2.9 Conclusions and reflections from the country reports

The last decade has witnessed the beginning of what is likely to be a fundamental, irreversible transformation of the power and wider energy sectors, on a scale similar to that seen in information and communication technologies with the rise of the desktop PC and the smartphone. This is primarily because of decarbonisation and digitalisation. Digitalisation is part of the General Purpose Technology (GPT) family which has now effectively come to energy. When combining this with decarbonisation – a general societal transformation of the same sort as a GPT but in policy terms – a fundamental technological and societal shift is unleashed towards decentralisation.

These forces also suit differing country needs. For example, in India decentralisation fulfils goals of access, reduced pollution, domestic jobs and decarbonisation. In China, it supports regional development and technological growth as well as decarbonisation. In the United States, it fosters state independence from federal policies along with multiple state-based priorities, whether energy independence, security, GHG reduction, air pollution reduction, and so on. In Europe, it helps meeting climate change objectives and industrial strategies. In Australia, and an increasing number of countries and regions, the rapid growth of decentralisation is linked to the competitiveness of renewable energies under favourable climatic conditions – households can buy cheaper energy via onsite technologies than from suppliers.

With the increased deployment of renewables, primarily solar and wind, renewable generation has become the dominating investment opportunity globally, and changes the way in which the sector operates.

Enabling a system that can efficiently integrate these new technologies implies a fundamental change in energy governance. Most regulatory frameworks have been designed to secure reliable operations of the centralised power system, but they may not have changed sufficiently to reflect the imperative to meet internationally agreed decarbonisation objectives. Change may be triggered by climatic events, such as Hurricane Sandy in New York, or storms and heat waves in Australia. However, all country reports suggest that governance is a decisive factor in the successful process of the transformation, as **governance can act as an accelerator or decelerator of the transformation.**

The difficult task for regulators and policy makers is facilitating a rapid but smooth transformation from the 'old' energy system to the 'new' in a dynamic technological and economic environment.

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2.9.1 The eight requirements of rapid transformative governance

At the beginning of this chapter, we provided an overview of the key reasons for why these countries were reviewed to assess their potential and actual pathways to decentralisation. Derived from the country reports, eight areas that require political action are identified, and these are discussed below:

1. Transparency and ligitimate policy making and institutions.
2. Availability and transparency of data.
3. Customer focus, enabling customer choice.
4. Markets to encourage flexibility in supply and demand.
5. Local system coordinators and a coexistence of the central grid and decentralised micro-grids.
6. Reforming regulation – Including performance-based elements.
7. Reassessing investments in the long-distance transmission grid.
8. An integrated approached to sector regulation.

Transparency and legitimate policymaking and institutions

A transition towards a low-carbon decentralised energy system can take many technological pathways, and the distributional impacts of those choices can be both positive and negative on societal stakeholders. Governance mechanisms of the energy system transformation are most likely to be supported by the general public if they are 'legitimate' – and one important characteristic of legitimate policy making is transparency in how decisions are made. If the policy-making process is flawed by, for example, governmental institutions undertaking myopic regulatory decisions, pursuing short-term political interests, decision makers underestimating the complexity of the system, or corporations successfully lobbying for their particular interests, legitimacy and authority may be jeopardised, and a regulatory regime may emerge that excludes alternatives which might suit social interests and preferences better.

Some countries have established a consensus culture, entailing several dimensions: the actual political process of voting in governments, proportional representation versus First Past the Post (such as in the UK) the degree to which decisions are devolved, for example, federal versus state in the United States and Germany; and the extent to which local areas can in some way make their wishes known;[49] the degree to which a society is knowledgeable about issues and so can meaningfully decide about them; the degree to which efforts are made by a society to ensure that society members are able to express their wishes, and the desired customer proposition is put in place. Transparent decision-making processes enhance public support for politicians and the overall transformation.

[49] For the power sector, this translates into a possibility of buying of local networks, as it happened in Hamburg, Germany.

For example, one of the principles of California's energy policy is to ensure that the state's implementation of these policies is transparent and equitable.

Denmark might be seen as a country that tries to find consensus in multiple ways, whereas other countries, for example Italy or Germany, may have implemented to some extent a consensus culture, or try to do this in a very limited manner, such as China.

In political practice, creating 'consensus' is a conflict-laden road whatever the country. Countries have to establish structures and institutions to be able to deal with conflicts. For example, Danish governance is a set of rules and processes that enable conflicts to end up in solutions. This can be linked to the Danish parliament with its many parties, where the large parties need a smaller coalition partner to get majority in parliament. In effect, proportional representation in a national parliament may be more suitable for constructively handling conflicts than largely two-party regimes. However, a proportional system may lead to the fragmentation of political parties and create political instability or paralysis, as can be seen in Italy's politics in the 1980s.

Government and communities need capacity – institutions, financial resources, human agency – to encourage consensus and understanding of what society wants:

- **Stakeholder involvement:** One way to deliver 'legitimate' decision making is to ensure a process that is designed to be transparent, coherent, and to deliver an acceptable consensus. This requires listening to as many stakeholders as possible and keeping up to date with information about societal preferences, not just economics. For example, in the United Kingdom the Committee on Climate Change (CCC) is statutorily required to provide advice to the UK government on what level of GHG emissions there should be, and by when. However, whilst the government must provide a written reply to the advice, there are no direct requirements on actors within the energy system for themselves to work towards the CCC outputs, despite the importance of their recommendations to the energy system and the importance of the energy system in meeting the recommendations of the CCC.
- **Government involvement:** Energy regulation needs to be recognised and voted on by elected representatives to ensure legitimacy and consumer acceptance, rather than delegating decisions to an independent regulatory body. The distributional impacts of any policy will be different. For example, an energy policy that includes nuclear power as a decarbonisation technology will have very different impacts on different stakeholders than an energy policy without nuclear plants. Making any trade-offs between outcomes that have a significant impact on one particular stakeholder group should not be the responsibility of a regulator or a network company, but should be the direct responsibility of government and consistent with broader public objectives. In addition,

efforts to harmonise national and regional policies may encounter challenges, as it can be observed between the European Union and its Member States. For example, the International Emissions Trading Association (IETA) detects problems within the European Emissions Trading Scheme, whose operation does not consider the success of separate policies encouraging energy efficiency and renewable energy deployment (IETA 2015).

- **Local governance:** A requirement of a smart and flexible energy system is coordination and balancing at the distributed, decentralised level. Energy regulation should encourage the involvement of different actors at different levels. This can be individuals, but also cooperatives or community groups, local authorities or small, decentralised companies through to bigger, more conventional actors, as shown by Denmark, California, New York State, and others. Larger entities can continue to be involved, but the new distributed energy resources require coordination at the local level if the system is to be run efficiently – that will need local governance, which of course needs to fit with the wider energy system governance.

Many traditional electricity generating companies are limited in their ability to transform their operations to keep pace with the changing technology environment. This is not only due to their nature of their existing assets, but also due to lack of familiarity and experience how to handle these new technologies to achieve optimal operational and financial outputs. Consequently, there may be political pressure to support these companies, either by slowing the changes to the regulatory environment, or by introducing specific measures to support their continual existence in the market, or both.

Large utilities may attempt to exert pressure on governments to implement policies and regulatory rules that suit their corporate strategies rather than the public interest, as is highlighted in some of the country reports, including China and Italy (Sections 2.3 and 2.7 of this chapter). Until recently, incumbent generators and large-scale investors in the power sector have had significant influence on development of policies and regulations, for example, seeking assurance and the inclusions into contracts indemnity from policy changes that might have a material impact on their investments. Ensuring the greater engagement by consumers and people in the sector comes with a need for a greater role for them in participatory processes to set regulations, measures, and policy objectives. In many countries this has been recognised by policy makers, and there have been ample opportunities for consumers and people to be consulted on the introduction of new regulations and policy frameworks, including responses to draft regulations or white papers, opportunities to attend 'townhall meetings' and discuss topics such as transmission grid extensions or wind parks in roundtables with various relevant stakeholder groups.

Availability and transparency of data to enable entrants to pursue the route to market of emerging business models

The ability to measure, collect, analyse, and share data has become cheaper and quicker across all aspects of our lives. In the energy sector, this enables individuals to monitor their own consumption in real time, and for companies to immediately act upon it. This has significant implications for the efficiency of grid operations, for generation, distribution and consumption. With access to smart grid data, companies and grid operators can offer better customer services. New private sector entrants, local communities and cooperatives need system and consumer data to be able to figure out whether there is a business case for them to provide a new service. To ensure competition and a level playing field, an entity that acts as a market monitor and data provider makes the data 'freely' available and controls that those with data or market power do not misuse that information.

Some countries or states are more active than others to package data in a more accessible way. As the report in Section 2.8 of this chapter has shown, some jurisdictions move from individualised customer data to system data. Both California and New York states consider assessments of their regulated distributed energy resources. For interested stakeholders, the data may be freely available, based on the argument that this will enable new entrants to understand what the potential of distributed energy resources is in their states.

The introduction of smart meters, whose deployment is driven by domestic or regional policies, allows a first level of information. They cannot, however, work in isolation; rather they can serve as enablers to integrate new actors into the sector, as well as to integrate different segments of the energy value chain into a smarter system. In the EU, the European Commission expects that by 2020, 72 per cent of electricity customers will have a smart meter (European Commission 2017). However, within the European Union there are already and are expected to be significant differences in the deployment rates. For example, by 2020 Denmark and Italy will achieve almost full coverage, while in Germany only 23 per cent market penetration is expected, due to concerns over economic efficiency. China is currently the world leader, with 450 million (from a global total of 700 million). In the United States, more than 60 million households have a smart meter, but adoption rates vary across states. However, privacy concerns, ownership of the data and cybersecurity all pose real threats to the rapid widespread introduction of smart meters (see also Burger, Trbovich & Weinmann 2018). Furthermore, with the ever-increasing opportunities of digitalisation, the fear that newly installed smart meters may become outdated relatively quickly is reducing enthusiasm for wide-scale rollout in parts of Europe. While much of the public is willing to share personal information in other areas of their private lives, in particular communication and social networks, the power industry will have to show the benefits and safeguards for individual consumers.

Furthermore, as private platforms are developed for new resource provisions, for example peer to peer trading, more data is derived which is 'outside of' of the conventional energy system but which will become a larger and more important part of it. Whilst this creates further opportunities for new players in the energy system, it is also likely that there will be a need to understand and resolve fundamental questions regarding data security and the protection of consumer privacy.

Customer focus, enabling customer choice

It seems commonplace nowadays that energy policy is customer-focused. For example, in the European Union the legislation on electricity market reform proposes to put consumers at the centre of the Energy Union; to empower consumers, to provide them with better information on their energy consumption, to make it easier to switch supplier, and to be able to generate and store their own energy (European Commission 2016).

A central determinant of the new energy system is the ability of customers to explore new, revenue-generating opportunities related to their energy use or self-generation. As the prices of supply technologies fall, as governments encourage greater energy efficiency, and as ICT becomes smaller, cheaper and easier to use, more customers are becoming more actively engaged in the energy system. Households, community groups and energy co-operatives, small and medium enterprises (SMEs) and heavy industry turn into producers, who can also play a significant role in balancing the grid (Hoggett 2016).

A combination of factors drives the changing role of consumers in the electricity, and wider, energy system. In many countries with liberalised markets, consumers are able to play an active role in power sector,

- by switching their supplier, choosing a new supplier based on price, fuel mix, ownership structure or combined utility offer, with heating, water or communications;
- by becoming prosumers (producers and consumers) through investment in individual or community level supply options, usually solar or wind;
- by investment in energy infrastructure, such as storage or even grid, as an individual or as part of a community project.

In most countries the rise in the deployment of renewables was accompanied by, and in many countries, such as Australia, Denmark, Germany, Italy, and the United States, driven by small-scale solar and wind deployment financed by private residents – the rise of the prosumers. Increasing customer involvement is seen as a key driver of the energy transformation in many countries (Energy Networks Australia 2017; European Commission 2016). When variable renewables contribute more significantly to overall supply, the success of the transformation will depend on greater engagement of customers in three areas – as investors and operators, as willing participants who pay for the new market and consumers of new products, and as supporters of policies and measures that deliver decarbonisation.

Transactive energy is technically similar to what in Europe goes under a variety of titles including 'Community self-consumption' (France), and 'Tenant self-consumption' (Germany). France, in April 2017, made changes to Article D of its Energy Code to support electricity self-consumption at the grid's edge. Germany has likewise amended the German Renewable Energy Sources Act (EEG 2017) to explicitly include self-consumption of PV electricity by buildings tenants. Both of these anticipated changes foreshadowed the proposed fourth EU Electricity Directive, which substantially enhances measures to proactively support consumer participation in the energy system (Butenko 2018).

In a number of countries, such as China, Denmark, Germany, India, and Italy, households and micro-producers may suffer from disadvantages and discrimination in the electricity system, though. For example, in Germany auctioning and tender systems favour larger suppliers. In countries without liberalised markets, they are not able to choose suppliers, become autonomous, or feed their power into the grid.

China may be indicative of a development trajectory that emerging economies can pursue without customer involvement: While reforms have occurred, with the introduction of new ministries and a move towards independent power production, individual consumers, either through their use of power or their rights, have marginal influence on the power sector. Despite this, the Chinese renewable sector is by far the largest producer and deployer of renewable energy, especially solar and wind. This is driven by top-down targets rather than bottom-up initiatives. This raises questions, can the Chinese system create a long-term, sustainable and engaging power system. How to achieve 'meaningful' consensus has many dimensions – knowledge transfer, education, places for discourse, and decision-making processes that take note of individual preferences.

As the Finkel Review in Australia states:

> 'The retail electricity market must operate effectively and serve consumers' interests. Improved access to data is needed to assist consumers, service providers, system operators and policy makers. Increased use of demand response and changes to the role of networks and how they are incentivised are required to unlock these benefits. Governments also need to take steps to ensure that all consumers, including low income consumers, are able to share in the benefits of new technologies and improved energy efficiency' (Finkel et al. 2017)

There are multiple cases of significant consumer involvement in energy policy:

- Germany offers an example of the success of long-term citizen's empowerment. The beginnings of what is now known as 'Energiewende' date back several decades and have their roots in the oil, nuclear and environmental crisis of the 1970s and 1980s, which resulted in the transformation of energy supply as a bottom-up process. Citizens mobilised significant resistance against the conventional energy policy of those days and activated social engagement for structural changes in the energy policy and supply system. Decades of critical social debates about the existing energy policy led to a counter-proposal to the conventional energy supply, which was adopted by the government in the early 1990s and led to the unprecedented rise of renewable energies.
- The commitment and investment of citizens still remains a key driving force of the German Energiewende: As outlined in the country report in Section 2.5 of this chapter, citizen energy has a market share of 47 per cent of the installed renewable electricity capacity in Germany. Therefore, while public involvement is important, key to longer-term consumer engagement is access to the market. The experience of cooperatives enabled a tested route for citizens to investment and gaining a stake in the sector.
- A similar development has been seen in Denmark where wind power survived on a fragile home market due to a continuation of parliamentary support and subsidies for wind power, which probably would not have prevailed without the policy pressure from the many wind turbine shareholders, including local citizens. As the country report in Section 2.4 of this chapter shows, the conflict regarding the establishment of the new heat and power integration infrastructure leads to the question how the sector can be rooted in a bottom-up and smart energy system to ensure that further integration of renewables is possible without difficulties and unnecessary expense.
- Following the Fukushima accident in Japan in 2011, German citizens expressed increased public and political concern over nuclear power, especially regarding the oldest reactors. This resulted in the introduction of a new direction for energy policy in Germany – the Energiewende (or energy turnaround); to phase out the use of nuclear power, by 2022; to accelerate the deployment of renewables and to increase energy efficiency. This was a dramatic change in the domestic policy, since at the same time the administration had only just introduced legislation to enable the nuclear power plants to continue to operate.
- The nuclear accident in Fukushima also resulted in changes in nuclear power deployment rates in China, the cancellation of new build considerations in Italy, following a referendum; recent announcements of no more nuclear in South Korea; and the cessation of all nuclear power in Japan, with local opposition delaying the restart of many reactors.

- A similar external event led to changes in the electricity sector in New York. Audrey Zibelman, the then chairperson of the NY State Department of Public Service (DPS) described how Hurricane Sandy was a major driver in the NYS decision to articulate a new vision for energy. Hurricane Sandy provided the desire for change of the NYS people, as well as the DPS focus of providing customers with the services they want – which includes security and cost effectiveness.

Customers, together and as individuals, are driving energy policy by their investment decisions, too. This is currently most obvious with respect to residential solar installations – whether in sunny places like Australia or Italy, or non-sunny places like Germany, where the take-up of solar has been far greater than expected and is driving regulatory change. Governments should welcome these murmurating situations, because they have significant benefits from an investment point of view. If customers, individuals or consumer co-operatives, are de facto becoming the investors on the system, there is less need for investors from other sources or – as technology prices fall – state financial support or subsidies. Other potential decentralised murmurations, possibly storage and electric vehicles, may follow. A customer-focused energy policy would be supportive of this murmurations and work with them.

Globally, competitiveness and levelised costs of solar PV and wind are changing, now routinely estimated below operating costs of coal-fired generation. On a retail level, tariffs faced by a vast majority of consumers, for example in India, are substantially higher than the cost of rooftop PV. Non-economic barriers, such as access to credit, are getting addressed by governments and regulatory bodies. Once they are minimised, growth of decentralised renewable energy supply is likely to further accelerate.

Decentralised renewable power can also be part of broader public policy goals by creating local employment, decreasing brain drain from rural areas and urban migration. As the report on China in Section 2.3 states, distributed generation and in particular solar are used as a tool for reducing poverty alleviation. In fully industrialised countries, such as Germany, substantial benefits for local employment have been observed.

On a global scale, significant differences in consumer focus remain, with many people still not having access to any or reliable supply, such as in India; or those that do, many have no choice about their supplier, payment system or tariff, such as in China. In the European context, for example, Italy also experienced a considerable growth in small-scale renewables systems, but policy is still dominated by large supply-side operators.

Designing markets to encourage flexibility in supply and demand

The greater deployment of renewables over the last decade has led to a recognition of the need for a more flexible system in order to accommodate variable producers.

To date four main mechanisms have been suggested to add the necessary flexibility, which are: interconnections, greater flexibility of generation from more predictive plants (often currently promoted through capacity markets or payments), storage, and demand side measures. These mechanisms vary in their suitability according to geographical and economic conditions of energy markets. For example, the transmission network and interconnections between systems may act as a flexibility backbone and as the 'net' balancer, for example in a largely integrated system with different climatic zones, such as in Europe. Flexible tariffs can sensitise customers to become aware of their energy use and encourage certain behaviours helpful to network operations. Decarbonisation in other sectors may create opportunities for further flexibility, in particular the electrification of transport and heating.

The extent to which these options are used will determine how quickly the system moves toward decentralisation, and bottom-up optimisation. For example, capacity payments in the United Kingdom provide financial support to the incumbent producers, and help to maintain the status quo. In Italy, a capacity market is envisaged, where producers will receive a remuneration for the generation capacity they make available. The European Commission approved the design of the Italian capacity market in February 2018. Capacity payments can significantly distort the market and offer financial support for a broad range of operators, often which other policy objectives are seeking to phase out (as has been the case in GB and its support for diesel) (Lockwood 2017). In Germany, the government created a requirement that network operators procure 2 GW of capacity to be held in reserve outside the market. This scheme not only bears advantages for incumbent generators, but might further restrict the balancing market to, for example, the detriment of demand side measures. Similarly, exporting excess power through large interconnections may reduce the need for much smaller scale storage and also negatively affect the economic case for demand response.

A different framework for the provision of grid services may better fit the requirements of the new system in terms of cost recovery, with every unit, including the low-carbon ones connected to medium and low voltage networks, being able to participate in network services if they wish to, thanks to the low-cost control technologies now available. For instance, in the wholesale electricity market in Australia the reserve capacity is undergoing a review for change to a capacity auction to commence in 2021, including changes to rules for demand side management, due to the current over-capacity and associated costs to consumers. Trialling has begun to alleviate demand peaks during high summer temperatures or to control the frequency of the network with virtual power plants (VPPs), composed of up to 1000 domestic solar and battery systems.

One policy option is to work towards a hierarchy of flexibility measures, with priorities for those with higher system efficiencies, higher greenhouse gas (GHG) reduction potentials, and those that have longer-term value. This is not a static consideration, especially given the system changes that large data management capabilities will bring, and the opportunity to evaluate and match supply and demand regionally or even locally.

This, plus an attempt to deliver greater integration across sectors, implies a move from the traditional top-down optimisation to a more bottom-up optimisation. Regulation may achieve superior outcomes if it is based on principle of subsidiarity, where first the total energy use is reduced on a local level – house by house, street by street – and then resources are integrated as much as possible towards the next higher level, before expensive high-tension networks and interconnectors are built. Government or the regulatory agency could entitle a Distribution System Provider or Distribution System Operator to prioritise incentives for the different mechanisms.

Any monetisation of flexibility services will lead to a shift in the allocation of revenues among economic agents. Thus, while evidence is now showing that providing more value in the energy system for flexible operations enables a more cost-effective whole system development and operation (i.e. cheaper overall and therefore beneficial for customers), there will be resistance to those changes (Shakoor et al. 2017). A balance has to be found between the new rules and incentives within those markets, networks, tariffs and services, and new institutions and actors – whether distribution market coordinators; system operators, and so on – who enable and coordinate the services and resources.

Strengthening the role of local system coordinators, thereby allowing for a coexistence of the central grid and decentralised micro-grids

In developing countries with fast growing electricity markets, such as India, the central grid suffers from low reliability and insufficient coverage. In this context, the construction of decentralised micro-grids could be encouraged and incentivised to complement the existing infrastructure and leapfrog towards more reliable, decentralised supply. In industrialised countries and states with a fully functional and reliable central grid, such as Australia or New York, decentralised micro-grids may be more resilient against climatic events like Hurricane Sandy in New York or storms and heat waves in Australia.

To accommodate more generation on the distribution network its system operator needs to have greater power and more strategic oversight. The DNO, which has often been relatively passive, with a fixed rate of return on their asset base, may be replaced by a coordinating distribution entity.

In New York State, distribution system providers (DSPs) encompass a new system function intended to coordinate an area system operation and to stimulate markets in that area. The distribution utilities retain both wires and system operator functions and have a public service obligation placed on them. The utility currently obtains its revenues from traditional cost of service. In the future, this is likely to move more towards performance-based regulation, one desired output of which would be a resource and cost-efficient system operation. This is effectively a new way of allocating costs in the energy system – more closely reflecting its use and needs, and the value of different resources within the energy system – including distributed energy resources, flexibility and demand side management.

New York state illuminates that regulation is adapting to the new configuration within energy systems. The state's system coordinators are still obliged to fulfil public policy goals. They are incentivised to minimise infrastructure costs of system transformation, and to maximise customer satisfaction. Tariffs become important to encouraging customer connection to their energy use, and this in turn links to network development (and network regulation) and meeting public goals. Currently network operators receive all the revenue related to networks, but over time new ways of paying for networks and other system functions may emerge – again more closely related to the system use, the providers of new services, and to what customers want the system, and networks, to do. Since liberalisation, electricity markets have always had certain links to network operation and system costs, but this is likely to become more complex, as greater levels of decentralisation and demand response occur. Thus, system operation, network charging, tariffs and markets – which have always worked together – are becoming more closely intertwined, and sophisticated. Australia is currently the world's most extreme example of this. On-site generation has reached a point where it makes financial sense for households to use solar and storage, even without subsidies. However, network charging and the regulatory mechanisms are lagging behind this momentum, and many systemic problems could have been avoided if they had been addressed earlier.

In the example from New York, system operation includes managing the distribution wires. But equally, a distribution market facilitator could be a 'system operator only' company or not-for-profit institution, while the distribution wires company becomes a regulated entity with a new role. Whatever configuration of the entity at distribution level, it will have to interact with the transmission system operators. A new system coordinator must allow and encourage the development of systems that support different functions on the grid, such as demand side actions, generation and storage. Small actors will often combine activities to accumulate revenues and in doing so offer important supply and grid stability services. A distribution system coordinator needs to recognise these advantages of multi-functionalism. It is still too early to know how these entities will be set up and how their interactions will work – both in developing and industrialised countries. It is clear, though, that the roles of both distribution and transmission companies will change.

Reforming regulation – including performance-based elements

Often, new business models develop *despite* the system rather than with the help of it. In many countries, the existing system maintains payments for the 'old' technologies and services and does not provide payments for the services that would enable the new, flexible system, for example many of capacity market incentives, which favour existing generators over demand side measures. Its institutions do not act as a driver, but as a barrier to emerging innovations.

Technology changes and the subsequent requirement for new operational regimes, coupled with emerging opportunities for active consumer engagement, are driving the need for far-reaching regulatory reforms. The new regulatory framework should be ambition driven, shaping the regulatory framework towards clearly defined policy objectives. If the energy policy remains too focused on conventional centralised technologies, change may be slower and, in the longer term, more expensive, due to larger stranded assets and wasted opportunities (Shakoor et al. 2017).

The traditional cost-of-service method of regulation requires utilities calculating their costs for the next X amount of years, the regulator checking their calculations and agreeing on the money they can spend over the time period. This amount is then turned into a charge on customers.

By contrast, performance-based regulation (PBR) is a form of regulation that aims to incentivise outputs in return for payments. It is very different from the more traditional cost-of-service mechanism. PBR decides what it wants to achieve (desired outputs) and then establishes an incentive mechanism whereby the utility is paid to the extent it delivers the desired outputs, as opposed to cost-of-service regulation. The value of outputs has to be worked out dynamically, as they will change over time, so that the payment to utilities per output is not too great or too low. Under the regime of performance-based regulation, inputs may change provided the desired outcomes are met, which means that there will be more flexibility of choice in delivering those outputs rather than being locked into the inputs. This regulatory regime is likely to lead to a better use of resources and cost-efficient system operation, as the report of the states of New York and California suggest. It also facilitates dynamically linking revenues, tariffs, connections and network operation charges with the desired market design.

Compared to cost-of-service regulation, PBR is also more flexible and better placed to incentivise these requirements from a public policy point of view, because outputs can be more easily changed. It also facilitates dynamically linking revenues, tariffs, connections and network operation charges with the desired market design.

Reforming regulation will encompass how to deal with winners and losers of the new regime. Trade-offs have to be discussed to ensure that, on the one side, networks are paid for and public service obligations are met, and on the other side the wishes of prosumers and users to have a high degree of autonomy are respected. In the move from cost-plus regulation to one where a higher proportion of network fees are linked to performance-based regulation, the roles and responsibilities of all stakeholders need to be addressed.

Reassessing investments in the long-distance transmission grid, given the rise of decentralised energy supply

As more customers connect to PV, they use fewer units of electricity, and the transmission and distribution lines must be paid for by fewer customers on fewer units, if the same governance for network regulation and for charging for network use is maintained. This increases the network portion of the bills and makes self-generation more economically attractive. This is the so-called 'death spiral' for the conventional energy supply industry. The reaction from some governments or regulatory agencies has been an attempt to stop subsidising the deployment of PV – rather than seeing it as part of a move to a sustainable energy system. Consequently, feed-in-tariffs for small-scale renewables have been reduced in an increasing number of policy frameworks, for example Germany, and an additional network charge 'or insurance premium' is proposed for consumers that self-generate, because they use – in conventional energy provision terms – the grid as backup (Gosden 2016).

In many countries, the construction of new and reinforcement of existing transmission infrastructure incurs costs in the billion-dollar range for final customers. These investments may lead to stranded assets, because the uptake of local supply reduces the need for long-distance transportation of the electricity. Some countries, such as Australia, have recognised the need for a reassessment of the necessity of long-haul transmission investments.

Network utilities have hitherto made their money primarily from their cost of service regulated payments; per unit of energy transmitted across their networks; and from connections to their grids. They have been in control of how their network is used and operated – who connects and how much those connections cost. Increasingly, however, as technologies decentralise there are new ways of ownership, network connection and network use. With these changes, the structure and origin of revenues for network entities have to be reassessed.

More decentralised production changes the volumes of electricity flowing across different segments of the grid. The sources, predictability and volumes on the transmission system will change as a result of new, sometimes large-scale renewable generation, such as offshore wind. By contrast, the tendency towards more production and consumption within the same regional distribution grid may reduce the overall flows in transmission systems. Self-production has already resulted in an increasing number of consumers who have reduced their consumption from the electricity grid, leading to a decline in the overall revenues for grid operators. Given that the grid operation costs are largely fixed, grid operators will, all other factors remaining, have to increase their unit cost per kWh of transported electricity. In turn, this encourages customers to buy more on-site generation, and raises important questions about how further grid costs need to be allocated to active and passive consumers alike.

In New York, the reduction in the revenue for utilities generated from electricity sales across the grid may be compensated for by payments for meeting specific policy objectives. In other countries, such as Australia, consideration is being given to a tariff similar to mobile phone charging, where the customer would choose a plan based on their peak kilowatt usage, for example not exceeding 3 kW of consumption at any time. If consumption is above this limit they would have to pay a fee. In Italy, an increasing part of the bill will be charged per unit of capacity and not just on consumption.

New rules should enable distributed generation while ensuring the network remains reliable and secure. In Italy, electricity generation is a liberalised activity, and grid operators are obliged to connect all renewable generators at a cost which is proportional to the distance from the connection point. However, as of 2018, the owner of a renewable energy plant does not have alternative solutions to self-consumption or sale to the grid. The direct sale of electricity to other consumers, as well as load aggregation, is not permitted, with the exception of the one-to-one supply under SEU ('Sistemi Efficienti di Utenza' or Efficient User System) scheme.

The next step in the operation of networks will be the ability of individual producers to sell directly to consumers. Blockchain and other open ledger technologies are now being tested in some countries – for example in Vienna with the municipal utility Wien Energie – and may accelerate changes in the regulation of the network: In a peer-to-peer scheme, one neighbour might want to connect to the grid and sell to another neighbour, but might want to pay only for use of a few metres of distribution grid. How should this be paid for, and how will this feed into the overall cost of running an energy system?

Box 2: To upgrade networks or not?

As the share of decentralised renewable energies rises, the default response of a traditional government or regulatory agency is to allow and promote investments in the distribution and transmission grid. In Germany, for example, around 1800 km of high-voltage transmission lines are under construction to transport the offshore wind energy produced in the North Sea and in the Baltic Sea to the country's industrial hubs in the South. As grid operations in most countries are still regulated, the costs for reinforcement are borne by all consumers via grid fees and levies. In Germany, the costs of grid services and concessions have been almost uninterruptedly rising from 1.02 €-cts per kilowatt hour in 2009 to 6.79 €-cts in 2018 for an average household with a consumption of 3500 kilowatt hours per year (BDEW 2018).

If energy systems with a larger share of intermittent, weather-dependent power sources continue to be operated in the same way, then reliability problems are likely to increase. Grid operators have to intervene more frequently to maintain the balance between supply and demand. This happens either by shutting down individual renewable energy plants if there is excess generation injected into the grid, or activating additional conventional capacity in case of excess demand.

For example, interventions in Germany's largest transmission grid operated by private company TenneT increased from fewer than 10 interventions per year in 2003 to almost 1000 interventions in 2014 (Weinreich 2016). The costs of grid interventions of Germany's four large transmission grid operators rose from €436 m in 2014 to €1130 m in 2015 and €848 m in 2016. The decline from 2015 to 2016 was caused by a lower intake of wind and solar energy in 2016, as well as optimised operations and redispatch of the grid operators, according to the German federal grid agency (ZfK 2017). In 2016, compensation for temporarily shutting down renewable energy installations amounted to more than €370 m (ibid.).

However, if a country starts to operate their electricity system differently, and adds cheaper flexibility resources, then these expensive networks upgrades are not required and reliability problems would occur less frequently, which keeps a cap on infrastructure cost increases.

In addition, transmission grid operators could start building expertise and a digital and technical infrastructure to cope with the new and more challenging system requirements. For example, German transmission grid operator 50 Hertz was able to reduce costs for and quantities of congestion management from 2015 to 2017 by 47 and 41 per cent, respectively, because of the optimisation of redispatch, as well as new transmission connections (Reinke 2018).

Regulators should be open to differing analyses of different scales of development when deciding on their regulated company agreements.

At root, the way we cost our energy systems and energy provision is changing. Renewable electricity is not yet ready for a flat rate system, just taking fixed costs into account, but in many industrialised countries the cost of generating electricity is less than half the cost of the retail price to customers – the remainder is related to network, system and environmental costs.[50]

[50] In the United Kingdom, it is about one third, see http://www.energy-uk.org.uk/customers/about-your-energy-bill/the-breakdown-of-an-energy-bill.html

As renewables are becoming considerably cheaper, the non-energy costs of energy provision become greater, and the focus will turn to how to pay for networks, system operation and the social and environmental costs of energy use rather than for energy itself. This is an entirely new focus of energy system economics. Network charges and access rules, which role prosumers play in the system, and what obligations and rights they have, is a new fault-line in energy regulation.

An integrative approach to sector regulation

The conventional energy system tended to have separate sector regulation, for example in electricity and gas, and they were top down optimised with few players. As the energy system decarbonises and decentralises, the convergence of heat, mobility and power on the distribution level requires coordinated regulatory instruments and actions. Regulators have to be flexible to changes and establish processes whereby regulation can keep up with and be adaptive to changes – rather than undermining them.

The decarbonisation of the heat and cooling and the transport sector has not been as rapid as for power. Consequently, in addition to the promotion of the greater use of renewables in these sectors, for example biofuels in transport and district heating, the electrification of these sectors is being promoted to reduce emissions. In both contexts increased attention is being placed upon sector coupling, that enables the co-production, combined use and substitution of different supply and demand options. In addition, sector coupling may increase the resilience of the system, given the variability of renewable energy production.

With a Bloomberg New Energy Finance forecasts suggesting that there could be 11 million EV sales per year globally by 2025 (up from 1.1 million in 2017), smart charging of electric vehicles could massively expand and create an unprecedented opportunity for grid balancing through customer engagement (BNEF 2018). In some countries, such as Denmark, piloting has already begun (Fuelincluded 2017).

From a regulatory perspective, sector coupling raises important questions of how to set up a framework that does not only optimise the deployment of different technologies and distributed energy resources in individual sectors, but also for an encompassing regulatory and institutional framework. The electrification of new sectors is likely to increase electricity demand, which would be significant in many industrialised countries that have experienced no or little growth over the last decades.

Going forward, the development and implementation of a smart, holistic energy system will require coordination between the variable renewable producers, the transmission system operator (TSO) and distributed system provider (DSPs), the municipalities and even the vehicle fleet owners to achieve maximum efficiency and stability.

Most energy systems in the world have a very clear public service obligation on monopoly providers of services to customers, and they have customer licenses of some sort on the non-monopoly providers for other functions.

The changing energy world is altering the roles of different actors and stakeholders, but there still needs to be a clear requirement on actors and stakeholders to provide a certain level of service to customers. It is remarkable that the Public Service Commission (PSC) of New York, the Regulator, has come to the view that upholding their public service mandate, which is about a century old, can only be fulfilled by fundamental changes to their energy system – but they still hold fast to their mandate. Vulnerable customers will need to be looked after, and networks, if they are needed, still need to be paid for.

2.9.2 The way forward: transformation and acceleration

Energy systems are changing and becoming more decentralised for all the reasons for all the reasons and drivers discussed above this transformation needs to be undertaken in the most cost-effective way possible if it is to be accelerated with a parallel acceleration in greenhouse gas reduction. This chapter argues, from evidence taken from the country sections, that a key enabler of an accelerated transformation is a coordinating governance framework made up of 8 key elements, we now move to business models which can thrive from in situations where those governance mechanisms are in place.

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