Introduction to Energy Regulation in the Green Transition: An Anthology

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ABSTRACT

This article presents the background of the anthology on energy regulation in the green transition and the three overarching topics that the contributions to this volume cover. Part one on Regulation and Tariff Design discusses the importance of ownership, the relationship between innovation and regulation, and tariff design. Part two on Governance and Legal Aspects investigates the role of existing legal frameworks on the social acceptance of renewable energy infrastructure and the revenue-cap regulatory framework. Part three on Investment Decision Frameworks offers a critical analysis of methodologies and views on the role of the social discount rate and the valuation of environmental benefits. The introduction concludes with a number of insights from the anthology of specific importance for the Green Transition.

1. INTRODUCTION

The Green Transition, or the society-wide effort to transform the way economies produce, consume and trade goods and services, such that environmental impact is mitigated or eliminated, is a well-established concern on the political agenda. Throughout the past two decades, Europe has implemented policies and binding legal frameworks to deliver on the commitments it has undertaken, such as the Kyoto Protocol (1997) and the Paris Agreement (2016). More recently, Europe has put forward a Green Deal,[1] which aims to transform the continent's economy into an emission-neutral society by 2050, where economic growth is decoupled from resource use by moving to a clean and circular economy, boosting the efficient use of resources, and recycling. In accordance with the trajectory of achieving climate neutrality within the energy sector, energy efficiency, energy affordability and security of supply are the main concerns that must be taken into consideration.

The Green Deal has several objectives, which will require action from all sectors within the economy in order to turn climate and environmental challenges into opportunities.[2] In particular, objectives such as investments in environmentally friendly technologies, supporting industries to innovate and decarbonizing the energy sector constitute the core challenges for energy regulation in the Green Transition, which are investigated in this anthology.[3] The Green Deal also includes a framework for achieving EU climate neutrality and introduces an action plan for each member state – a road map – with key actions to attain the goals of the Green Deal as well as regular assessment of progress made.[4]

In Denmark, the Climate Act of 2020 establishes the goal of becoming a net-zero emitter by 2050 at the latest, and sets the most ambitious medium-term and binding climate goal of any country in the world. That is, reducing greenhouse gas emissions by 70 per cent by 2030, relative to 1990.[5] In the first 30 years of this period (1990-2020), it is estimated that Denmark will have reduced emissions by approximately 38 per cent, leaving approximately one-half of the remaining reduction goal to be achieved within the next ten years.[6] The Climate Act of 2020 also establishes new climate governance in Denmark, which is described in section 3.1.

1.1 REGULATION OF THE ENERGY SECTORS IN AN AMBITIONS GREEN TRANSITION: IMPLICATIONS AND DILEMMAS

The Green Transition has far-reaching implications for all sectors of the economy, and they are perhaps most visible in the energy sector. The confluence of a technological shift, increasing efforts to couple energy and related sectors, and the presence of organized markets and natural monopolies, creates a unique set of challenges. Regulating energy util-

[1] European Commission, 2019. The European Green Deal.

[2] European Commission, 2020a. EU Green Deal: Actions and Priorities 2019-2024.

[3] European Commission, 2020a. EU Green Deal: Actions and Priorities 2019-2024.

[4] Florence School of Regulation. The European Green Deal.

[5] The Danish Climate Act excludes emission reductions in international shipping and aviation. Aftale om klimalov.

[6] From Klimarådet, 2020. Vejen til 70 pct. Reduktion.

ities – electricity, gas and district heating – in the context of a highly ambitious Green Transition, consequently poses a series of important and unresolved issues, not only in Denmark but also in the European Union and international society.

In the face of an ambitious Green Transition, economic efficiency continues to be a valid regulatory objective as ever, but the focus is now on nuancing and shifting the objective from being cost-efficient to being cost-effective. However, traditional models of economic regulation incentivize regulated utilities to prefer capital investments over operational expenditures in novel operational and network management strategies, although these can be more efficient from both an economic and environmental perspective. Without proper adjustments to the regulatory frameworks for utilities, there is a risk of overinvestment leading to stranded assets, to be borne by energy end users. At the same time, underinvestment in modern network assets and innovative solutions can come at a high economic and environmental cost. The existing models of economic regulation need to improve in order to rise to the challenge: incentivizing utilities to innovate and invest in the Green Transition, while ensuring cost-efficiency to the benefit of end users.

The Green Transition also creates uncertainty with respect to the technological choices that individuals and utilities make, which in turn poses the risk of creating adverse, long-term lock-up effects. The emergence of new business models in the energy sector also increases the risks of emerging stranded assets, which could translate into losses for the utilities and in turn for society as a whole.

Besides economic regulation, there is a broader array of regulatory issues, ranging from the governance and decision frameworks underlying investment decisions to the social acceptance of energy infrastructure that consumers experience. Creating trust in the technological aspects of the Green Transition is among the key priority areas that regulation must address. Indeed, much of the needed progress towards decarbonization of the energy and other sectors is contingent on advances in (economic) regulation models.

1.2 ENERGY REGULATION IN THE GREEN TRANSITION: ISSUES AND TRENDS

In light of these issues the present volume on E*nergy Regulation in the Green Transition* attempts to contribute novel, applicable knowledge and possible answers as to what effective and efficient regulation should be able to achieve. The present anthology is the first volume in the Danish Utility Regulators' series of anthology projects on Better Regulation in the Energy Sector.

As the regulatory authority has engaged in dialogue with academics from diverse areas of specialization and schools of thought, it has given rise to some inherently different perspectives. Rather than attempting to agree on a single vision, the present anthology has embraced pluralistic perspectives that combine specific regulatory knowledge with a broader understanding of issues and trends influencing the energy sector. Within this framework, the authors bear sole responsibility for the methods they use, the results they present and the claims they make. The anthology is thus limited in its ability to provide unique answers to all the questions that have been investigated, as well as to pose all relevant questions worthy of further investigation.

The collection of articles in this volume is organized according to three overarching topics, around which the contributions revolve. Each of these topics is introduced and discussed briefly, followed by a short introduction to the individual contributions that fall under each theme and key insights. Regulation and Tariff Design is the first such broad topic, where ownership, the relationship between innovation and regulation, and tariff design for ambitious electrification are discussed. The second topic, *Governance and Legal Aspects*, investigates the role of existing legal frameworks on the social acceptance of infrastructure and the income-cap regulatory framework. The important role of regulatory experimentation in light of the experience of several European countries is also discussed here. The third topic addresses questions relating to existing Investment Decision Frameworks employed by utilities in the Green Transition. With the aid of specific case studies and a critical analysis of methodologies, this group of contributions presents insights on the role of the social discount rate and the valuation of environmental benefits. While the organization of articles in the anthology attempts to draw some clear-cut lines to facilitate the discussion, the issues inevitably overlap.

In light of the topics around which the present anthology revolves, the editors have attempted to identify perspectives, dilemmas and open research questions. In the identification and discussion of these perspectives, the Council of European Energy Regulator's (CEER's) 3D Strategy (2019-2021) has been particularly inspirational. Its core elements: Digitalization in the Consumer Interest (D1), Decarbonization at Least Cost (D2), and Dynamic Regulation: European Solutions for Adaptive Regulation in a Fast-changing World (D3), have given the editorial team orientation with respect to what may become best regulatory practices in an ambitious Green Transition.[7]

2. REGULATION AND TARIFF DESIGN

As owners and operators of the energy infrastructure, natural monopolies in the energy sector play a critical role in the Green Transition. They are defined as such because they are the sole providers of services that would otherwise be too costly for the society to produce under competition conditions. In their capacity, natural monopolies must ensure the efficient and secure operation of complex networks of pipes, cables, converters and many other assets, which secure the transmission and distribution of electricity, gas, and district heating. They must also decide on crucial investments that enable them to expand or reinforce their asset base to meet future demands, to ensure medium and long-term security of supply.

In consequence, regulatory models exist to ensure that they provide a reliable service in a cost-effective way by mimicking the market outcome. Considerations beyond economic efficiency, such as environmental impact or innovation, that are relevant for the Green Transition, have

[7] CEER, 2019. Digitalisation, Decarbonisation and Dynamic regulation.

not traditionally been at the centre of these frameworks. Adding to the complexity of the task, under an ambitious Green Transition, network utilities also need to make cost-efficient, green choices. Although, in principle, network companies will not perform certain roles in the revised energy supply chain under an ambitious Green Transition, they will still be required to meet increasing and novel challenges. For instance, electricity networks will have to be expanded and reinforced, even if network companies do not actively participate as suppliers of new infrastructure for electro-mobility and storage, as established in the 2019 Clean Energy Package (CEP).

Gas networks may come to face similar or even greater challenges, as an increasing amount of biogas is supplied at the distribution network level, and the emergence of Power-to-X technologies and hydrogen require either brand new or adapted infrastructure. In Denmark, for example, biogas production accounted for 12 per cent of the total demand for gas in 2019,[8] and the production of biogas is expected to increase further over the coming years in parallel with a decline in consumption. At the time of writing, biogas production accounted for almost 25 per cent from January to October 2020. This development has already resulted in the need to invest in the transmission network, to manage local production during the summer when demand is very low.

Energy utilities face a common dilemma, which is also shared by the societies in which they operate. The Green Transition is a pressing task, as climate science reveals, but addressing environmental concerns is costly. In the coming years and decades, regulation will play a central role in decarbonization efforts, as the link between energy sector, economy, and the society. Advances and innovation in economic regulation of infrastructure will therefore be as crucial as that of innovation in the energy sector itself.

One of the most pressing dilemmas for regulation in the Green Transition is the urgent need for green, innovative investments but also cost-efficiency in energy sector utilities. Without an effective regulatory framework, the Green Transition can easily become too costly for consumers, as there is a risk that firms will overinvest. Conversely, regulatory frameworks must not become a barrier that stands in the way of the transition. Regulation must rather facilitate the transition, yet existing frameworks do not seem completely fit for this purpose. For example, revenue-cap regulation may assume a linear evolution of expenses over a short to medium-term perspective, whereas the Green Transition may involve non-linear expenses throughout a longer-term period. What modifications to existing models of utility regulation will work best, given the individual circumstances of EU member states?

Getting the regulatory framework right is also a subject to which the Danish Utility Regulator (DUR) has devoted some attention. In its analysis of the Green Transition and economic regulation from April 2020, DUR argues that the income-cap regulatory framework adequately addresses the regulatory challenges stemming from the Green Transition. The analysis recommends that green investments be included in the revenue-cap regulatory framework via a supplement to the revenue-cap, granted ex-post based on an application. For the application to be accepted, it must show that the investment contributes to the green transition, is cost-effective and is necessary. The disadvantage of an ex-post application driven supplement is the administrative burden upon both the utility companies and the regulator. DUR argues that the administrative burden should be regarded in relation to the projected investments in the utility sectors, and that transparent communication and processes will ease this burden. DUR contends that this disadvantage is outweighed by the accuracy of how the compensation matches the green investments made. Other approaches – e.g. the use of an automatic indicator – greatly increase the risk of overcompensating the utility companies at the expense of the consumers. In particular, an automatic indicator does not take into account specific network conditions (e.g. the capacity available), but is rather an aggregate measure. In addition, this implies that an automatic indicator does not take into account the heterogeneity of the utility companies. This may lead to inefficient investments or overcompensation of the utility companies, at the expense of consumers. DUR therefore makes the case that other approaches entail a greater risk of overinvestment and could jeopardize a cost-effective Green Transition.[9]

One specific question worth elucidating relates to the risks associated with the ex-ante vis-à-vis the ex-post allowance for green investments in regulated utilities. Understanding the trade-off between administrative regulatory burdens and the real possibility of overinvestment will constitute valuable knowledge.

Another point of concern for the Green Transition is that tariff design in all utility sectors, but in electricity in particular, appears to be outdated and to stand in the way of both sector coupling and electrification. Insufficient flexibility and an inadequate representation of cost causation in the prices paid for the usage of networks, are among the barriers that hinder the expansion of business models like distributed Power-to-X. That is, facilities that intake power at various points in the network to produce hydrogen, heat and flexibility services for the distribution and transmission network. A tariff system that coordinates distribution and transmission network charges with other surcharges, such as taxes, would better reflect the "green" value of electricity and the relative scarcity in networks and the wholesale market.

Tariffs that send reliable price signals to electricity network users are usually described as the missing link to enable much-needed flexibility in the Green Transition. Together with behavioural changes in residential and commercial electricity consumption, tariffs would mitigate the need for some of the imminent green investments, ultimately favouring both energy and cost efficiency. Cost-reflective tariffs are also vital for the emergence of innovative business models, such as Power-to-X, and as a principle to ensure a level playing field between different energy carriers in a more integrated and cross-sectoral energy system. Nevertheless, there remains considerable work to be done with respect to coordinating distribution, transmission and other surcharges, so they send reliable signals to end users. Ensuring simplicity and transparency, and finding the right mechanisms to trigger behavioural change are other important issues to which there still are no satisfactory answers.

Perhaps surprisingly, the effect of consumer ownership on the price efficiency of natural monopolies is not very developed in either nation-

[8] Forsyningstilsynet, 2020b. Markedsrapport for gas 2019 and own calculations.

[9] Forsyningstilsynet, 2020a. Grøn omstilling og økonomisk regulering.

al or international economic textbooks or in the scientific literature, despite its importance as an essential part of a governance system for natural monopolies. The ownership influences the ability of the state regulator to keep energy prices of large natural monopolies low. In the case of consumer ownership, there is a shared motivation to decrease consumer prices. While in the case of profit driven owners, the state price regulator and the company regulated have directly opposing price goals, and due to asymmetry of power and resources between the regulator and the regulated, price regulation by the state regulator is hampered.

DUR has also presented studies on what drives efficiency in the energy sector. In 2012, DUR examined the relationship between prices and key characteristics for Combined Heat and Power (CHP) plants.[10] The analysis presents several reasons for price differences. Among these are the choice of fuel, location, size of the CHP plants (due to the advantages of economies of scale) and ownership. However, DUR did not find that the analysis provides evidence that suggests that efficiency hinges on consumer ownership. In a more recent DUR analysis from 2020, the overall efficiency potential for the production and transportation of heating is analysed.[11] The analysis shows that price differences do not hinge on consumer ownership, but on the operation of the CHP plants.[12] The operation of the plants is the key contributor to the occurrence of price differences across different types of ownership. The analysis also concludes that implementing a different revenue-cap regulatory framework will give the different CHP plants an incentive to have more efficient operation in the future, and thereby secure the lowest possible prices, for the companies as well as the consumers.[13]

The coexistence of different ownership models for energy utilities may make it relevant to consider more flexible and customized regulatory models rather than a one-size-fits-all model without regard for the characteristics of the ownership.[14] The leadership of energy utilities should be able to make decisions that benefit the company, its end users and, by extension, the Green Transition. Independence and an explicit requirement for active ownership may call for the application of fit and proper rules, which account for the different forms of ownership and ensure sound corporate governance.

Other questions also follow from the ongoing reconfiguration of the energy supply chain in light of the Green Transition. What is the boundary between regulated natural monopolies and competitive markets, particularly when activities are closely related? How can we ensure that emerging business models evolve in both the competitive and regulated segments of the supply chain? More generally, what are the relevant regulatory principles for integrated, multi-carrier energy systems and how should they be applied in practice?

2.1 CONTRIBUTIONS ON REGULATION AND TARIFFS

Chapter 1: *Energy Network Innovation for Green Transition: Economic Issues and Regulatory Options,* by Tooraj Jamasb, Manuel Llorca, Leonardo Meeus and Tim Schittekatte, identifies innovation expenditure as the key enabler for the Green Transition. However, the authors point out a potential trade-off between the existing regulatory models for network utilities and the insufficient expenditure on research and development (R&D) as the underlying reason for the slow uptake of new technologies in energy networks. The primary focus on economic efficiency, together with reduced economies of coordination in unbundled utilities may explain their preference for short-term over long-term profitability. As part of the solution, Jamasb et al. argue that competition in energy network R&D and innovation is inefficient and suggest the creation of an EU-wide collaborative innovation research fund for energy networks. In addition, the authors suggest a 'value-based' approach to innovation funding, where the value of energy benefits is perceived to be society-wide rather than sector-specific.

Chapter 2: *Price efficiency, the green transition and channels for regulating natural monopolies: The case of power distribution system operators (DSOs),* by Frede Hvelplund, Finn Arler and Henrik Lunds analyses the governance system of electricity DSOs in Denmark and its relationship to price efficiency and the Green Transition. Regarding price efficiency, the authors claim that regulating consumer-owned DSOs is an inherently easier task for the regulator, as the incentives to attain lowest possible prices between both parties are aligned. Regarding the Green Transition, Hvelplund et al. highlight the fact that the role of DSOs is undergoing a process of fundamental change, from that of a mere distributor to that of a coordinator in a smart energy system. In their view, consumer-owned firms are best placed to drive a cost-efficient Green Transition because their inherent incentive for cost-efficiency gains can be used for both price reductions and for green projects.

Chapter 3: *Consumer ownership of natural monopolies and its relevance for the green transition: The case of district heating,* by Søren Djørup, Karl Sperling, Ole Odgaard and Henrik Lund, argues that under the existing regulatory model for district heating in Denmark, cost efficiency hinges on consumer ownership. Based on a logical reasoning framework, which accounts for acceptance and trust, the authors claim that the incentive to reveal true cost information to a regulating entity is only present when consumers directly own district heating utilities. To prove their claim, the authors present empirical findings which suggest that for-profit utilities systematically charge higher prices than their consumer-owned counter parts. They complement their analysis with empirical findings that upon divestiture of for-profit utilities to consumers, district heating prices tend to decrease. Lastly, Djørup et al. only mention the consumer ownership as being the sole cause of the price differences.[15]

10 "Store forskelle i varmeprisen – Hvorfor?", 2012, Energitilsynet

11 The different suggestions on efficiency align with the DUR analysis of March 2020: "Økonomisk regulering og grøn omstilling". Efficiency optimization within the CHP plants can contribute to the green transition in the energy sector.

12 "Store forskelle i varmeprisen – Hvorfor?", 2012, Energitilsynet

13 Since there are still district heating companies that use fossil fuels, that are expected to invest in climate-friendly production echnologies in the coming years to replace the existing ones. The new framework can ensure this will be done appropriately in the most efficient way.

14 See, for example, Forsyningstilsynet, 2020. Effektiviseringspotentialet i fjernvarmesektoren.

15 The article by Djørup et al. is based on the DUR analysis from 2012. See section 2.1.

Chapter 4: *Electricity Tariffs in the Green Transition,* by Nicolás Morell, Jose Pablo Chaves and Tomás Gómez, is based on the pressing need to rethink the methodologies used to design electricity tariffs in the face of imminent electrification. Morell et al. differentiate among different types of costs and argue that network costs should be divided into long-term incremental costs and residual costs. Based on a series of case studies and international experiences, the authors show how the principles put forward can contribute to efficiently integrating the required technologies for the energy transition. Morell et al.'s thinking on tariffs evolves around digitalization, decarbonization and decentralization. The first and last put the consumer in the centre of the energy transition. However, new technologies allow consumers to change consumption, self-produce and provide self-storage options, which the current tariff design is not suited to coping with. This creates distortions across the system, inevitably affecting the consumers. Moreover, the authors believe that the consumer must become an active market participant in order for the market to ensure a full decarbonization of the electricity systems. Morell et al. argue that there is no one-size-fits-all tariff design for a system in transition.

3. GOVERNANCE AND LEGAL ASPECTS

Besides the economic aspects of regulation, there are a number of broader regulatory challenges in the energy sector which are either motivated or exacerbated by the level of ambition established in the Green Transition.

Legislative and regulatory frameworks tend to create norms and well-established practices that define the interplay of actors in an industry and society in general. Adapting these frameworks to new realities and ambitions, such as the Green Transition, may be challenging. Abrupt changes in the legal framework may face resistance or trigger unforeseen conflicts, which could end up delaying the progress of the Green Transition.

A case in point is the revenue-cap regulatory framework, which has been applied to electricity and gas distribution companies in Denmark for more than two decades. Based on historical costs, the regulator establishes a revenue cap, which incentivizes firms to attain efficiency gains. However, green investments will require higher capital expenditures, which will mean the cap needs to be increased. Defining a transparent and efficient way to account for these higher expenditures and to compare them with the benefits they produce is one concrete challenge faced by the legislative framework in the face of an ambitious Green Transition.

Overall, the present-day regulatory principles came into existence several decades ago, under a different technological reality and different political priorities. As technological evolution is quicker than regulation, the latter may prove to be a barrier for some of the business models that are expected to be vital for the Green Transition. Well-established principles such as unbundling or third-party access may prevent new technological solutions being developed. A critical but orderly revision of some principles may therefore be necessary to ensure that the Green Transition evolves and consolidates under cost-efficiency principles, to the benefit of consumers and society in general.

The social acceptance of energy infrastructure is another element that regulation must not overlook, as the physical landscape is likely to undergo substantial transformations during the coming stages of the Green Transition. The electrification of transportation, which will require the extensive deployment of charging stations, combined with the widespread deployment of solar panels and possibly bigger, more efficient solar farms and wind farms, could be met with even more public opposition. Today, wind farms are subject to specific planning requirements, while solar farms are not, despite the massive areas of land that this renewable energy source will be occupying if the projects in the pipeline are implemented. Moreover, the development of the legal framework to accommodate the Green Transition is progressing noticeably faster in the area of energy law, than in the environmental and planning law areas. Consequently, more coordination between different sectors and in particular different ministries and agencies across the institutional energy, environment and planning silos will be crucial to ensuring that the Green Transition takes place with respect for the environment, other land use interests and the communities hosting the large new infrastructures.

Legislation can enable, institutionalize and incentivize the Green Transition. At a European level, framework laws have formalized binding targets, as in the Renewable Energy Directive and its recast versions.[16] It has also pushed forward broad policy initiatives, such as the CEP and the Green Deal.

The Green Deal also comes with a governance structure to ensure that Europe delivers. In Denmark, the Climate Act of 2020 establishes the goal of becoming a net-zero emitter by 2050 at the latest. Denmark's Climate Act also lays the groundwork for new climate governance, by requiring government to deliver concrete action plans, and by setting a system of checks and balances to ensure the attainment of climate goals. The Danish Climate Act of 2020 gives the Danish Council on Climate Change (DCCC) three roles: that of a 'watchdog', monitoring the adequacy of the government's climate policies; that of an advisor, providing science-based policy recommendations; and that of a 'convenor', engaging stakeholders formally and also more informally. According to a recent overview of national advisory bodies, this endows Denmark with a "robust framework with a high level of detail and degree of accountability" (Ecologic 2020). In terms of effective and independent climate advisory bodies, Denmark is in the top league in Europe, together with the British Committee on Climate Change and the French High Council on Climate.

In its report from March 2020, the DCCC provided its first advice to the Danish government on how to reach the ambitious target for 2030. Entitled "Known paths and new tracks to 70 per cent reduction – Directions and measures for the next 10 years' climate action in Denmark". The report identifies a number of initiatives that can be implemented immediately, since they are based on known technologies. In addition to this implementation track, the DCCC also suggests a development track that is based on new technologies and for which research, development and demonstration need to be started immediately. Across these

16 "European Commission, 2020d. Renewable Energy Directive.

two tracks and across all sectors, the DCCC advises the government to take a number of measures that ensure nationwide GHG reductions.[17] First among those is a general greenhouse gas tax to be paid by all polluters, but the DCCC also recommends rethinking regulation to ensure that sector-specific regulation does not hamper sector coupling and system wide solutions.

Nonetheless, good governance frameworks are incomplete if they are unable to articulate policies and efforts operating in potentially different directions. In this respect, a focused inter-institutional effort on the cost implications and policy choices for the Green Transition could be a relevant initiative to take. To what extent can policies, such as a generalized greenhouse gas emission tax, be complemented with supply-side measures, such as subsidies? What are the cost implications of such choices and for the broader Green Transition goals?

Existing regulation may also be an obstacle and hinder the implementation of certain policies or the evolution of some business models. Good energy regulation that facilitates the Green Transition should allow for the implementation of regulatory sandboxes, i.e. controlled experimentation with regulatory models through the introduction of derogations to established regulatory principles; and lessons learned from experimentation should be disseminated amongst regulators and governments. Organized knowledge exchange may help in weighing the trade-offs involved in the options for regulatory innovation and experimentation, without undermining the stability and predictability of existing frameworks.

Despite its benefits for the flexibility of regulatory frameworks, the application of regulatory sandboxes also hides risks. Special rules applied to certain transition elements or technologies may create unequal conditions, particularly if they are allowed to remain for prolonged periods. The application of special rules in specific geographic areas or for specific technologies may also be difficult to revert. More generally, what are the limits to regulatory experimentation?

3.1 CONTRIBUTIONS ON GOVERNANCE AND LEGAL ASPECTS

Chapter 5: *The Danish revenue-cap regulation in the power supply sector: A legal perspective considering the Green Transition,* by Bent Ole Gram Mortensen, takes a jurisprudential perspective to the income-cap framework in Denmark. The author notes that this form of regulation has experienced numerous changes over the years, making it an evolving and unfinished, yet flexible concept. Gram Mortensen also notes that parties involved in the administration of the framework, such as the Danish Board of Energy Appeals, have gained considerable experience in the administration of the framework. In general, the author suggests that investments directly related to green investments are kept outside the income-cap framework and advises legislators to consider other tools to advance the Green Transition. However, if expenses associated with the Green Transition are to be kept within the revenue-cap framework, Gram suggests an ex-ante approval of the investment expense by the regulator. This, in Gram Mortensen's view, would help the regulated monopoly mitigate the risks.

Chapter 6: *Regulatory experimentation in energy: Three pioneer countries and lessons for the Green Transition,* by Tim Schittekatte, Leonardo Meeus, Tooraj Jamasb and Manuel Llorca, summarizes and compares the experiences of Italy, the Netherlands, and Great Britain with respect to the introduction of "regulatory sandboxes" in the energy sector. The sandboxes are a form of structured regulatory experimentalism, in which temporary derogations from normal regulation are given to specific market participants. The derogations help regulators enable the emergence of specific technological innovations, while allowing them to assess the intermediate welfare implications. The authors furthermore make a case for an EU-wide framework for regulatory experimentation and suggest that this framework should also be allowed at the transmission level, where Power-to-X will be critical to enabling sector coupling

Chapter 7: *Acceptance issues in the transition to renewable energy: How law supposedly can manage local opposition,* by Birgitte Egelund Olsen, addresses the newly introduced measures of the Danish Renewable Energy Act and their impact on local acceptance of renewable energy projects in Denmark. For more than a decade, the act has applied various financial and, in most cases, compensatory measures, which are based on the assumption that renewable energy facilities – wind turbines in particular – create negative impacts. Drawing on a legal doctrinal analysis, Olsen warns that the current framework may be perceived as buying consent or bribery, posing the risk of stirring up even stronger opposition. Olsen advocates a more transparent and less complex framework based on standardized principles and rates for compensation. In addition, she favours a regulatory approach that is not based solely on principles of compensation and tort law, but which is more positive, dynamic and flexible, and considers the inherent variations in the specific places, people and communities involved. Moreover, she points out that there do not yet exist any corresponding legal measures in relation to offshore renewable facilities. She recommends that a more flexible and adaptable approach be considered when developing such measures. As a starting point, she suggests revisiting existing mechanisms, such as the offshore tendering processes, to take into account non-economic aspects such as community acceptance in the tender criteria.

4. INVESTMENT DECISION FRAMEWORKS

Since utilities are the key drivers behind investments in the Green Transition, their appraisal frameworks are another important aspect to analyse. In places such as Denmark, these are part of the existing regulatory and planning framework, where district heating utilities and transmission operators must be able to demonstrate a positive socio-economic value before an investment decision is approved. The methodology to value and discount environmental benefits may therefore have important consequences for the Green Transition, as many of the investments tend to be lumpy and irreversible. The choice of parameters in an in-

[17] The Danish Climate Act does not specify which GHGs are going to be reduced. The CCC report implicitly accounts for a reduction of all GHGs by explicitly mentioning GHGs in terms of CO_2-equivalents.

vestment appraisal framework has the potential to inadvertently favour certain technologies and create long-term technological lock-in effects. For example, under certain assumptions, a biomass-fired plant may be preferable to a large-scale heat pump or a geothermal solution. However, under closer inspection, the environmental implications of each choice differ significantly.

The Green Transition depends largely on the deployment of new technologies, the implementation of energy efficiency measures and the switching of fuels. Because the majority of such investments are long-lived, they create significant long-term lock-in risks. Consequently, the parameters of the decision framework – not least the discount rate – primarily determine what is perceived as the "right" or the "wrong" investment.

Although the possible presence of systematic biases in individual decisions has important implications for the Green Transition, these are potentially greater when investment decision models are part of the regulatory framework of energy utilities. In such situations, it is important to ask is if the existing decision framework systematically favours the cost-effective green choice, and how externalities can be adequately incorporated. Should investment appraisals rely on projected prices for emission allowances, such as the EU ETS scheme, or is this a highly uncertain choice?

A related but distinct question is whether decision frameworks capture the urgency of the ongoing Green Transition. That is, if the parameters in the decision framework favour early gains rather than later gains. This also raises the question of inter-generational equity. The social discount rate is crucial for assessing the benefits of emission reductions, i.e. how much society is willing to invest to limit the environmental damage from emissions. By doing so, society is weighing the benefits for future generations against the cost of investing today, i.e. the cost current generations will have to bear. But future generations will most likely become richer than current generations. Finally, but equally important: who bears the risk of failed investments? Is there a case for risk-sharing agreements between energy utilities and consumers?

4.1 CONTRIBUTIONS ON INVESTMENT DECISION FRAMEWORKS

Chapter 8: *The lack of proper discounting of CO_2 reductions,* by Frederik Øvlisen, investigates two methodological shortcomings that arise in the appraisal of green investments: i) the lack of discounting of CO_2 emissions, ii) the absence of an explicit time horizon which accounts for the 2030 and 2050 goals, and iii) the lack of proper summation of CO_2 reductions. With the use of the discount factor and impatience from tipping point theory, Øvlisen presents a new basis of decision making by taking a proper approach towards discounting CO_2 reductions. Øvlisen highlights that the assessment of the CO_2 profile is crucial because it contributes to a truer and more comprehensive image of the Green Transition in regards to actual accumulated effect on CO_2 reductions. The approach increases the accuracy of the basis of decision making by discounting the CO_2 reduction itself, thereby eliminating uncertainty from the underlying assumptions behind the CO_2 price profile. Hence, the approach discussed, reflects the entire CO_2 reduction profile instead of focusing on the impacts from reductions in isolated years. Considering the tipping point theory, this calls for more projects that immediately reduce CO_2 instead of projects that uncertainly reduce CO_2 in the future.

Chapter 9: *Discounting and the Green Transition: District Heating in Denmark,* by Mark Freeman, Frikk Nesje, Daniel Møller Sneum and Emilie Rosenlund-Soysal, describes how Danish energy regulators can apply the existing body of theoretical and empirical work on social discount rates to their domestic policy context. Focusing on one specific example (district heating), the authors evaluate a single concrete project proposal on geothermal energy in Denmark: a 100 MW geothermal energy investment for Aalborg, Denmark's fourth-largest city. Freeman et al. argue that due to the long-time horizons for which carbon dioxide remains in the atmosphere, the benefits from emission reductions are very sensitive to the choice of the discount rate, consequently affecting the investment in projects, either leading to a false rejection of the project or simply setting the wrong domestic energy prices. Using the PRIMES, GCAM and EVA models, the evaluation of Aalborg geothermal plant results in different discount rates, bond yield and WACC. Moreover, the analysis shows that the results are based on different underlying assumptions regarding the discount rates, annuity rates and cost of capital, which further supports the importance of setting the appropriate social discount rate on long-term environmental projects during the Green Transition. This expands the realm of the regulator to secure alignment between socio-economic and private economic desirable outcomes by finding the best available practice.

5. ENERGY REGULATION IN TRANSITION: CONCLUDING REMARKS AND FUTURE PERSPECTIVES

The contributions in this anthology offer different perspectives o*n Energy Regulation in the Green Transition* from an interdisciplinary perspective. The contributions, however, share the same aim, namely to explore regulatory dilemmas and identify obstacles and impediments that must be addressed going forward in order to ensure that the Green Transition does not become unnecessarily expensive for our societies and the end-users.

It is possible to discern a number of insights and key issues from the anthology, where further thinking is important and warranted in order to deliver a cost-effective Green Transition going forward.

- *Cost control in an income-cap regulatory framework involves dilemmas*

A common approach to the regulation of natural monopolies is a revenue-cap regulatory framework, but designing a framework fit for purpose that addresses the challenges inherent in an ambitions transition is challenging. Traditional models of economic regulation incentivize regulated utilities to prefer capital investments over operational expenditures. The DUR argues in its report from April 2020 that green investments should be included in the revenue-cap regulatory framework by a supplement to the income-cap and granted ex-post based on an application. A strong case can be made that the income-cap regulatory framework adequately delivers on the regulatory challenges stemming from the Green Transition and that this framework is fit for purpose in terms of delivering a cost-effective Green Transition. The disadvantage of an ex-post application driven supplement is the administrative burden upon both the utility companies and the regulator. On the other hand, Chapter 5 considers that investments associated with the Green Transition may be kept within the income-cap regulatory framework and granted *ex ante* by the regulator to mitigate risk for the regulated monopoly. Chapter 5 also highlights the fact that from a legal and his-

torical perspective, the income regulatory framework has evolved over time and proved to be a flexible concept. The point is that the design of a regulatory framework is not a trivial exercise and carries with it different priorities in terms of cost control, risk mitigation, bureaucracy and the ability of the regulatory models to adapt to change. The need for a regulatory change in both the electricity and district heating sectors is further substantiated by chapter 2 and chapter 9. Chapter 2 emphasizes the need to rethink the fundamental role of the DSOs in the future smart energy system, going into the Green Transition. In addition, chapter 9 invites a joint economic framework that aligns the discount rates of economic models to ensure a consistent evaluation of intertemporal welfare. Altogether, the chapters encourage regulatory change wholeheartedly moving forward in order to succeed with the Green Transition.

- *Attention to detail: Appraising investment in light of the Green Transition*

The appraisal of investments in the energy sector is often crucially dependent on the choice of underlying assumptions, as these projects are often very capital intensive and have a long investment horizon. Chapter 8 and Chapter 9 point to the importance of using the proper methods of discounting and setting the correct parameter values when appraising investment projects. Chapter 8 addresses the importance of discounting CO_2 emissions with the use of the discount factor and impatience from tipping point theory. Chapter 9, on the other hand, makes the case that the choice of underlying assumptions regarding the discount rates, annuity rates and cost of capital is paramount and that it should be within the realm of the regulator to secure alignment between socio-economic and private economic desirable outcomes by finding the best available practice.

- *Tariff design must take the new role of consumers in the energy system into account and reflect that the energy system is in transition: There is no one-size-fits-all design*

New technologies will enable consumers to change consumption, self-produce and provide self-storage options, which can have distortive effects on tariffs. Chapter 4 presents an approach to tariff design which suggests that tariff design should reflect and better understand the new role of consumers in the energy system and the implications for future tariff design. Delivering a tariff design that provides the right incentives in the transition, is cost-reflective and yet administrable and points forward in terms of addressing the new role of consumers in the energy system is an important challenge which must be understood further. This way of thinking also suggests that there is no one-size-fits-all tariff design for a system in transition.

- *Getting the right balance: Regulatory models with short horizons and the need for innovation and R&D*

R&D and innovation hold the promise of a more cost-effective Green Transition. In chapter 1, it is argued that innovation expenditure is the key enabler for the Green Transition and suggested that there is a potential trade-off between the existing regulatory models for network utilities and the insufficient expenditure on research and development (R&D). This is because the primary focus of regulatory models on economic efficiency may result in a preference for short-term over long-term profitability, which can result in underinvestment in R&D and innovation. There is perhaps a need to further develop how to handle investments in R&D and innovation in regulatory models to achieve an optimum level of investments.

- *A more positive, dynamic and flexible approach to attaining local acceptance and assessing compensation for green investments is called for*

The Green Transition will, if anything, make discussion of local acceptance and compensation for green investments more relevant. Chapter 7 addresses the newly introduced measures in the Danish Renewable Energy Act, and their impact on local acceptance of renewable energy projects in Denmark. The chapter calls for a more transparent and less complex framework based on standardized principles and rates for compensation. In addition, the chapter advocates a regulatory approach that is not based solely on principles of compensation and tort law, but which is more positive, dynamic and flexible, and that considers the inherent variations in the specific places, people and communities involved.

- *The role of experimentation: The Green Transition poses new challenges which require new regulatory solutions*

The energy systems are expected to involve the integrated and harmonized operation of otherwise independent energy systems and infrastructures. Chapter 6 argues that experimental sandboxes can be crucial for society, in order to take advantage of the synergies between the electricity and gas sectors, facilitate new solutions for possible regulation and governance[18] and exploit prevailing market circumstances in a further integrated energy system.[19] This sort of approach is also supported by ACER-CEER in their 'White Paper Series', which advocates that the regulation of hydrogen should depend on how the hydrogen sector evolves, i.e. a dynamic approach.[20] Chapter 6 suggests that regulatory sandboxes can be used to find the right regulatory model for new emergent technologies and new challenges posed by the Green Transition. There is definitely a case to be made for the use of sand boxes within a broader regulatory framework, with proper controls and oversight and for a limited duration. There is a need to further develop the thinking on when and how sand boxes can be used and under what conditions.

- *An improved understanding of the relationship between ownership and efficiency is warranted*

Is there a benefit for society in customizing regulatory models of natural monopolies to better reflect the organizational characteristics of each monopoly, such as ownership, geography and size? Chapters 2 and 3 argue that ownership has an impact on efficiency. It is argued that regulating consumer-owned DSOs, in contrast to private ownership, is an inherently easier task for a regulator (chapter 2) and that district heating utilities only have an incentive to reveal true cost information to a regulator when they are consumer owned (chapter 3). Chapters 2

18 CEER, 2020. Long-Term Storage: CEER "European Green Deal" - White Paper series (paper I).

19 ACER, 2020. Regulation on Hydrogen Networks.

20 ACER, 2020. Regulation on Hydrogen Networks.

and 3 point out that we need an improved understanding of the role of ownership for efficiency in natural monopolies, as well as the interplay between different forms of regulatory oversight and types of ownership.

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