration phases.

In this context the notions of cost-optimization and technology neutrality — principles often invoked by regulators — are fundamentally challenged. Once we start linking innovation to societal challenges, technology neutrality is impossible and the issue is rather at what level of aggregation selective policies are designed. Given that established technologies and actors have already matured via years of learning-by-doing and are aligned with institutions, technology neutrality is de facto support for the status quo (Azar & Sandén, 2011). Once cost efficiency is used as a policy design criterion, this will favour mature technologies (already on the shelf) but inhibit further development of less mature but promising technologies (novelty on the shelf). Using cost efficiency as a main criterion is thus one way of picking winners. But fulfilling short-term goals cost efficiently can undermine longer-term goals (Sandén & Azar, 2005). Instead, in order to be transformative, governance should be about a portfolio approach to technology development and strategically selective; especially because of the urgency involved in sustainability transitions.

## 2.2 Energy transitions and the requirements for network regulation

Having looked at a general level at different types of failures that prevent innovation and system transition, we now zoom in on the role network regulation in energy transition. We start from the observation that energy transition does not only require new power generation technologies, but also innovations in the network and consumption, and that changes in these subsystems are interdependent. This also puts pressure on the regulatory framework, which is part of the current socio-technical regime in the power sector.

### 2.2.1 The conventional approach to network regulation

In liberalised markets, networks are generally run by privately-owned, profit-oriented network operators that are unbundled from other parts of the industry and the governance of electricity networks is based on network regulation through independent, sector-specific regulatory authorities.

A major institutional innovation that has come along with power sector liberalisation is the so-called ‘incentive regulation’ or price-based regulation (Joskow, 2006). This has been adopted in most countries and network bound sectors, replacing the previously predominant cost-based regulation. Incentive regulation explicitly seeks to mimic the incentive structure of competitive markets, to make up for the lack of competition in the network monopoly and remedy the corresponding market failure. The core of incentive regulation is to provide companies with an economic incentive to improve efficiency. This is done by temporarily (i.e. within one regulatory period of three to five years) decoupling the prices network companies are allowed to charge from their costs. To that end, the regulator sets a price- or revenue-cap for a regulatory period. The focus of regulation is on individual networks. The regulator is to be independent from the political process and regulation is seen as a mainly technical task. As a consequence, the regulator is set up as a separate institution to avoid any political interference.

This regulatory approach has been designed for power sectors where the main objective is to fulfil stable network functions at least cost and where the network plays an important role for generation and consumption, but where it is assumed that changes in the network can be carried out without much interaction with the other subsystems.

These conditions are no longer given with the energy transition and the question arises of how the regulatory framework can adapt. We examine the role of the failures described in section 2.1 in the context of network regulation and provide an overview of mechanisms to overcome these failures.

### 2.2.2 Regulation and economic incentives for innovation

As price-based regulation was introduced to mimic competition in the network monopoly, it was thought to provide sufficient incentives not just for short-term efficiency, but also for innovation. However, there are a number of arguments and empirical evidence showing that price-based regulation can stifle innovative activities (Bauknecht, 2012; Matschoss et al., 2019). There is evidence that even for cost-saving process innovations that help DSOs to become more efficient, price-based regulation may weaken the incentives for RD&D. It can be more attractive for DSOs to reduce RD&D expenditures to meet the efficiency targets in the short-term, rather than trying to reduce their costs through innovations in the medium to long-term – a “market failure” resulting from regulation.

The innovation incentives become even more ambiguous once the innovations not only aim at reducing the network costs, but also at enabling other objectives outside the network (i.e. at the grid's 'edge') or at meeting these objectives at lower costs, as in the case of accommodating new generation from renewables or new demand. These kinds of innovations become more relevant with the energy transition. In this case, at least part of the innovation benefits emerge as externalities for the DSOs and can therefore not be appropriated by the DSOs.

As a reaction to this, there has been both an academic debate as well as practical examples of additional regulatory mechanisms that are geared towards promoting innovations in the network. This can be interpreted as correcting "market failures" resulting from the regulatory framework.

Examples include the German case, where 25% of RD&D project financing can be passed on to consumers or the various mechanisms that have been introduced by the UK regulator OFGEM in recent years, including the Innovation Funding Incentive and Registered Power Zone, the Network Innovation Stimulus or the Low Carbon Network Fund (Bauknecht, 2012; Frame et al., 2018; Lockwood, 2016) .

### 2.2.3 Promoting innovation beyond economic regulation

Network regulation is a reaction to the natural monopoly market failure in the network infrastructure. The specific innovation mechanisms within network regulation that are sketched out in the previous section build on that view. They are an attempt to gear this approach towards more innovation by providing economic incentives for network innovation and internalising the positive innovation externalities.

However, following the structural system failures argument, this will not be sufficient. Rather, innovation processes need to be understood in a wider context that facilitates or constrains the innovation process. Arguments beyond economic incentives that need to be taken into account in the case of network innovations include:

- The RD&D capacity of regulated companies that is a prerequisite to react to external price signals (*capabilities failure*)
- The RD&D culture and routines within companies and the industry that guide the search for new solutions (*institutional failure*),
- Innovation networks, e.g. the link between DSOs and equipment suppliers on the one hand and actors on the generation and consumption side on the other hand which are necessary for the regulated companies to introduce innovations in their network that address development in the other subsystems (*interaction failure*),
- The broader regulatory framework that does not only shape the general innovation incentives for the network operators, but may also represent a barrier for specific solutions, either because it makes them economically unviable or because they are legally not allowed (*institutional failure*).

These issues can be supported by innovation mechanisms within network regulation (see previous section), but also require RD&D policies that are typically not within the realm of network regulation. This points to a need for policy coordination.

The last point concerning the broader regulatory framework has led to the recent development of regulatory sandboxes, i.e. regulatory exemptions that enable the development and testing of new technologies, services and business models. For example, such exemptions have been provided in Germany in the SINTEG demonstration programme as well as in the UK by the

regulator OFGEM (IEA ISGAN, 2019). These sandboxes are typically geared towards providing regulatory exemptions for new technical solutions or business models, rather than testing new regulation itself.

## 2.2.4 Network regulation and energy transitions

The regulatory approaches described in the previous sections focus on specific innovations in individual networks. In terms of energy transitions, such innovations are important but insufficient because of the particular governance issues of energy transition. Based on the literature reviewed above, we now make propositions regarding how network regulation could change to embrace transition governance ideas.

As Bauknecht (2012) has shown network regulation as it is typically applied today (see section 2.2.1, also referred to as the standard model) has not been designed with regard to the energy transition, yet there is still some common ground between the two: *“The standard model acknowledges bounded rationality and uncertainty, the need to remain adaptive and the limited control capacity of the regulator”*. However, as opposed to the energy transition, network regulation focuses on short-term efficiency and is hardly concerned with long-term systematic effects, including the link between network, generation and consumption. It focuses on the regulated company rather than the heterogeneous actor arenas that become more relevant with transitions”

In terms of the directionality failure, the standard model is not concerned with developing the network in any specific direction, but involves a narrow remit for regulators. Their objective is to increase efficiency, promote competition and ensure a level playing field for all market participants. As soon as societal visions and political objectives about where the system should go come into play, this is at odds with the institutional set-up of independent regulators, where regulation is seen as a neutral and technical task and where one main rationale is to keep out politics. At the same time, the regulator is in a unique position to facilitate the development of such transition visions. This leads to a discussion about broadening and redefining the regulatory remit and developing the regulator into a “transformative organization”.

In terms of setting directions and articulating demand, the standard model analyses the relationship between the regulator and the regulated company in a principal-agent framework. However, there are other actors that have a stake in network development and these tend to be left out. With energy transition, the regulatory process needs to be extended to a broader and more heterogeneous set of stakeholders with different perspectives and interests. For example, both equipment manufacturers which provide innovative network solutions and developers of distributed generation and use (e.g. electric vehicles) projects have a stake in regulation and are important actors for system transformation.

As for policy coordination, the interactions between network regulation and other policy instruments are manifold. There are interactions between network regulation and (a) policies addressing other parts of the system (e.g. financing mechanisms for renewable generation), and (b) RD&D policy instruments for the power system, including the network. For a network regulator this implies the need to understand how regulation interacts with other institutions and policies in influencing the energy transition.

Regarding the need to increase reflexivity and policy learning, regulation can be seen as adaptive institutions with predefined regulatory periods, yet again within the narrow regulatory remit. One approach to become more reflexive, i.e. to develop new regulatory knowledge and experiment with new regulatory instruments in practice is to set up “regulatory innovation

zones” (Bauknecht et al., 2015). These can be seen as taking the sandbox approach one step further. Instead of just providing regulatory exemptions, regulatory innovation zones can provide a laboratory for new regulation before it is rolled out. Different regulatory options can be tested, and practical implementation issues and side-effects of new regulation can be explored and addressed. This also implies that the regulator does not just provide spaces for individual innovations, but thinks about how the future system can be designed and what kind of regulation is needed for that. While there are a number of initiatives to develop regulatory sandboxes (see section 2.2.3), regulatory innovation zones are still hard to find in the energy sector.

## **3 Case study approach**

### **3.1 Case description**

In 2017 the power sector in Norway produced 149.4 TWh of electricity with renewable energy from hydropower accounting for about 96% and wind power accounting for 1.9% (SSB, 2019a). This gives Norway a unique starting point for the energy transition. Despite the high share of hydropower, the sector is strongly affected by the energy transition due to technological developments and ambitious policy goals for decarbonization. In 2012 Norway, together with Sweden, introduced an electricity certificate scheme to support investment in renewables. As a result, small-scale hydropower and onshore wind have grown (Ministry of Petroleum and Energy, 2016). Wind power was further stimulated by internationally falling technology cost. Indeed, wind power reached 3.9 TWh in 2018 (2.6% of total) and is expected to grow strongly (SSB, 2019b). Also, despite lacking policy support, solar PV has commenced a growth spurt in recent years due to increased interest from businesses in self-sufficiency as well as drastically falling technology cost (Multiconsult & Asplan Viak, 2018). Moreover, to support energy efficiency, Norway has implemented a 100% smart-meter roll-out (completed January 2019) (Ministry of Petroleum and Energy, 2016). Norway also has the highest market penetration of electric vehicles (EVs) accounting for 45% of new car sales the first half of 2019. After decades of policy support, diffusion of EVs accelerated around 2010 to a reach 215.000 EVs (March 2019) which is accompanied by 10,711 public, grid-connected charging points (The Norwegian Electric Vehicle Association, 2019). Norway is also commencing electrification of near-shore passenger transport with drastic implications for power networks in peripheral locations (Sjøtun, 2018).

Looking forward, Norway is committed to ambitious climate targets including reducing emissions of greenhouse gases by at least 40% by 2030 and 80-95% by 2050 (reference year 1990). Since these cuts cannot come from the power sector, Norway targets decarbonization of transport, industry and building sectors with electrification expected to play a key role. This inter alia implies reducing CO<sub>2</sub> emissions from transport by 50% before 2030 (reference year 2005). With these changes domestic power production is expected to expand by around 30-50 TWh based on ‘new’ renewables (Statnett, 2019).

The main incumbent power generation technology is hydropower. Emerging niches include new renewables (wind and solar), electric transportation, commercial prosumers, and other flexibility technologies (i.e. alternatives to grid such as storage and demand response). Within the network subsector there is niche experimentation with alternatives to grid enforcement such as battery storage and demand response. Also, there is widespread experimentation with ICT which can both support and disrupt the status quo. When ICT innovations optimize use of existing assets rather than promoting system innovation, we do not consider it a niche technology.

The core principles of the current regulatory framework for the power sector were established with deregulation and liberalization of the Norwegian electricity market in 1992. The thrust of the reform was enshrined in the Energy Act whose main purpose is to: *"...ensure that the production, transformation, transfer, turnover, distribution and use of energy takes place in a socially rational manner, including the general and private interests that are affected"* (Ministry of Petroleum and Energy, 1990). It is the task of the national regulator, NVE (Norges vassdrags- og energidirektorat), to enforce the law by promoting efficient power sales, cost-efficient energy systems and contribute to efficient energy use (NVE, 2019a). Prior to the energy law, electricity was considered a strategic public good for economic development in the form of hydropower and aluminium industry. However, during the 1980s this led to overcapacity and power surplus. The situation changed the understanding of electricity from a public good to a commercial product that should be managed based on cost-efficiency thinking (Hanson et al., 2011, p. 133). Against this background, the Energy Act instilled a new regulatory framework in the power sector based on economic cost-efficiency as the overriding goal. It further implied that regulatory measures and political interventions that could not be justified or derived from the consideration of cost-efficiency should be discontinued (Thue, 1995). In 2018 there were 124 DSOs and 1 TSO in Norway.

In acknowledgement of the changes happening in its power system, NVE has in recent years attempted to combine the cost-efficiency logic with preparing for a fundamental energy transition. Major initiatives include an innovation mechanism, an ongoing revision of the framework for RD&D / pilot projects, and the establishment of the 'forum for the future grid'. Those initiatives are the study objects of this paper.

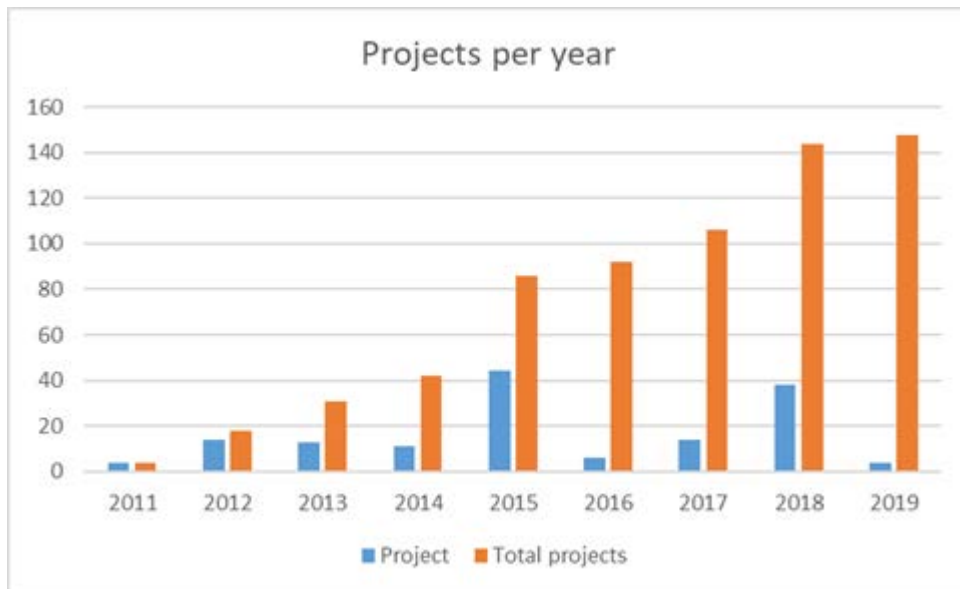
## 3.2 Case selection, data and analysis

The combination of a pending energy transition, a 'classical' cost-efficiency regulatory framework, and a regulator that attempts to meet the transition challenge makes the Norwegian case suitable for studying how network regulation and regulators are challenged in enabling energy transition and what their experiences are in practice.

In the empirical analysis in Chapter 4 we assess three recent initiatives of NVE in accordance with the themes discussed in section 2.2. The analysis of each initiative follows two steps. First, we describe the particular initiative. Second, we assess the implementation challenges and practical effects of the initiative. Finally, in chapter 5, we summarize and synthesize insights of the analysis with a view to distil main lessons from our case for regulators and policymakers as well as key insights for the academic literatures on network regulation and energy transitions, respectively.

Our main source of data are 28 interviews carried out over three rounds in the period 2017-2019. Interviewees included DSOs, the national regulator, technology suppliers, industry associations and public agencies. Interviewees represent both incumbent and niche technologies, see appendix for detailed information. The theme in all interviews was to understand drivers of and barriers to structural change in the Norwegian power sector with particular attention to the role of regulation and the challenges for DSOs. All interviews were transcribed and coded in Nvivo. Another source of data is the 148 RD&D projects for network innovation that the regulator approved in the period 2011-2019 (June), see figure 2. In addition, we use secondary literature, industry reports, and news items.

Figure 1: Number of RD&D projects approved by NVE



Source: RD&D project database

## 4 Analysis: Network regulation and transition in the Norwegian power sector

In this chapter we assess the extent to which recent initiatives taken by the Norwegian regulator NVE address the regulatory functions required for a transition in the power sector, cf. section 2.2.

### 4.1 Regulation and economic incentives for innovation

#### 4.1.1 How is the specific Norwegian regime designed

In 2013 NVE, the Norwegian regulator introduced a novel Research, Demonstration and Development (RD&D) scheme. The decision was based on the expectation that pervasive decarbonization of society via electrification is certain to happen over the coming decades and on the understanding that electricity networks, system operators and network regulators are key gatekeepers for facilitating that energy transition.

NVE observed that innovation by DSOs would be a necessary ingredient in energy transition but also that Norwegian DSOs at large did neither sufficiently think about nor pursue innovation. The main point was therefore to give the DSOs increased financial incentives to engage in RD&D activities by compensating for the potential economic disadvantage caused by such projects. This change mirrored a European trend and was considered a major topic by many national regulators across Europe. Previously, RD&D investment did not receive any dedicated consideration within the tariff regulation. Rather, investment in RD&D was treated like any other investment. This means that it was subject to a revenue cap model, i.e. the revenue of the DSOs is partly determined by a cost norm, which in turn is determined by comparing DSOs' performance. In this model, expenditure on RD&D is not different from other costs. Unless RD&D leads to short-term efficiency gains, DSOs investing in RD&D will have a comparatively lower efficiency and will therefore be financially penalized (Interview 29).

In order to correct this bias, the RD&D scheme was introduced. Within the scheme, DSOs can apply for RD&D projects with an overall budget of up to 0.3% of a DSOs' net capital. Based on a cost pass-through-model, the DSOs can then transfer these costs directly to the grid customers over the grid tariff. Thus, these project resources come as an addition to the revenue cap, so that increased costs do not entail a lower return to the DSO. As a result, the DSOs can avoid a financial penalty even if the RD&D project does not yield short-term efficiency gains.

In order to avoid that DSOs exploit this preferential treatment, there are two safeguards in place. First, there is the 0.3 percent cap mentioned above. Second the projects must be considered as eligible by an institution that grants funding for RD&D projects, so as to guarantee that the project has the potential to contribute to improving the efficiency of the operation and development of the grid. NVE does not have the competence to make this assessment itself, so the DSOs must have the projects considered eligible by the usual funders of RD&D such as the Research Council of Norway, Enova or Skattefunn.<sup>1</sup> This implies that DSOs need a research organization as a partner in the project. By June 2019, NVE had approved 148 RD&D projects, see Figure 2.

#### 4.1.2 Implementation challenges and effects

DSOs did not immediately embrace the initiative with only 10% of possible investments made in the first year. This however increased to about 40% in 2017. Despite a slow start, DSOs have gradually developed more and more RD&D applications (NVE, 2019b). Still, overall the practical effects of this scheme have been lower than expected and is still not considered a success by Energi Norge (main business association for the power industry) (Lie, 2016; Nilsen, 2014). Indeed, the initiative has created frustrations with both the regulator and the DSOs. Another issue is that it is mainly a few large DSOs that participate in multiple projects, while the smaller DSOs are less represented (NVE, 2018).

There are several factors that together explain this situation. We highlight two issues: First, weak innovation capabilities and capacity within the companies (system failures). Second, general uncertainty about where the system is going and what NVE wants (transition failure).

First, one important factor is that DSOs are not sufficiently capable and/or willing to engage in innovation. Although there is a financial mechanism within the regulatory framework for companies to address innovation, companies often do not have the required capability and capacity to take advantage of this mechanism. The lack of innovation capability results to some extent from a general "cultural" barrier (e.g. conservatism), partly due to the companies' long monopoly history and a lack of experience of how to integrate and implement innovation projects (Interview 6; 7; 8; 11). For example, a representative from a smart grid technology company argued that: *"DSOs are conservative and cautious and think about regulation. For something to happen it must be imposed on them via regulation. This cultural barrier [to innovation] is a heritage of the monopoly situation "* (Interview 6).

Besides weak innovation capabilities, there is also a lack of innovation capacity in companies; e.g. human resources that can work on innovation projects. The innovation scheme provides the DSOs with additional resources for innovation, but the companies do not have sufficient organizational capacity for using these resources and the mechanism does not seem to be sufficient to build up such capacity. For example, one of the largest and most RD&D proactive

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<sup>1</sup> Enova is a public agency owned by the Ministry of Climate and Environment and contributes to reduced greenhouse gas emissions, development of energy and climate technology. Skattefunn is a R&D tax incentive scheme designed to stimulate firm R&D by granting tax reliefs to compensate R&D investment.

DSOs say about only 50% of total RD&D cost associated with a particular project can actually be covered by the funding received from the scheme (Interview 18). A main reason is that even though the scheme provides funding for projects, there is not support for administering and preparing for projects which involves building new routines and teams including new skills.

In addition, even without considering how to fund activities, DSOs are challenged by scarce and inflexible human resources. According to one RD&D manager, once a project is granted she asks employees about *“their availability. It's fine that I have money so time spent on projects is funded, but time spent on RD&D projects is then missing in the daily work. That is perhaps the biggest challenge we have, and the reason why we do not use the whole pot”* (Interview 18). This situation is obviously even worse for smaller DSOs that have less resources to reallocate (Interview 18; 24). As for the second key factor, interviewees further emphasized that general uncertainty about the direction of change in the power system paralyze investment in innovation. This concerns both the configuration of the future power system and the role of DSOs within that system, e.g. what will the revenue model for DSOs look like, will DSOs be allowed to own and operate battery systems, and what type and extent of competition from new actors can be expected (Interview 6; 7; 8; 19). Depending on these developments, current investments can become sunk cost in the near future. The latter highlights the important link between the overall long-term vision on a system level and the innovation activities by individual companies, cf. section 4.3.

DSOs' difficulties to take up the innovation scheme is also reflected by the fact that the DSOs experience the initiatives put forward by NVE as confusing. This especially relates to clarity of rules and vocabulary such as the meaning of terms as pilot, demonstration and R&D-projects. DSOs experience this as a barrier for innovation. One large DSO for instance states: *“...when NVE says they want the DSO's to conduct pilot projects and demo projects, the DSO's are uncertain of what NVE thinks such projects should contain and whether NVE is satisfied with the activities that have already been launched.”* (Interview 18).

## **4.2 Promoting innovation beyond economic regulation: creating spaces for innovation**

### **4.2.1 How is the specific Norwegian regime designed**

For many years NVE granted regulatory exemptions for RD&D projects in a rather ad hoc way. This was not seen as problematic due to the small number of projects. As of 2019, a new framework is being introduced with the goal of formalizing and systematizing procedures.

Regulatory exemptions are mainly meant to provide a 'space' for RD&D projects, rather than aiming at regulatory experimentation. The Norwegian case thus represents a regulatory sandbox, cf. section 2.2. In the previous framework, a process of regulatory exemption was typically characterized by a DSO contacting NVE to discuss its idea for a pilot and to explore whether exemptions were required. Communication was bilateral and exploratory both for NVE and the DSO. NVE viewed these processes as opportunities to learn and clarify what is possible to do within existing regulation. In general, NVE assesses the juridical case for granting exemption according to the energy law and in line with the principles applied for the innovation scheme (Interview 28).

## 4.2.2 Implementation challenges and effects

The previous ad hoc approach caused a number of problems for both NVE and DSOs due to a growing number and new types of projects. For example, DSOs complained about long processing times per application as well as uncertainty regarding rules for RD&D projects, particularly regarding the rules about regulatory exemptions (Interview 17; 18; 23; 25). Formalising the approach thus aims at increasing the efficiency within the regulator in processing applications by institutionalizing routines for internal cross-departmental coordination and at reducing uncertainty among DSOs about what NVE expects from them and what the rules for pilots are (Interview 16). It is too early to assess how this works in practice.

As for new types of projects, these tend to be more complex than previously because they require multiple exemptions; local energy community projects are a case in point. Previously there were projects on zero-emission buildings that encompassed many interacting technologies (i.e. renewables integration at micro level) but because these are located 'behind the meter' they did not need regulatory exemptions. With energy communities, however, this changes, requiring exemptions from for example regulations on energy trading and plant ownership. Processing such applications involves different departments within NVE resulting in a demanding process. This development also shows that regulatory issues and exemptions are not only limited to the network, but can cut across different parts of the system.

From an energy transition perspective, the scheme can be assessed as follows. Energy transition requires both technical and regulatory innovations. While the innovation scheme described in the previous section can be used to develop technical innovations, the regulatory exemption scheme could do the same for regulatory innovations. However, the interviews have revealed that there are significant concerns about regulatory stability and about protecting existing large-scale investments in today's system (Interview 16; 21). In the words of the regulator: *"On the one hand, we must follow and ideally anticipate technological developments although that is impossible. On the other hand, we must be predictable. Many long-term investments in the power sector are based on current regulation. Sudden changes in regulation impact the value of investments made 5-10 years ago."* (Interview 16). This tension makes some industry actors doubt that NVE can be a 'transformative organization': *"...NVE is concerned with protecting existing large investments in today's system and security of supply. It is a bit ambiguous because you get afraid of the new technologies that could create a 'death spiral' in the system such that no one covers the cost of running it but at the same time you want to promote and grow those same technologies"* (Interview 21).

For these reasons, NVE does not see regulatory exemptions as a direct way to test and develop the regulatory framework needed for the future system, which would include an overall review of the regulatory framework. Rather, the exemptions can be interpreted as a way of providing flexibility for the increasing number of RD&D projects, while at the same time maintaining stability for the regulatory framework as a whole. NVE also emphasises that for many pilot projects there are no exemptions needed if one takes a closer look (Interview 16). With this approach, NVE can still learn from the experiences made with the regulatory exemptions, but these exemptions are more defined from the perspective of individual pilot projects rather than from a future system perspective and what kind of regulation is needed for that.

## 4.3 Network regulation and system transitions: Actor coordination and developing long-term system visions

### 4.3.1 How is the specific Norwegian regime designed

In response to a pending energy transition in Norway including more decentralized and variable renewables on the production side and several new power consumption segments, the Ministry of Petroleum and Energy in 2016 called for the establishment of a “forum for the future grid” to be specified and organized by NVE. The aims were, firstly, to *“assess what a smarter power grid will entail for the DSO’s, and how technology can be used, utilized and further developed in the best possible way for the grid”*. A second aim of the forum was to *“help identify issues that are relevant to NVE’s further development of the regulatory framework”* (Ministry of Oil and Energy, 2016, p. 185).

The forum consists of a working group with people from different divisions within NVE and a reference group of 14 persons from industry actors such as DSOs, business associations, utilities and one research institute (NVE, 2019c). The working group decides on both topics and members of the reference group. NVE also interacts with industry actors in bilateral discussions, conferences, and research projects but emphasize that the forum is the main mechanism for interaction with industry (Interview 13). The forum provides industry actors with an opportunity for understanding their conditions and possibilities regarding new technology and experiments. So far, key issues in the forum have been the future role of DSOs, new regulation for pilots and experiments, and the role of batteries. Between March 2017 and June 2018 the forum had 4 meetings. The forum is not tasked with developing multiple visions for the future grid, but is rather a meeting place for incumbent industry actors.

### 4.3.2 Implementation challenges and effects

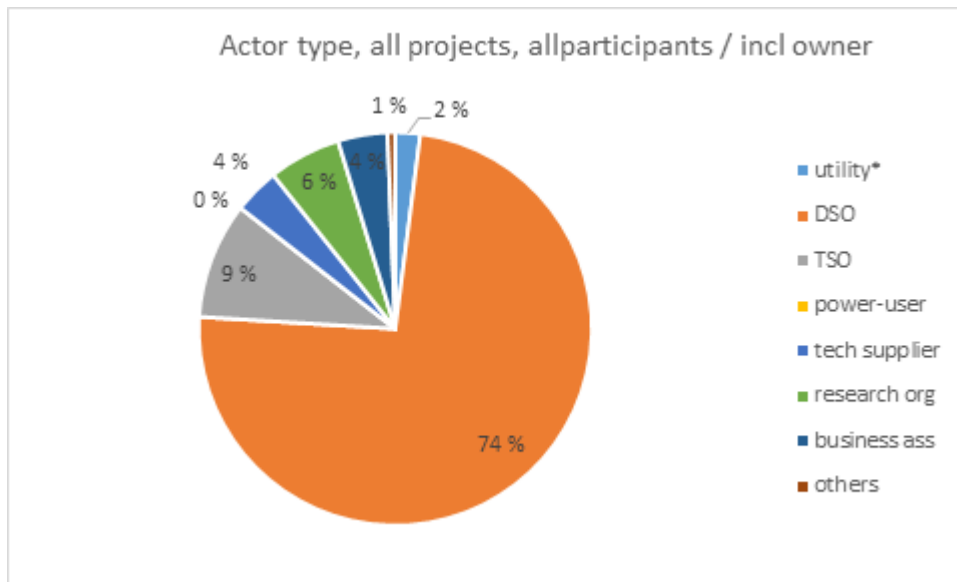
As an energy transition initiative, the forum falls short due to its focus on industry incumbents (i.e. DSOs and utilities) and the limited involvement of a broad range of new key stakeholders. This effectively restricts a broader dialogue between network industry incumbents and actors representing the new niche technologies and practices, which would be needed for representing different visions of the future system. NVE justifies a narrow actor selection by arguing that *“we have selected people from the power system but mostly from grid companies because it is forum for the future grid.”* Moreover, the forum is considered a *“specialized niche on regulation”* that should not *“be made bigger than it is”* (Interview 13).

Moreover, in the implementation process the forum was seen mainly from the regulator’s perspective. One analyst from NVE recalls that *“we spent a long time trying to figure out how to organize the forum...the process ended with the insight that the forum can be an important resource for us. We can handpick people we think have interesting ideas and speak freely with them while being allowed to think about the longer-term developments in the system”* (Interview 13). In its implemented version the forum does not explicitly focus on supporting DSOs overcoming uncertainty but rather informing the regulator. This reflects the classical principal-agent thinking of regulation rather than an attempt at distributed governance.

The exclusion of new innovation actors undermines the forum’s ability to inform and guide an energy transition where misalignments and bottlenecks between activities of network actors and of new innovation actors are likely to occur. The forum thus does not apply a whole systems view but rather considers the network in isolation. It further limits the knowledge about the needs of new actors and what they expect to happen. This is likely to lead to a rather limited

understanding of possible future system pathways and important bottlenecks. This narrow perspective is also reflected in the range of stakeholders participating in the 148 RD&D network projects approved where DSOs and TSO make up 83% of the participants, see Figure 2. Moreover, only 1 (Ocean Sun) of 637 participants (including duplicates) qualify as a niche actor (here we exclude a dozen ICT firms focussed on grid optimization). These observations give an additional indication that the scope of interest for NVE regarding relevant stakeholders does not go much beyond the incumbent industry actors.

Figure 2: Types of participants in RD&D projects



Source: RD&D project data

Despite the points made above, NVE sees itself as the actor “*who can take the role of looking at elements in a holistic perspective*” (i.e. a whole systems perspective) in relation to the energy transition (NVE, 2010) (5). Still, the regulator’s future vision for the energy system is mostly described in terms of maintaining the principle of societal cost-efficiency as the main instrument for guiding the energy transition.

For example, in relation to the new framework for RD&D projects, a senior advisor from NVE acknowledges that clearly setting a direction can reduce uncertainty for DSOs and explains that “*we want to be clear on the direction in which we want the industry to move. And this is related to our regulatory compass.*” NVE advisors further explain that the main principle underpinning the regulatory compass is “*that we believe in markets whenever possible*” (Interview 28) and that the compass shows direction “*according to the goals of the energy law, i.e. that production, conversion, and distribution must take place cost-efficiently*” (Interview 16). NVE formulates this as the need for “*technology neutral and market based system operation*” (NVE, 2019d). NVE’s regulatory compass thus enshrines the main principles of the energy law. Despite the general insight that technology neutral and market-based governance is inadequate for governing energy transition, NVE does not see any “*contradiction between the energy law and the green transformation [...] our work with minimizing network cost makes it cheaper to charge your electric vehicle and to install charging points for maritime transport*” (Interview 28).

To NVE, the direction of change is thus decided in terms of which ‘pathway’ is most cost-efficient, rather than promoting a transition pathway through which societal objectives are met in the most cost-efficient way. This limited view of its own role and future pathways implies that it is not on NVE’s radar to try to coordinate industry actors across the whole energy system to avoid bottlenecks as well as promoting change. This approach is unlikely to reduce the uncertainty experienced by DSOs which hold back their investments in innovation.

## **5 Discussion and conclusions**

In this paper we have outlined why and how the governance of electricity networks is likely to become increasingly important as energy transition progresses. We integrated insights from transition and innovation policy with the state of the art of network regulation to identify new governance challenges for network regulation with regard to system innovations and energy transition as well as mechanisms to address these challenges. We further explored these issues in a case study of the Norwegian network regulator. In this chapter we summarize our findings and discuss their implications for theory and policy.

### **5.1 Main findings**

Regarding the first category of economic incentives for regulation within the regulatory paradigm of incentive regulation, we studied a recently introduced scheme aimed at stimulating innovation in DSOs. We found that it does not work as expected, partly because companies do not have the adequate capability and capacity to take advantage of the scheme. This confirms previous arguments and empirical findings in other countries that economic incentives, albeit important, are often insufficient to trigger innovation. Moreover, such a scheme has only limited impact in the context of energy transition, because the overall uncertainty about the future system configuration cannot properly be addressed.

Regarding instruments beyond economic regulation, we focussed on regulatory experiments and analysed an ongoing initiative by the regulator for establishing regulatory exemptions for RD&D pilot projects. However, the new scheme for RD&D is not meant to provide a direct input into the design of the future regulatory system and does not indicate that the regulator takes a proactive stance on that. Its main objective is to provide exemptions for individual technical pilot projects. Thus, it is in line with the development of regulatory sandboxes in other countries

Regarding visions and stakeholder coordination, we analysed a recent initiative for “looking ahead” and deal with the uncertainty of future system development, rather than just looking at the efficiency of individual networks. We found that the “forum for the future grid” so far hosts discussions of pressing contemporary issues among DSOs rather than developing visions for future pathways to guide today’s innovation activities. Moreover, participants are mainly DSOs and some utilities. The forum does thus not provide wide stakeholder involvement and coordination of actors across the ‘whole system’ as suggested by a ‘transition logic’. Indeed, the long-term vision and coordination objectives seem to have been watered down during the implementation phase such that the forum mainly is an information sourcing point for the regulator. Instead of developing long-term visions to guide innovations, the regulator claims that the principles of cost-efficiency and technology neutrality suffice for setting direction and reducing uncertainty.

An interesting aspect of this case is that NVE attempts to embrace ideas of system failures and transition failures through its initiatives such as the framework for pilots and sandboxes, and creating a forum for the future grid. But at the end of the day, a rather narrow and market

failure based governance perspective dominates. NVE identifies major changes in the power sector and beyond for Norway, but the organization interprets these signals in such a way that it thinks that a market failure logic is sufficient for governance.

## 5.2 Main insights

Through our findings we identify three main insights for governance of networks in transitions.

### **Whole systems view**

First, at a general level, our study confirms that a ‘whole system’ perspective which encompasses interdependencies between power sector subsystems is important to avoid bottlenecks in the acceleration phase of energy transitions (McMeekin et al., 2019). This means that, on the one hand, typical transition policy (e.g. feed in tariffs, green certificates, or carbon tax) targeting mostly power generation and consumption must also take into account change mechanisms in power networks. On the other hand, governance of electricity networks must be attentive to rapidly growing niches on the ‘grid edge’ (i.e. other subsystems).

### **Adapting the network governance regime to the requirements of the energy transition: New regulatory instruments**

Second, it has been argued that transition governance must look beyond niche building and specific transition instruments and pay more attention to how established institutions can block or stimulate further change (Köhler et al., 2019). Our study calls attention to the fact that there already is a specific governance regime for electricity networks in place with major influence on transition processes. This means that the generic governance challenges for innovation and transition must be addressed in relation to that specific institutional arrangement. It implies taking into account that the ‘mode of innovation’ in the network subsystem differ substantially from the mode of innovation in power generation and consumption subsystems (Andersen, 2014; Markard, 2011).

This paper has highlighted a number of ways of how network regulation and its established toolbox can be amended and broadened to tackle innovation and transition. Yet the Norwegian case has also shown the difficulties of making these new instruments effective within the existing institutional arrangements. While some of the reasons for this are case-specific, these difficulties are also likely to be due some more fundamental reasons.

### **Transformative regulation: How to design network governance that can address both transition and efficiency?**

This leads to our third insight. When looking at how the network governance regime can be adapted to transition challenges, just looking at the instrument level, which was the focus of this paper, is important but insufficient. Rather, it is also necessary to address the underlying/broader institutional set-up.

This becomes particularly visible in the case of network regulation where the regulator as an organisation is typically set up to increase economic efficiency in the network. The very reason for having a regulator as a separate organization is that it can make decisions independently of any political considerations.

As we saw in the Norwegian case, guiding principles of network regulation are cost-efficiency and technology neutrality. These are the main components of the regulatory compass.

Technology neutrality is itself justified by a cost-efficiency logic (the cheaper the input, the more efficient the overall process). Cost efficiency is an important principle for spending the money of

electricity consumers wisely via optimization analysis of stable systems in a low-risk context with reasonable foresight. Applied to the issue of innovation, it implies correcting ‘market failures’ (i.e. ensure sufficient economic incentives to innovators). As a governance principle it will however also tend to favour mature and incumbent technologies over immature and newer ones, cf. section 2.1.

For that reason alone, cost efficiency is insufficient for supporting energy transition which is characterized by a context of high risk and limited foresight. Indeed, it may rather hinder energy transition. Energy transitions require additional governance approaches related to system and transition failures logics such as setting direction to reduce uncertainty and stronger articulation of and support to new actors and solutions. Moreover, the question of how to design the future system is a highly political one.

At the same time, the efficiency rationale of network regulation is still valid and should therefore remain a central consideration for developing transition strategies but it cannot be the only one.

Thus, our findings point to a regulatory dilemma in the context of network governance and indeed transition policies in general. In the case of network governance, the question is how this can be tackled within the current institutional set-up and how the regulator itself could be redesigned to turn it into a transformative organisation, while maintaining its efficiency objective.

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