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Florence School of Regulation

FSR GLOBAL FORUM REPORT

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Foreword

The energy sector is undergoing a serious transition, being subject to the challenges and opportunities brought by the unstoppable global trends of decentralisation, decarbonisation, and digitalisation. As perhaps the most flexible component of the energy sector, the power sector is rapidly changing, through the introduction of distributed energy resources (DERs), the adoption of cleaner technologies, and the utilisation of ICT technologies at all levels.

The common idea or the motive underlying the portfolio of topics that are brought for discussion in this Global Forum is that the primary objective of the regulatory institutions and the regulation itself must be to facilitate and enable the best technical and economic solutions, to minimise unnecessary regulatory interference and to encourage efficient results.

The thematic lines of the forum were:

- Universal access to electricity
- Power market and networks
- Decarbonisation
- Electric vehicles
- Electricity storage
- Digitalisation

The topics selected for debate via our Knowledge Space sessions were:

1A) Removing barriers to massive electrification business models

1B) The role of regulated electricity tariffs in competitive retail markets

2A) A "utility-like" approach to large-scale electrification: the electricity company of the future

2B) Unlocking the value of storage in market-based power systems

3A) Incentivizing the development of network resilience

3B) Regulatory challenges of distribution networks with distributed resources

4A) Establishing priorities for regional power market integration in emerging economies

4B) The role of indicative planning in the ongoing economy electrification process

5A) Enhancing the efficiency and effectiveness of regional power markets in emerging economies

5B) Unlocking the potential of electric vehicles in the power system

6A) Transitioning to a more efficient and competitive power market in emerging economies

6B) Challenges and opportunities of digitalisation for the electricity sector

Jean-Michel Glachant
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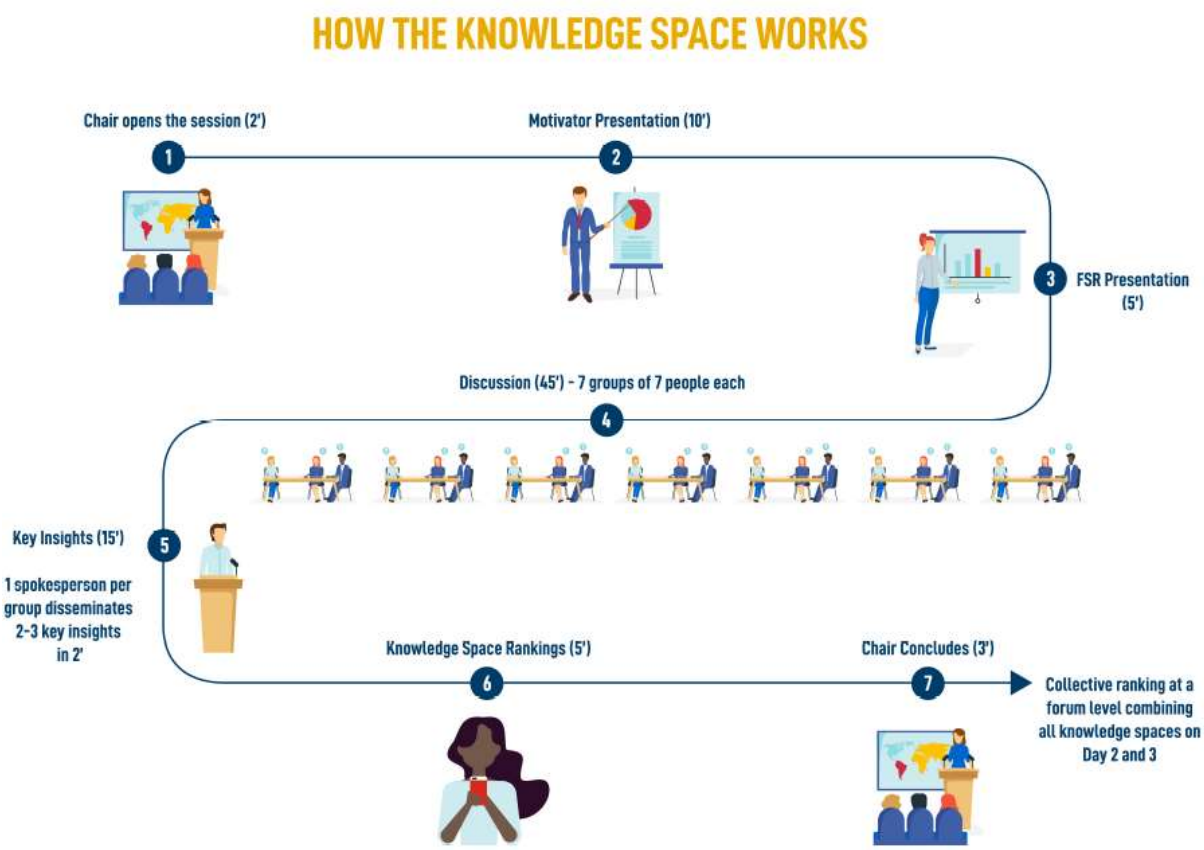
Digitally powered Knowledge Spaces

The format of the forum is unique as it combines interactive discussions powered by a digital interface. The insights of each knowledge space will be translated into digital insights, which will be ranked at each session level and again at the forum level.

See below how a knowledge space works:



The forum was centred on 12 knowledge spaces, and each delegate participated in 6. This post forum dossier contains a short brief ***introducing the topic***, the ***key questions*** that were debated and a summary of some ***key insights*** from the discussions.

Refer to the knowledge space numbers to easily navigate through the document.

Contents

Summary of key questions debated at the FSR Global Forum

Knowledge Spaces	Key Questions
1A) Removing barriers to massive electrification business models	1. What are the viability gap reducing measures? What successful experiences exist? 2. What institutions and instruments could provide a sufficient guarantee to prospective investors? What successful experiences can be useful here?
1B) Role of regulated electricity tariffs in competitive retail markets	1. Should regulated electricity tariffs be abolished in competitive retail markets? 2. And, for those countries that have not yet introduced retail competition: Do they need retail competition and if so, to what extent?
2A) A "utility-like" approach to large-scale electrification: electricity company of the future	1. Is a "utility-like" business model the most adequate – perhaps the only adequate – long-term approach for electricity supply to the population that presently lacks acceptable electricity access in developing countries? 2. Does the Integrated Distribution Company (IDC) with any necessary adaptation to the policy, regulation and other characteristics of each country meet the requirements to become the "utility-like of the future" or "electricity company of the future" that can achieve universal electricity access at region or country level? Based on existing successful and failed experiences and your judgment, what would you add, remove or modify in the provided description of the IDC? With any necessary adjustments, do you think that it could work?
2B) Unlocking the value of storage in market-based power systems	1. How to unlock the value of storage in market-based power systems, both at centralised and distributed levels? 2. Should storage be allowed to participate in wholesale markets? Should the wholesale market rules be adapted to accommodate the presence of storage? 3. Should storage be allowed to compete in the provision of network services such as investment network deferral, both at transmission and distribution levels? 4. Who should be allowed to own storage and what services should this storage be allowed to provide?
3A) Incentivizing the development of network resilience	1. What are in your experience the technical characteristics of the power network capable of enhancing resilience at best? 2. Do you think that policies are sufficiently and holistically taking into account the benefits of resilience with appropriate cost-benefit analyses? 3. Do you think that financial tools and regulatory schemes should be specifically tailored to develop network resilience? Which are the most appropriate and likely to succeed schemes providing a long-term view, appropriate remuneration and protection from risk?
3B) Regulatory challenges of distribution networks with distributed resources	1. How to determine the efficient revenue requirement for a distribution company with large penetration of distributed generation, storage and/or demand response?

	2. How to mitigate or eliminate the pushback from distribution companies towards the massive installation of DERs? 3. How to combine efficiency, fairness and equity in the design of electricity regulated charges and market prices? 4. How to create incentives for the individual agents that own the DERs to contribute to the efficient operation of the electricity markets?
4A) Establishing priorities for regional power market integration in emerging economies	1. Should countries prioritise the reform of their respective national energy markets before engaging in regional energy markets? To what extent? 2. What are the institutional and regulatory arrangements needed to sustain and optimise the selected reform strategy?
4B) The role of indicative planning in the ongoing economy electrification process	1. Is indicative planning necessary to provide a long-term vision of the coupling among sectors and the achievement of the common decarbonisation objective? 2. How to make use of the insights provided by indicative planning? Just information? Should "indicative" planning results be transformed into regulation to guide towards specific objectives for each sector? 3. How "intrusive" should regulation be? Only price signals (e.g. the price of CO2) or also targets (e.g. on the penetration of clean technologies) or limits (e.g. car emissions)?
5A) Enhancing the efficiency and effectiveness of regional power markets in emerging economies	1. What responsibilities should be assigned to the regional regulatory authority and the regional system operator? 2. How to make regional institutions effective in helping realise the required coordination in planning and investment decisions? 3. How to allocate the costs of "regional transmission projects" (i.e. those transmission links – whether crossing borders or not – that facilitate cross-border trade)?
5B) Unlocking the potential of electric vehicles in the power system	1. How can the potential of electric vehicles be unlocked and monetised to provide services with economic value to the power system? 2. How relevant is the potential contribution of electric vehicles in the provision of the different types of services? 3. How should the aggregation of the services provided by electric vehicles be managed? 4. How to design and implement efficient economic signals (energy prices, network cost-reflective charges, and regulatory charges)?
6A) Transitioning to a more efficient and competitive power market in emerging economies	1. How should cross-border physical bilateral contracts be efficiently dispatched through a market mechanism? 2. What is the role of intermediaries in attracting investment and facilitating power trade?
6B) Challenges and opportunities of digitalisation for the electricity sector	1. Can established utilities react to this profound digitalisation change and preserve a viable business model? If so, in which way? 2. Will customers and the society at large be better off? 3. Do you see any special issue of privacy and cybersecurity?

Achieving universal access to electricity

While the world transitions towards an electrified economy driven by innovation, as many as 1.1 billion people still cannot even switch a light at home, and many more often switch it on but nothing happens. The issue of electricity access is predominant in the regions of Sub-Saharan Africa, emerging countries from Asia, and – to a lesser degree – Latin America. Despite significant progress over the past years, at the present rate the United Nations' Sustainable Development Goal 7 will not be achieved by a wide margin. Based on the current trajectory the IEA estimates that 674 million people will continue to lack access to electricity in 2030.

The enormous challenge of universal electricity access cannot be taken up by the public sector alone. The scale of investments needed amply exceeds the financial capabilities of most low access countries and the usual channels of support from bilateral or multilateral organisations. Therefore, significant efforts must be made in planning, institutional development, policy, and regulation to create an enabling environment that can bring in private sector participation and capital. To implement economically sound and sustainable electrification business models, close cooperation between energy firms, governments and regulators, the incumbent electricity companies, international lenders, the development banks, and a wide range of local firms is needed.

Thus, it is imperative to 'think big', and it is important to involve all the relevant stakeholders while considering solutions to solve the electricity access problem. Providing electricity for all is a multi-dimensional endeavour and one that cannot be addressed in silos. It combines a complex set of topics ranging from social, environmental, technical, and economical to political.

Traditionally, grids have been the default pathway for the provision of electricity access. However, the distribution utilities in most low-access developing countries are failing in connecting the un-electrified population at a desirable rate. Politically-motivated subsidised tariffs lie at the heart of the problem. Distribution companies incur economic losses when extending the grid at a high cost in rural areas or when improving the existing grid — lack of investment results in poor performance and customer dissatisfaction, leading to non-paid bills and electricity theft.

The advent of decentralised off-grid solutions mainly using renewable generation has provided an alternative pathway – where the off-grid condition may be transitory – that has gained momentum in recent years. Although mini-grids and stand-alone systems have been instrumental in providing electricity access, a more strategic approach is necessary; one that combines all the pathways of electrification to ensure that reliable and continued access to electricity needs is implemented. However several barriers remain.

Firstly, the crucial challenge for providing electricity access has been securing investments for the last mile (distribution), which obviously depends on being reasonably certain that the electrification business is financially viable. For the existing distribution utilities, financial viability can be improved by increasing the efficiency in revenue collection and reducing theft via consumer engagement, reduction in network technical losses, asset standardisation, productive uses of electricity, cost-reflective tariffs although applying cross-subsidization as needed, access to long-term, low-cost capital and, if appropriate, subsidisation mechanisms with the help of public funds.

Secondly, the regulatory and policy frameworks in low access countries need to reflect the peculiarities in the activity of providing mass electrification, so that viable business models are possible. Lessons can be learnt from the successful experiences of other countries. Sound regulatory measures are needed to ensure cost-reflective revenue requirements for distribution and retail activities, reliable upstream supply backed by adequate generation and transmission assets, compliance with any unbundling requirement, methods of determination of the tariffs for the end customers, legal instruments to help fight power theft and unpaid bills, and guarantees of governmental support in the coordination and implementation of these measures.

Two of the sessions of the Forum (Knowledge Space 1A and Knowledge Space 2A) will be devoted to discussing the removal of barriers to electrification and the design of viable business models. It follows a brief introduction to these two topics and the key questions to be addressed.

1A) Removing barriers to massive electrification business models

Chair: Anoop Singh | Indian Institute of Technology Kanpur

Motivator & FSR Presenter: Ignacio Pérez-Arriaga | Florence School of Regulation, Massachusetts Institute of Technology, Comillas Pontifical University

The necessary contribution of private investment will not be possible unless the electrification business is economically viable. Since rural electrification is expensive and, in most developing countries faces an access problem, the tariff is not cost reflective; the result is a "viability gap", i.e. a deficit of the collected revenues to cover the supply costs.

The viability gap is an essential impediment to the viability of any electrification business model. Two fundamental approaches are needed to address this problem: i) a portfolio of measures to reduce the viability gap as much as possible; ii) a credible guarantee that whatever subsidy that is needed to fill any remaining gap will be delivered.

The questions debated during this session were the following:

1. What are the viability gap reducing measures? What successful experiences exist?
2. What institutions and instruments could provide a sufficient guarantee to prospective investors? What successful experiences can be useful here?

The discussions of the session highlighted the need to have cost reflective tariff with targeted subsidy that considers the ability to pay of various customer groups. It also highlighted the importance of attracting private investment, which among others requires support and commitment of central government; appropriate regulatory treatment of each activity in the electricity supply chain; transparent planning process and clear long-term investment signals; capacity building and awareness creation; and the coordination among government, industry, consumers and other stakeholders.

Key insights based on ranking were:

1. Cost reflective tariffs are effective but need to be complimented by targeted subsidies keeping in mind the ability to pay of the various consumer groups.
2. The need for central government support to the development of the electrification including the commitment of the States with Investment agreements.

3. Transparent planning, data sets and clear long-term signals for concessions will go a long way in bringing in private sector companies to supply energy services.
4. Integrated planning and coordination should first be strengthened at intra-national levels with government, industry, markets and consumers, and regional cooperation will complement.
5. To establish a regulated framework that will allow establishing energy communities supported by efficient capacity building and awareness.
6. We should start with small micro grids coupled with energy storage around key priority areas (hospitals, schools) which foster social and economic development and productive use.
7. The need for a private intermediary who could provide the standard guarantee of the investments (not project based).
8. We should take the opportunities coming from the decreasing price of RES-based off grid energy systems, but we should keep in mind the long-term goal of 24×7 reliable and quality electricity supply.

Summary by Igancio Pérez-Arriaga | Florence Sschool of Regulation, Massachusetts Institute of Technology and Comillas Pontifical University

There no avoiding the s-word. The iron law in electricity access is that "there is no rural electrification without subsidies". Extending the grid to reach low and typically disperse loads results in per unit costs of delivered energy much larger than in densely populated urban areas with higher household demands. Off grid solutions become competitive with grid extension in these situations, but they are still more expensive than the electricity supplied to urban customers. Should the rural poor pay the highest per-unit price for power? They do today in many developing countries (any customer, even the poorest, is willing to pay much for the smallest amount of an essential good), but this is morally and politically indefensible.

Rural electrification has never been achieved without some kind of subsidy anywhere in the world. Cross-subsidization from urban, commercial and industrial customers towards poor rural customers should be part of the solution to reduce the viability gap. And we should be aware that in most countries – developed or not – electricity tariffs are the same at country, state, province or utility level, regardless whether the residential customers live downtown of a large city or in the countryside. In many developed countries residential customers subsidize industrial ones, as part of the country's "industrial policy". We implicitly accept massive cross-subsidization in electricity tariffs everywhere.

Although cross-subsidization between categories of customers is an appropriate measure to reduce the viability gap, in general it is not sufficient when the unelectrified customers are too many and because the measure itself has its own limits (to avoid social push back and network defection). Direct subsidies to the customers or to the electricity suppliers so that social tariffs plus subsidies complete the cost-reflective revenue requirement are a necessary condition for viable rural electrification business models and to attract serious private capital.

2A) A "utility-like" approach to large-scale electrification: the electricity company of the future

Chair: Kristina Skierka | Power for All

Motivator: Ganesh Das | TATA Power DDL

FSR Presenter: Ignacio Pérez-Arriaga | Florence School of Regulation

Universal electricity access needs an obligation of supply over the considered territory so that nobody is left behind. Sustainability, meaning here unlimited permanence in time, requires a "utility-like model", with a long-term vision and commitment. When integrated into such a "utility-like" model, mini-grid & solar-kit firms also become sustainable. An "integrated distribution company, IDC" could be defined as a **zonal franchise**, i.e. a company with a comprehensive obligation of electricity supply in the assigned territory, by any electrification mode. When facing full electrification of a territory, the concessionaire would look for the least cost electrification plan, which is typically a mix of delivery modes (grid extension, mini-grids and standalone systems) that evolves with time towards higher electrification levels. The necessary managerial, financial & operational change will be possible by some form of PPP with a large private global energy firm & the participation of local companies with the capability of effective consumer engagement.

The questions debated during this session were the following:

1. Is a "utility-like" business model the most adequate – perhaps the only adequate – long-term approach for electricity supply to the population that presently lacks acceptable electricity access in developing countries?
2. Does the Integrated Distribution Company (IDC) – as described in the text above, and with any necessary adaptation to the policy, regulation and other characteristics of each country – meet the requirements to become the "utility-like of the future" or "electricity company of the future" that can achieve universal electricity access at region or country level? Based on existing successful and failed experiences and your judgment, what would you add, remove or modify in the description of the IDC above? With any necessary adjustments, do you think that it could work?

The discussions recognized the need for an innovative solution to integrate and coordinate the activities of a "utility-like' model, which combined pathways such as the grid, mini-grid and solar kit in the provision of electricity access. Such models should be adaptable, interactive and customer centric. However, there were differences in the approaches including if a government institution, state-owned utility, or private firm should take this role. Should there be a need for territorial concession as proposed by the "Integrated Distribution Company" model; or if an "integrated distribution service provider", which will be defined across the lines of services and customer experience but not traditional commodity, were a better option.

Key insights based on ranking were:

1. Encourage adaptive, interactive and consumer centric IDC to realise potential for electrification as they have access to more managerial financial and operational tools.
2. Centralised responsibility and coordination should be combined/conducted together with planning and investments from decentralized parties.

3. Markets can provide most of the solution, but it is the planning and operation that needs an intermediary such as an IDC.
4. The utility of the future does not require territorial concession, however regulations shall ensure non-discriminatory access for new entrants which brings innovation
5. A utility like model of the future can be an institution to maintain regulatory oversight aimed at giving the service of electricity access to the people who will be active participants (i.e. prosumers), and let the market evolve through technological innovation (i.e. EVs, blockchain, etc.)
6. A territorial concession involving the incumbent/utility is essential to guarantee access for all, but it can be combined with any model of decentralization.
7. There are options for IDCs in the future, but they will be an Integrated Distribution 'Provider' defined along the lines of services and customer experience, not the traditional commodity.
8. Managing tariffs-fairness and payment certainty is a key issue and could be done with centralized guarantees (not project per project) thanks to an intermediary financial institution.

Summary by Igancio Pérez-Arriaga | Florence School of Regulation, Massachusetts Institute of Technology and Comillas Pontifical University

The electricity company of the future, in its different formats – since it can be inserted in different points of the electricity supply chain and has to adapt to the specific conditions of each country – must be ready to exploit the concept of "integration" at multiple levels.

- Integration of the three delivery modes under a comprehensive electrification plan to achieve universal access and a common responsible entity with a territorial concession. This can be compatible with outsourcing mini-grid developments and the default provision of standalone systems. This integrated business model should be more attractive for serious investors than the fragmented ones. It allows treating all customers equally with a single platform and helping them to transit from one delivery mode to another. Advanced methods of electrification planning can provide guidance about which electrification mode to use for each individual demand.
- Integration of the incumbent distribution utility (publicly owned in general) and external private investors under private / public partnerships (PPP) with diverse formats. The public presence in the integrated company, with its objective of universal access, is more likely to get the support of politicians, regulators and the public. The external private investor can provide financial resources, management, advanced technology, improved service, and a new approach to customer engagement.
- Integration of electrical access and the services that electricity can provide, at residential, community and productive uses levels. The electricity company can go beyond access to provide technical, logistic and financial support to the electricity services demanded by customers.
- Integration of the national (or state, or provincial) power systems at higher "regional" level to form power pools, with numerous advantages, resulting in efficiency, security and environmental gains.
- Integration of the power sector with other industrial sectors: ICT, agriculture, water and sanitation, cooking, or transportation.

1B) Role of regulated electricity tariffs in competitive retail markets

Chair: Leigh Hancher | Florence School of Regulation

Motivator: Jorge Vasconcelos | Florence School of Regulation, NEWES

FSR Presenter: Pradyumna Bhagwat | Florence School of Regulation

As part of the liberalisation of the electricity sector, many countries have introduced wholesale and retail markets with design and implementation approaches that differ widely. In Europe, in parallel with the mandatory full liberalisation of electricity retail, the unbundling of the retail companies is not complete, and some form of regulated prices continues to exist in several member states. In the US, all states but Texas have not unbundled distribution and retail, and only 14 states out of 50 are open to retail competition, out of which in 13 states the incumbent retailers are obligated to supply customers that do not choose another retailer. In most countries in the world, the retail and distribution functions remain unbundled.

Some authors argue that retail liberalisation does not lead to significant efficiency gains due to the transaction costs incurred by retailers, the homogeneity of the product (Bertrand Paradox), the absence of value-added services, and barriers to consumer switching. In practice, reasons usually cited in support of regulated prices include the protection of vulnerable customers against high prices, ensuring supply for customers under exceptional circumstances and meeting political objectives.

Supporters of retail competition also point out its advantages. Price determination is left to market forces, with customers being able to choose, rather than leaving to the regulator the decision of how to calculate the “retail market price”. Competition incentivises retailers to become more innovative and leaner. The suppliers should become more proactive towards consumer preferences and provide new products to retain their market share. Customers can choose the set of services that best suit their needs.

On the contrary, ill-conceived regulated prices can destroy the retail market. Experience has shown that regulators have sometimes designed the energy component of regulated price below the wholesale energy price, therefore rendering the retailing activity practically inviable. Price caps can protect consumers from the risk of price volatility. However, they create an additional risk for retailers, as was the case in California in 2001.

An intermediate position views the two approaches to electricity retailing as complementary rather than contradictory. Electricity retailing can be opened for competition while retaining some form of a regulated price. A properly designed regulated price would act as a safeguard by protecting consumers from the exercise of market power without jeopardising competition. A first dilemma in the design of the regulated tariff is the mix of short and long-term energy prices to be employed in the regulated price of energy. A second design decision is the value of the markup to be included in the regulated price so that it leaves some room for the retailers to compete with it.

In addition to the design of the retail market, other factors, such as advanced metering systems, ease of consumer switching, and cybersecurity concerns have to be considered to ensure the efficient and effective functioning of retail competition.

In summary, many countries or states that have introduced competition at the wholesale level have not done so at the retail level. It has been argued that a well-defined electricity retail

tariff can serve the end consumers as well as retail competition. Most power systems that have introduced retail competition have maintained a default retail tariff that is defined by the regulator and offered by the incumbent distribution company, while a few have eliminated this regulated tariff. Many voices claim that regulated retail tariffs should be eliminated where retail competition has been introduced.

The questions debated during this session were the following:

1. Should regulated electricity tariffs be abolished in competitive retail markets?
2. And, for those countries that have not yet introduced retail competition: Do they need retail competition and to what extent?

The discussions in this session revolved around various aspects of electricity retail and went beyond whether or not retail competition is required. The need for a mature market, robust market design and a strong institutional set up were identified as the fundamental prerequisite for introducing retail competition. However, diverging insights emerged on the use of regulated prices to protect vulnerable consumers. On one hand, the need for some type of regulated prices for protecting vulnerable consumers was identified. On the other hand, an alternative view presented was to use schemes outside the energy sector to support the vulnerable consumer.

Key insights based on ranking were:

1. A well-functioning market and unbundled distribution/retail are preconditions for abolishing regulated tariffs. The process to achieve this should be gradual.
2. Vulnerable/poor residential customers should be helped but not via a regulated retail tariff. They should be helped via other schemes financed, where possible, out of the energy sector.
3. rather than abolish regulation altogether, we need to move from a classical to a differentiated regulatory approach, valuing the different characteristics of electricity, e.g. reliability.
4. For the introduction of an efficient retail market, some preconditions must be fulfilled such as the size of the market, generation mix, enabling technologies.
5. the move to a more sophisticated retail tariff structure is more straight-forward in emerging economies where a large portion of the customers had only been recently connected to the grid
6. Strong institutions required before opening retail market in developing countries
7. Regulated tariffs should be considered as a transitional measure to ensure a sufficient level of competition
8. Electricity is a basic need for life so there's a need for regulation as a back-up to protect vulnerable consumers, but we need to carefully identify consumers that really need protection

Summary by knowledge space chair Leigh Hancher | Florence School of Regulation

This panel focused on a key theme affecting the regulation of the energy market globally – the role of regulated tariffs at wholesale and retail level. In many countries, consumers are still dependent on a narrow choice of suppliers – if they have any choice at all. Indeed, many electricity markets around the world are not yet subject to competition and many markets may be too small (and in the case of islands, too isolated) to develop and sustain any real level of competition. Can competitive markets develop if such regulation is not abolished or can competition and some forms of retail price regulation exist side by side? The experience with full retail competition has not been uniformly positive and in some markets retail price caps have been re-introduced, most notably in the United Kingdom.

On the other hand, as the transition to renewables progresses in markets already open to some degree of price competition, the sale of energy as a commodity is not likely to be the key source of revenue for energy producers and suppliers: they will increasing diverge their activities in into adjacent service markets such as aggregation and energy efficiency services. Retail regulation may therefore also have to be re-directed towards ensuring energy services are offered on fair terms.

This also raises the question of who should regulate energy prices in the interests of vulnerable and/or captive customers. Should this be the national energy regulator or another authority such a consumer protection authority? How much independence should such institutions be given in practice to impose retail price caps? Finally there was considerable discussion as to the best means to protect consumers - either through retail price controls or through social contributions. Again, the choice came down to the stage of market development. There was general agreement that the process of removing retail regulation would have to be gradual.

2B) Unlocking the value of storage in market-based power systems

Chair: Robert Stoner | Massachusetts Institute of Technology

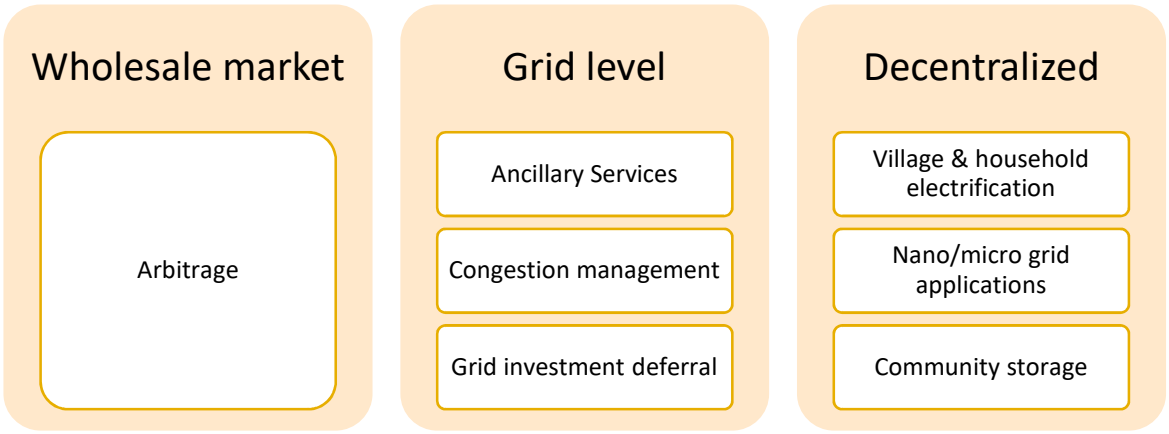
Motivator: Pablo Rodilla Rodriguez | Comillas Pontifical University

FSR Presenter: Pradyumna Bhagwat | Florence School of Regulation

A power system based on variable renewable energy needs the flexibility to keep the system in balance. Flexibility can be defined as the *"Ability of a power system to maintain continuous service in the face of rapid and large swings in supply or demand."* Storing electricity is one way of providing flexibility to the system. Electrical storage can be defined as any device that can store electrical energy and make it available when required. Therefore, it could be said that while "copper wires" transmit electricity over geographical distances, storage transmits electricity across time.

Due to rapid innovation, batteries or electrochemical storage devices are becoming economically viable for use in the power system. Batteries (utility scale or distributed) can participate in different segments of the electricity value chain (markets, grids and

decentralised level) as presented in the figure below. They have the potential to transform the power sector in the present time of digitalisation, decarbonisation and decentralisation.



The functional versatility of batteries makes it difficult to integrate them into the current regulatory framework. In order to unlock the full potential of this new versatile technology, several regulatory issues need to be addressed.

Allowing batteries to participate in competitive markets has the potential to improve the operational and economic efficiency of the system, as well as to provide new business opportunities. However, there is a risk of discrimination when two similar resources are treated differently, or two different resources are treated in the same way. Whether it is just a modification to the current market structures or implementing special markets, the solution lies in developing an approach that utilises the full potential of batteries while keeping the level playing field intact.

Apart from providing system flexibility, the possibility of using batteries for congestion management and grid investment deferral makes them an attractive proposition for either transmission or distribution system operators. However, in regions that are at an advanced stage of liberalisation and unbundling (especially Europe), the convenience of ownership of batteries by monopolistic firms has become a contentious issue. On the one hand, system operators are in an excellent situation – because of their expertise and knowledge of the power system – to make the best use of storage. On the other hand, system operators with storage could participate in market activities or could displace other flexible resources from providing services with economic value by giving priority to their own storage facilities.

In summary, the regulation of most power systems is presently inadequate to deal with the versatility of storage in providing a variety of services with economic value. Regulating storage in silos, i.e., as a generation, or load, or network asset impedes the development of storage to its full potential. This shortcoming is exacerbated by the increasing presence of distributed storage facilities deployed by private agents, whose potential value should not be ignored. This brings the additional problem of who can own storage to avoid potential conflicts of interest without jeopardising the effective deployment of this technology.

The questions debated during this session were the following:

1. How to unlock the value of storage in market-based power systems, both at centralised and distributed levels?

2. Should storage be allowed to participate in wholesale markets? Should the wholesale market rules be adapted to accommodate the presence of storage?
3. Should storage be allowed to compete in the provision of network services such as investment network deferral, both at transmission and distribution levels?
4. Who should be allowed to own storage and what services should this storage be allowed to provide?

The discussions highlighted firstly an ex-ante assessment for the need for storage in a particular system should be conducted. Secondly, it emphasized the necessity for the development of robust market design and regulation that eliminates barriers for storage to participate in various power markets, while limiting any distortions and market-power abuse issues. In the context of network operator ownership, the view appeared to be of allowing network ownership as a transitional measure while the market matures and as a last resort in the event of a market failure. Furthermore, the need for utilising the full potential of storage for optimising grid investment was also highlighted.

Key insights based on ranking were:

1. Regulators should allow storage providers to innovate and play in the wholesale and ancillary services markets, controlling for possible abuses of market power and manipulation.
2. Market design should enable storage without being technology biased
3. Regulation should ensure that storage enable optimisation of grid investments in large systems and in mini-grids as well.
4. The real requirements and needs of the system in question should be assessed prior to enacting regulation. Ownership, operation and lease of energy storage services by regulated entities should be on strictly regulated terms.
5. Storage will play a key role in providing flexibility to sector integration. Current issues linked to immaturity will be overcome with time. In this transitional phase, TSOs should own storage because intermittency given by RES still entails very high risks.
6. Storage shouldn't not be owned by grid operators except when the market can't deliver
7. The setting of access tariffs should be implemented carefully so as to avoid imposing double grid fees and thus discouraging energy storage deployment.
8. Nodal market would be better equipped to stimulate third party cost-effective investments but there are potential risks here – it would be dependent on competition law

Summary by knowledge space chair Robert Stoner | Massachusetts Institute of Technology

This session was concerned with the electrical energy storage on the grid. The regulation of storage generally is fraught, and it is not yet clear how we will deal with storage in markets as currently designed to enable further large-scale storage applications. Apart from pumped storage in some markets (notably parts of northern Europe), storage capacity is still very expensive and has so far entered the electricity system meaningfully only through ancillary services. Other valorisation opportunities - from network deferrals, operating reserves, and energy sales remain very challenging economically – arise only at relatively low levels.

Fortunately, in most markets we are far from reaching a situation in which a lack of storage on the grid substantially limits intermittent renewable deployment. The flexibility provided over timeframes of from seconds to years by hydro, and fast ramping turbines burning lower carbon fuels such as natural gas, is for the present time adequate. The North American and European trajectories may be very different as lower cost storage technologies emerge in the coming years: The US is a gas rich environment, whereas Europe is comparatively rich in pumped and stored hydro. What this means for the US is that even at very high levels of VRE's (> 60% capacity), absent strong policy favouring zero carbon alternatives, we may well see less grid-based storage and rather an increase in gas peaking plants to cope with daily and even seasonal wind and solar variability. No doubt gas peakers will play an important role in Europe as well, and as we were reminded in the "Renewable Gases" session on Day Two of the Forum, natural gas-hydrogen mixtures may emerge as an important lower carbon fuel. Electrochemical and thermal storage technologies must compete with this as a backdrop, and it seems likely that the emerging storage market with comprise many applications for which different technologies hold comparative advantage – although it is not obvious from our present perspective which technologies and at what cost.

Our table groups discussed the emerging need for storage in the grid at all levels, and debated how best to regulate it. A number of important themes emerged.

1. Regulation should be introduced with care to ensure competition, encourage intermittent renewable deployment, and minimize the added cost from storage on long- and short-time scales through advanced controls and demand response. This implies a need to avoid regulation favoring specific technologies.
2. Experimentation with new technologies should be encouraged in the near term to test cost and operating characteristics, and at sufficient scale to measurably impact operations.
3. Traditional prohibitions should be preserved such as barring generation (and by extension storage) ownership by wires companies. Indeed, one table went so far as to argue that storage should be regulated as generation when sourcing power, and as a load when consuming it, and therefore that no special regulation was required – although it was not completely clear how this could be achieved. Another table argued forcefully that TSO's should be allowed to own storage.

3A) Incentivizing the development of network resilience

Chair: Daniel Schmerler | Peruvian Regulatory Agency for Investment in Energy and Mining

Motivator: Piero Pelizzaro | Muncipality City of Milan

FSR Presenter: Carlo Papa | Enel Foundation

Humanity has already crossed three out of nine planetary boundaries that Rockström et al., (2009) argued must not be crossed to maintain a "safe operating space for humanity". In the near future, more thresholds will be crossed if we do not collectively pursue fundamental societal and systems transitions and transformations as pointed out in the last IPCC report. Scientists have come to realise that humanity has entered the "Anthropocene" era, a new geological era characterised by the influence of humans on the environment and climate, a new "normal" condition with increased hazard exposure and vulnerability.

This new normal is making its way out of the scientific realm and supranational organisations, and into government cabinets and boardrooms around the globe, starting to be factored in in strategic planning and daily operations. Firms are moving to a new operating environment that calls upon a holistic approach to resilience - defined as the capacity of a system to tolerate disturbances while retaining its structure and function – fully assumed with social responsibility by the business. Such a vision of a new normal requires awareness and preparation, and a consciousness that companies cannot isolate their operations from interdependencies with society, but rather, that business resilience depends on their embracing those dependencies.

Shaping a resilient future for business, such as the one involved in UN Private Sector Alliance for Disaster Resilient Societies ARISE, means aligning interests and informing debate and action plans. More specifically, facilitating the exchange of experience and knowledge on tangible disaster risk reduction projects – e.g. moving from Run-to-Failure Management to Preventive Maintenance, exploiting the full benefit of digitalisation, as well as promoting the adoption of innovative strategies, investment metrics/benchmarking and standards, and legal and regulatory frameworks incorporating the new normal vision.

Distribution Companies in the new operating scenario

Distribution companies, given their assets characteristics and dissemination, are indeed exposed to the new normal and, as top players in the industry, are already putting a tremendous effort into preparing their assets and organisation for the new operating conditions. Companies should, therefore, be incentivised not only to be cost-efficient in the short term but also to build resilient networks, especially in areas that are prone to experience extreme events.
Interventions to obtain higher resilience of distribution networks are of course (i) technical, such as design and size of cables and pylons, cooling of transformers, protecting substations from floods, realising new transversal remotely controlled lines, and (ii) organisational, such as smart mapping of the network and preventive alert systems.

Regulation and Insurance, as demonstrated recently in Australia and California, play a pivotal role. Some progressive regulatory bodies have already started to wisely interact with assets owners/operators in the electricity distribution sector on how to better prepare for the new normal scenario, and indeed have proven to be a dramatic force to start unlocking the value of resilience embedded in regulation.

Remuneration of distribution networks is usually strictly regulated. It is therefore necessary that Regulatory authorities recognise the need to take resilience into account, and the required investments to obtain it. This can happen at different levels:

- Institutional, through laws, which, in the public interest, establish appropriate remuneration schemes (check out the Finnish case, where, following blackouts provoked by snowstorms, specific incentives to DSO investments in resilience were introduced) or require independent regulatory authorities to consider resilience as a relevant topic.
- Regulatory, for example by:
  - modifying the systematic risk (ß) of distribution companies in case of RAB-based remuneration schemes;
  - introducing specific categories of recognised costs in case of remuneration schemes based on yardstick competition or approaches like the UK RIIO (Revenue = Incentives + Innovation + Outputs), designed to stimulate investments needed to address specific issues;
  - considering the possibility to reflect the new normal operating condition in the evolution of tariff components covering capital costs with specific reference to the rate of return on invested capital calculated as weighted average cost of capital (WACC);
  - Introducing specific rewards/penalties output-based schemes taking into account the timely completion of investments for resilience, as recently defined by the Italian Regulatory authority.

The questions debated during this session were the following:

1. In your experience, what are the technical characteristics of the power network capable of enhancing resilience at best?
2. Do you think that policies are sufficiently and holistically taking into account the benefits of resilience with appropriate cost-benefit analyses?
3. Do you think that financial tools and regulatory schemes should be specifically tailored to develop network resilience? Which are the most appropriate and likely to succeed schemes providing a long-term view, appropriate remuneration and protection from risk?

The discussion identified that current policy and regulatory framework should shift focus on encouraging network resilience instead of its current focus on only reducing cost. The discussion also highlighted the need for a common valuation methodology of risks and resilience, as well as the comprehensive resilience plan in collaboration with multi-stakeholders. Regarding schemes to cover the cost of resilience, two approaches have been put forward - adaptation fund that is sourced from polluters, and joint insurance fund for disasters.

Key insights based on ranking were:

1. Existing regulation is too focused on reducing the cost of service provision. We need to shift towards regulation of network companies that encourages investments into resilience and reflect quantification of associated risks and benefits.
2. Digitalization, distributed generation, diversification and redundancy are the most efficient tools to adopt in a holistic approach to network resilience.
3. Creation of an adaption fund sourced from polluters to reimburse extra costs consumers incur due to resilience investments

4. Need for enhanced collaboration between research community, governments and investors in establishing a common valuation methodology of risk and resilience.
5. Generation, transmission and distribution companies who hold on-the-ground technical knowledge should be mandated to develop specific/comprehensive resilience plans, which should be incentivized and reviewed by the regulator.
6. Solidarity at societal +regulatory/ financial level: set up an equivalent of 'electriciens sans frontier' – joint insurance fund for disasters – a regulatory scheme tailored to N-1 standard.
7. Policies are not sufficiently taking into account the benefits of resilience; however, cost benefit analysis is premature at this moment.
8. Clear definition of the new "normal" as well as what accounts for extraordinary conditions and who should cover the costs for each. Greater clarity of roles and responsibilities of all stakeholders including the regulatory authority.
9. Awareness: Use data analysis to define and manage the risks.

Summary by knowledge space chair Daniel Schmerler | Peruvian Regulatory Agency for Investment in Energy and Mining

Resilience is a crucial aspect of the electric service quality. A resilient energy system is one that can quickly recover from large shocks, by providing various means to supply energy whenever there are changes in external circumstances. On the one hand, companies need to make investments to guarantee resilience in the system and these investments are linked to key financial aspects. Tariff schemes, concession contracts and supervisory mechanisms, must incorporate this variable efficiently. On the other hand, interruptions (scheduled or unscheduled) have strong impacts on both commercial and industrial consumers. In this line, companies have to operate with a holistic approach that includes all the impact on society, being aware of the impacts on social welfare.

The main conclusions to which the group of participants arrived were these:

- From phenomena occurring in the near past, it is becoming more and more evident the strong influence that humans have been doing over the environment. So, new challenges and risk appear urgent to consider in the public policy.
- In this sense, it is necessary to change the approach of regulation to encourages investments into resilience. The new regulations could include digitalization, distributed generation, diversification and redundancy as efficient tools in a holistic approach about this problem.
- Investment in resilience mechanisms must come from a fund whose resources come from the pollutants. In order to make such investments, close collaboration between various members of the society is necessary: academia, the private sector, governments, regulatory agents. It is necessary to incentive solidarity at a societal level and between all the agents including regulatory, financial and energy firms, in order to take a fund to disasters.
- One specific topic of collaboration is the shape of an appropriate methodology of valuation of risk and resilience that it considers an efficient valuation of cost and broad perspective of benefits of resilience policy. One of the outcomes of this methodology should consider appropriate definitions in order to have a database to improve the managed of risk…

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- With the outcomes of this valuation, the companies in all the stages in the energy chain valued should be mandated to develop resilience plans and these plans must be supervised by the energy regulatory agency.

3B) Regulatory challenges of distribution networks with distributed resources

Chair: Annegret Groebel | Bundesnetzagentur

Motivator: Julian Barquin | ENDESA

FSR Presenter: Pradyumna Bhagwat | Florence School of Regulation

Regulating distribution networks must reflect the need for innovation and the numerous changes brought about by the impact of decentralisation, digitalisation and decarbonisation of the power sector (3Ds). In particular, the presence of distributed energy resources (DER) – including flexible demand, distributed generation, energy storage, and advanced power electronics and control devices – in the distribution grids is creating numerous challenges and business opportunities. The rapid advancement of information and communication technologies (ICT) is enabling consumers to respond to the power system conditions, expressing their preferences and actively participating in the provision of electricity services with economic value. Furthermore, the 3Ds are not mutually exclusive, as has been illustrated by MIT (2017), thereby adding to the complexity.

Regulators should identify unnecessary barriers and distortionary incentives that presently impede the efficient evolution of the power sector in the presence of DERs, and provide a framework that will enable an efficient outcome regardless of how technologies or policy objectives develop in the future. In this session, two key regulatory challenges will be examined: tariff design and the participation of DERs in the electricity markets.

Distribution remuneration and tariff design issues:

The determination of the revenue requirement of distribution companies has acquired a much higher level of complexity with the presence of DERs. It cannot be determined any more on the basis of the volume of energy that is distributed. Ignoring the impact of the presence of DERs negatively impacts the revenues of the distribution companies to such an extent that their business models are at risk, thus causing a push back from these firms towards the massive installation of DERs.

Moreover, maintaining the traditional methods of tariff design and the standard meters in the presence of DERs results in inefficient and socially unacceptable cost shifting among customers. Therefore, it is necessary to develop a network tariff design that recognises this new reality, leading to an efficient trade-off between cost reflectivity and fairness. Fairness issues become prominent in the allocation of “residual costs” that cannot be assigned using cost causality principles. Incentivising grid defection because of flawed tariff designs should be avoided. Novel solutions, including the use of general taxation for recovering residual costs, have to be considered.

Barriers to DER participation in the electricity market

The use of fast-responding resources such as batteries for balancing services has the potential to improve operational and economic efficiency and thus to lower the electricity cost. This is just one example of the potential contribution of DERs to the efficient provision of power system services with economic value. The design of electricity markets has to be revisited and modified where required to ensure a level playing for these new resources.

Day-ahead, intraday and balancing markets should enable participation of DERs. However, market structures may not be adapted yet, and they would need to be modified to allow the utilisation of such technologies. There are some examples where changes are necessary to include bid sizes, time granularity, product definition, trade-offs between continuous and bilateral trading in intraday markets, or asymmetric balancing auctions. This issue is technically complex and requires immediate attention.

In summary, the presence of Distributed Energy Resources (DERs) in the distribution networks requires regulation to address the classical problems under a new more complex perspective.

The questions debated during this session were the following:

1. How to determine the efficient revenue requirement for a distribution company with large penetration of distributed generation, storage and/or demand response?
2. How to mitigate or eliminate the pushback from distribution companies towards the massive installation of DERs?
3. How to combine efficiency, fairness and equity in the design of electricity regulated charges and market prices?
4. How to create incentives for the individual agents that own the DERs to contribute to the efficient operation of the electricity markets?

The discussion identified that for unlocking the potential of DERs it is necessary to have cost reflective tariffs and remove barriers for DER participation in the organised electricity markets. In the context of incentives, the importance of rewarding system flexibility was identified. One approach discussed was to incentivise DSO for procuring flexibility using a TOTEX approach. Another approach identified was to allow DSOs to build the local infrastructure and be remunerated via the DERs market value. From a regulatory perspective, before incentivising DERS, important issues highlighted were the need for precise definitions for DER and its role, reviewing support schemes and incentives periodically (with gradual elimination), consider the development of grid while designing network charges and levies.

Key Insights based on ranking were:

1. A move towards TOTEX remuneration scheme for fully unbundled DSOs to incentivize flexibility procurement.
2. Remove the barriers faced by final customers and new customers intermediaries (Aggregators and Citizens Energy Communities) for the access to organised electricity markets.
3. A regulatory framework that allows the periodic and dynamic review of the renewable support schemes to have a gradual elimination of subsidies
4. The structure of network charges and levies should take into account the state of development of the grid (developed vs developing countries). DERs should contribute to the cost-recovery of the grid.

5. Before addressing incentivisation of DERs it's important to acknowledge their visibility in operations and connection to the network. Information transparency is thus key and can be enhanced via platforms.
6. Local flexibility provided by DERs should not be disconnected from larger electricity markets.
7. System flexibility should be rewarded to incentivise investment in demand response and storage, and penalised to deter irresponsible customer behaviour
8. Ensure cost reflective tariffs and consider innovative approaches to enable DER – consider combination of time varying, volumetric and capacity based pricing approaches
9. A good model to incentivise DSOs consists in letting them build local infrastructure or getting remunerated via the DERs market value.
10. The incentives to demand response mechanisms (e.g. storage, prosumer) has to be defined by the regulators as priority.

Summary by knowledge space chair Annegret Groebel | Bundesnetzagentur

The session started with the Chair, Dr Annegret Groebel of CEER/Bundesnetzagentur, welcoming everyone and making a few points about distribution networks with distributed resources (DER). Dr Groebel noted that there is a rise in the amount of distributed generation, which can be advantageous if it coincides with demand but can require grid reinforcement. DSOs can procure flexibility instead of grid reinforcement, and DER will likely be part of Citizens Energy Communities/Renewable Energy Communities. She noted that the Clean Energy Package appropriately focused on some of these issues. She also mentioned that CEER had just published a conclusions document entitled "New Services and DSO involvement".

Next, the session Motivator, Dr Julián Barquín of Endesa, gave a presentation entitled "Distribution Networks and Distributed Resources". His presentation questioned how regulation must adapt to a new world of technologies and uses, such as active demand and active metering technologies, in the context of an expansion of the areas in which technology is used. For example, one can look at the electricity price and consider what it should take into account: not only energy costs, network tariffs and taxes but principles such as efficiency and equity as well as societal groups. Dr Barquín saw five main issue areas for consideration, pointing out some of their specificities:

1. Multiple goals of tariff design in light of more diverse electricity usage;
2. Who pays for policy charges and levies, give their distortionary effects;
3. Optimal network pricing with large-scale smart meter roll out;
4. Distribution remuneration – which schemes are best?;
5. New issues related to DER selling power and ancillary services.

Next, the FSR Presenter, Dr Pradyumna Bhagwat, presented on "Regulatory Challenges for Distribution Networks with DERs". Dr Bhagwat noted the new paradigm of an ever more complex, multi-directional power system and that the regulatory challenge lies at the intersection of distribution remuneration/tariff design issues and barriers to DER integration into the market. He then proposed the discussion questions.

National and regional power market integration for emerging economies

There is a trend in power systems towards integration into larger entities. Integration may take place at inter-state or inter-utility levels in large countries such as India, China, or the USA, but also across political borders as in the European Union, Central America, South East Asia, the Gulf Cooperation Council, or Southern, West, East or Central Africa. Increased integration of network infrastructure and trade can enhance energy security, bring economies-of-scale in investments, facilitate financing, enable more extensive deployment of renewable energy resources, and allow synergetic sharing of complementary resources. All these countries have benefited from the integration to a certain extent, depending on the political will to operate and expand their systems jointly, and the corresponding level of development of the regional market rules.

The success of regional power markets in many emerging economies is constrained by various factors, mostly related to the weakness in institutional governance, the inadequacy of regulatory framework and the flaws in regional market rules. Specifically, these include:

- Regional institutions lacking sufficient power and competence
- Unharmonized legal and regulatory regimes
- Unharmonized technical standards and network codes
- Inadequate regulatory governance for managing shared transmission network, dispute resolution, licensing, tariff design and cost allocation
- Misalignment of national and regional policies and investment decisions
- Uneven level of market opening of national electricity markets
- Lack of (or inefficient) short-term energy markets
- Inefficient use of physical bilateral contracts

These issues are frequently exacerbated by weak regional economic integration and unstable political contexts. Inadequate power generation and network infrastructure, as well as the poor performance of power utilities, remain barriers for the effective and efficient operation of regional power systems.

Within this context, three sessions of the forum (4A, 5A and 6A) will be devoted to discussing reform strategies, institutional setup and market design issues related to regional power market for emerging economies.

4A) Establishing priorities in regional power market integration for emerging economies

Chair: Honoré Djamah Segui Bogler | ECOWAS Regional Electricity Regulatory Authority Ghana

Motivator: Alberto Pototschnig | Agency for Cooperation of Energy Regulators, Florence School of Regulation

FSR Presenter: Samson Yemane Hadush | Florence School of Regulation

There is an urgent need to establish well functioning regional markets that can make use of economies of scale and coordination of dispatch in generation, as well as region-wide reliability support. However, the creation and success of regional markets require the participation of national markets, which must get internally ready to accept regional trade of production and supply and to open their networks to external agents. Trade opportunities, the liquidity of the energy markets and the level of efficiency in the coordination of resources will depend on the level of adaptation of the national market rules to the adopted regional market design.

Regional power markets in emerging economies have generally been introduced in a context where the national markets are not open. In many of these countries, national markets are still dominated by state-owned vertically integrated monopolies; tariffs are politically set and highly subsidized; generation is too small to fully benefit from economies of scale; network infrastructure is insufficient; regulatory institutions are weak and ineffective, and a large part of the population still lacks access to reliable and affordable electricity. These flaws have an adverse impact on the functioning of the regional power markets. Conversely, the existence of a regional market can help in addressing these national shortcomings.

This session will focus on the objective of encouraging the establishment of well-functioning regional power markets.

The questions debated during this session were the following:

1. Should countries prioritise the reform of their respective national energy markets before engaging in regional energy markets? To what extent?
2. What are the institutional and regulatory arrangements needed to sustain and optimise the selected reform strategy?

The discussion focused on the prioritization of reforms of national and regional markets and how the integration process should be undertaken. In terms of prioritization, it was noted that integration of national/state markets could go in parallel with national/state reforms. The process of integration could start from a bilateral trade by setting minimum requirements on commercial settlement, dispute resolution, coordinated system operation, and cross-border cost allocation. However, the discussion also identified that the effectiveness of the integration depends on the size of the market, political commitment, generation and cross border capacity, demand and third part access.

Key insights based on ranking were:

1. Overarching political consensus with the adoption of a regional framework with binding processes for commercial settlement and dispute resolution. A regional regulator with authority over national regulators is helpful but not essential.
2. Political will is essential as a first step to engaging in regional markets with rules that allow for a gradual approach
3. Start bilaterally. Bare minimum requirements: coordinated system operation, settlement, dispute settlement and cross border cost allocation. Harmonisation of regulatory requirements happens gradually.
4. Market liberalization is not a precondition but there should be a way of comparing marginal costs in the different constituent areas to avoid electricity to go in the wrong

direction and utilizing transmission capacity to facilitate market trading in addition to bilateral trading

5. Irrespective of whether a national or regional market comes first, certain criteria need to be met: size of the market, political commitment, sufficient capacity and demand, third party access etc.
6. Don't wait for national reform, political goals and maturity of countries are different. Start integrating directly, there are always benefits.
7. There should be some degree of liberalization (gradually growing) with common rules at national/state level for regional markets to work
8. The existence of a national regulatory agency can be beneficial, but it is not a precondition, and can be replaced through sufficient delegation of powers to regional authority.
9. Some common regional renewables goals will drive further integration.

Summary by knowledge space chair Honoré Djamah Segui Bogler | ECOWAS Regional Electricity Regulatory Authority Ghana (ERERA)

Mr. Alberto Pototschnig started his presentation by putting a light on the limited development of cross-border transmission capacity, due to a traditional reluctance to trade electricity across borders compared to other goods which are storable. He indicated the different aspects of regional electricity markets such as the reasons for regional electricity markets, the design of the regional electricity market and integration, the barriers to regional electricity market integration and the pre-condition for regional market. He finished his presentation on the EU experience of regional electricity market integration and its benefits and efficiency.

The presentation made by Mr. Samson Yemane Hadush showed what could be the benefits of regional power sector integrations (like energy security, economy of scale, financing facilitation), stating that " the deeper the integration, the larger the benefits are". However, he mentioned that most of the national markets are not yet ready for integration as they face several flaws calling for prioritization in the needed reforms. Afterwards, the discussion questions were submitted to the participants.

Based on the 3 top insights, the overall outcome of the session is that the establishment of a regional integrated power market need a strong and overarching political will and the adoption of a regional framework with binding processes for commercial settlement and dispute resolution. But a regional regulator is not essential even if helpful. The approach for the establishment of a regional integrated market shall be gradual and shall start bilaterally, then evolve with a minimum of requirements related to coordinated system operation, commercial settlement, dispute settlement, cross border cost allocation, and gradual harmonization of regulatory requirements.

5A) Enhancing the effectiveness of regional power market institutions for emerging economies

Chair: Ignacio Pérez-Arriaga | Florence School of Regulation, Massachusetts Institute of Technology, Comillas Pontifical University

Motivator: Pradeep Pujari | Central Electricity Regulatory Commission India

FSR Presenter: Samson Yemane Hadush | Florence School of Regulation

Regional integration of national markets can bring the benefits of economies of scale, market coordination, and reliability enhancement to the typically weak power systems of emerging economies that happen to be neighbours, with a clear trickle-down impact on quality of supply and universal electricity access. However, the benefits of integration are frequently hampered by the lack of strong regional institutions and flawed regulation. These regional markets could be made stronger and more effective with adequate regulatory enhancements and an upgrade of the executive power and responsibilities of regional institutions: a regional regulator, system operator and market operator.

The major challenge in the design of regional markets is to pool together the generation resources to meet the regional demand efficiently and to plan the expansion of electricity production and the interconnected network jointly while preserving the autonomy of each individual country or state as much as possible.

In this session, we shall focus on the institutional aspects of regional markets and the design of sound rules to share the costs of the network interconnections that make regional trade possible.

The questions debated during this session were the following:

1. What responsibilities should be assigned to the regional regulatory authority and to the regional system operator?
2. How to make regional institutions effective in helping realise the required coordination in planning and investment decisions?
3. How to allocate the costs of “regional transmission projects” (i.e. those transmission links – whether crossing borders or not – that facilitate cross-border trade)?

The discussion on strengthening regional institutions debated as to how the regulatory body should be formed - as association, forum, authority or agency? Some argued an authority rather than an association is required while others argue that it not necessary if there is enough cooperation among national regulators. It was also noted that this decision should consider the ambition of the regional market which could be a cross-border trader that only requires seams management or integrating markets that requires some minimum level of harmonization of national regulations and adequate regulation to ensure a level playing field. The discussion also covered the issue of cross-border cost allocation in which case it was suggested that the cost could be borne by the country the asset is located with financial reconciliation in case benefits are disproportionate.

Key insights based on ranking were:

1. First-best is a regional regulator. Key point is independence, only possible through 1/ budget coming from tariffs not national politics 2/ Independent hiring of staff. Depending on the region, only a regional forum is possible.

2. Building up effective regional institutions to realize the required coordination in planning and investments would evolve from strengthening national institutions and cross-national coordination.
3. The efficient management of a regional power market does not require a regional regulatory authority if sufficient cooperation is ensured among the national regulatory authorities. A regional system operator may be needed in a large synchronized market.
4. Regional system operator in charge of system planning and basic operation while regional authority sets rules on the optimal use of transmission lines especially on cross-border issues as well as system operators monitoring.
5. Cross-border trade requires only seams management. Integrating markets requires more: leveling the playing field through harmonising national regulation and policy to a feasible extent.
6. Basic principles of who benefits pay for the transmission lines. Commercially funded lines may be required to be backed by transmission service agreement.
7. A balance in responsibilities between the regional regulatory authority and the central governance body has to be found (EC+ACER *versus* central American regional regulator models).
8. As a simple starting position, cost of transmission lines should be borne by the country they are located in, but where benefits are disproportionate, financial reconciliation may be required

Summary by knowledge space chair Igancio Pérez-Arriaga | Florence Sschool of Regulation, Massachusetts Institute of Technology and Comillas Pontifical University

The main obstacles to achieving the known benefits of well-designed power pools were identified during the session: ineffective regional governance, lack of capacity of the interconnections, and flaws in the regional trading and network cost allocation rules. The debate focused on how to remove these obstacles or at least to mitigate their impact.

In emerging economies, the existing power pools generally lack executive powers in the two key regional institutions: the regional system operator and the regional regulator. These institutions are generally too weak and ineffective. This weakness results in the absence of transmission planning at regional level or, when it does exist in some form, it is not enforced. The weakness of institutions also results in lack of harmonization in other aspects where it is necessary: regional market rules, capacity mechanisms, incentives (to renewables, efficiency programs, etc.). Regional-wide regulation is necessary to mitigate some persistent risk factors in long-term contracts when established among parties in a multinational power pool: i) hedging price differences between countries; ii) regulatory intervention in scarcity situations; iii) uncertainty in the determination of transmission charges. Poorly designed or uncertain transmission charges are barriers that make difficult financing the necessary investments in transmission network infrastructure.

A deterrent for investors in cross-border transmission lines can be the lack of a sound commonly agreed procedure to allocate the transmission costs and, consequently, the risk of not receiving an adequate economic compensation. Insufficient transmission capacity impedes the installation of large existing hydro, solar and wind resources…

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There are proven regulatory solutions to address all these regulatory issues. In this case, the experience in the implementation of the EU Internal Electricity Market (IEM), with all necessary adaptations to the conditions of the power pools in emerging economies, has a significant value. Rules such as "beneficiary pays" (applied to interconnection infrastructures) or "transmission charges must not depend on commercial transactions", have been successfully implemented in the IEM and have universal validity.

The goal in the design of a power pool is the Single Market Paradigm, i.e., the outcome of the regional regulation should approach as much as possible a sound regulation for a single system of the regional dimension. When the prevalent rules of the operation of the pool prevent that this happens, efficiency and security of supply deteriorate. In power pools of emerging economies, typically poor implementation of physical bilateral contracts distorts the economic dispatch of generation & demand. Resistance to accept security of supply at regional level impedes that firm cross-border contracts have dispatch priority in emergency situations, undermining the willingness for joint construction of large power plants.

6A) Transitioning to a more efficient and competitive power market in emerging economies

Chair: Anton Eberhard | University of Cape Town

Motivator: Cathy Oxby | Africa GreenCo

FSR Presenter: Samson Yemane Hadush | Florence School of Regulation

Regional power markets in emerging economies are often characterised by lack of efficient short-term energy markets as most transactions are dominated by long-term bilateral contracts (usually in the format of power purchase agreements, PPAs). Regional markets supplement these PPAs with short-term markets. In this regard, two serious challenges have to be addressed. In the medium and long terms, bilateral contracts face the risk of default by the off-takers. In the short term it happens that the bilateral contracts are inefficiently dispatched, ignoring the economic prices derived from the short-term energy markets.

Regarding the first challenge, it will be interesting to closely follow the performance of some new regional players that are emerging to mitigate the risk of private independent power producers and off-takers, as well as to contribute to the development of competitive regional power markets by increasing the liquidity and scale of regional power trade. Examples of such new players include Africa GreenCo in Sub Saharan Africa, which positions itself as a creditworthy intermediary off-taker (Aggregator) and power pool participant (Trader). In more advanced markets, companies such as the Power Trading Corporation of India (PTC India) have been successful in acting as catalysers in the development of regional power trading markets.

To capture the full benefit of regional integration, the transition of emerging economies towards a more efficient and competitive power market requires due attention.

The questions debated during this session were the following:

1. How should cross-border physical bilateral contracts be efficiently dispatched through a market mechanism?
2. What is the role of intermediaries in attracting investment and facilitating power trade?

The discussion focused on mechanisms to improve the market efficiency in a context where the market is dominated by long term power purchase contracts and the role of intermediaries to achieve this. Contracts for differences and decoupling of financial and physical commitments of PPAs have been identified as approaches to increase the market efficiency. The discussion also highlighted the crucial role intermediaries can in facilitating trade and attracting investment by aggregating PPAs and reducing financial risks and improving the liquidity of the market.

Key insights based on ranking were:

1. Creditworthy Intermediaries give certainty of revenue stream which help attract investments. Intermediaries also facilitate power trade/multi-buyer multi-seller transactions, serving as a stepping stone to a more liquid market.
2. Contract for differences (CFDs) could help increase market efficiency and trading flexibility even in contexts where long term power purchase contracts are dominant.
3. To reach efficient dispatch, financial and physical commitments of PPAs need to be decoupled. A CfD is necessary which in its turn requires secondary markets (ranging in complexity depending on the existing arrangements).
4. Intermediaries aggregating PPAs are necessary. Both for generation to deal with intermittency and market risk but also for demand to be able to profit from economies of scale.
5. Intermediaries are crucial to cover financial risks and making the market more liquid and involving the local financial and regulatory institutions.
6. National reforms should introduce unbundling and provide third party access to non-utility generators and customers as the first step to move towards short term energy markets
7. Consider trade-off between short term market efficiency and ensuring long term generation and transmission capacity adequacy.

4B) The role of indicative planning in the ongoing economy electrification process

Chair: Giuseppe Montesano | Enel Foundation

Motivator: Szilvia Doczi | International Energy Agency

FSR Presenter: Swetha RaviKumar Bhagwat | Florence School of Regulation

Never has the energy system been as versatile as today. With the world economy growing and the standard of living improving, there is greater use of devices and services powered by a diversity of energy sources. Superimposed onto that diversity, there is a growing universal effort towards achieving a rapid decarbonisation of the economy. The electrification within and across sectors can play a critical role in the transition to a decarbonised economy. This

creates the need for more systemic thinking, one that proposes an 'integrated approach' or 'cross-sector nexus' or 'sector-coupling'.

Sector coupling is defined by BDEW (German Association of Energy and Water Industries) as

"the energy engineering and energy economy of the connection of electricity, heat, mobility and industrial processes, as well as their infrastructures, with the aim of decarbonisation, while simultaneously increasing the flexibility of energy use in the sectors of industry and commercial/trade, households and transport under the premises of profitability, sustainability and security of supply".

Trying to achieve the decarbonisation goals on time means that no sector (power, transport, buildings and industry) can be ignored. We need to widen the range of options being used, including attaining a fully networked system providing security of energy supply and system flexibility, and the active engagement of consumers, which goes beyond the current sector-specific approach. Electrification across sectors could be achieved through direct and indirect measures using appropriate 'power to x' or 'x to power' pathways. Other pathways such as carbon capture and storage and energy efficiency could complement the efforts.

The table below presents an overview of challenges from three different perspectives to be met in the process of electrification of the economy:

Challenges to electrification of the economy	
Planning & Operation	• Forecasting electricity demand in an increased electrification scenario • Coordination of the various sector agencies • Cross-sector system planning and operations • Enabling use of digital interfaces.
Technology	• Technology choices for electrifying: size of application and conversion efficiency • Direct electrification versus power to X model • Integration of digital platforms
Policy & Regulation	• Integrated policy vision • Clear measures for promotion and integration of renewables • Incentives for digitalisation, decentralisation, flexibility and energy efficiency • Incentives for promoting innovative business models

Notwithstanding the challenges, it appears that the future economy will become increasingly electrified with stronger coupling among key sectors linked by the common goal of decarbonisation. The process might be left to market forces under the stimulus of a carbon price or the need to meet some prescribed targets in each sector. In any case, an overall vision or perspective could be facilitated with indicative planning encompassing all relevant sectors.

The questions debated during this session were the following:

1. Is indicative planning necessary to provide a long-term vision of the coupling among sectors and the achievement of the common decarbonisation objective?
2. How to make use of the insights provided by indicative planning? Just information? Should "indicative" planning results be transformed into regulation to guide towards specific objectives for each sector?
3. How "intrusive" should regulation be? Only price signals (e.g. the price of CO2) or also targets (e.g. on the penetration of clean technologies) or limits (e.g. car emissions)?

The participants recognized that indicative planning is necessary, and it shall set clear goals and comprehensive rules to the implementation needs to involve all levels of governance and timing. It should be supported by proper pricing of externalities to promote more efficient and effective achievement of green electrification. However, where incentives don't work, mandatory targets are required, and they should be set based on a fair and transparent assessment and with the support of the government and stakeholders before being formally adopted.

Key insights based on ranking were:

1. Indicative planning is necessary, it shall set clear goals and comprehensive rules to the implementation, needs to involve all level of governance (e.g. state, regions, and local authorities) and timing.
2. Pricing externalities is a good way to link different energy sectors and promote a more efficient and effective achievement of green electrification.
3. Some mandatory targets are necessary to achieve the benefits of electrification; however, such targets should be based on a fair and transparent assessment and have the support of the government and the stakeholders before being formally adopted.
4. Indicative planning should translate into regulation enabling market development until technology matures. Mandatory targets might occasionally be needed, when incentives do not work.
5. Targets can be effective if a multi-stakeholder approach exists towards arriving at international standards to avoid market distortion and achieve fair competition
6. Demand reduction and efficiency across the sectors you intend to couple should precede indicative planning and be part of it. We need complementary policy instruments.
7. Complement long-term indicative planning with a short-term target for certain sub-industries (e.g cement, steel, etc…) and provide incentives.
8. Long-term planning for decarbonization have to use "indicative" and "intrusive" mechanisms, as optimal but intrusive should be considered as a last resort and consider a social impact assessment of the measure.
9. Entire planning process needs to be redone as often as possible (e.g. every 1 year) to keep up with new technological and market trends.

Summary by knowledge space chair Giuseppe Montesano | Enel Foundation

Why electrification

Electrification of the economy is a global trend clearly shown, among others, by data and analyses performed by the International Energy Agency.

The profound reasons of such a trend lie in the fact that electrification can improve access to energy and affordability of energy supplies. Moreover, electricity is the life-blood of new technologies and digitalization, bringing clean energy to consumers in a flexible way and paving the way to an ever more efficient use of energy. This is even more evident as long as electricity is generated by clean energy sources like renewables, which are indeed substantially increasing their contribution in most geographies thanks to dramatic cost reductions, which make them competitive with other sources.

It is therefore clear why policies for decarbonization, air quality & health, and energy efficiency should leverage the benefits offered by electrification. On these premises, the knowledge space addressed whether ensuring that energy is correctly priced in a market environment may be sufficient, or planning should play a role to enable electrification and therefore reap its benefits.

Planning vs price signals

Optimization is the keyword, which came out quite consistently from the discussions at the tables. In a nutshell, pricing definitely has a fundamental role and should include environmental externalities related to both climate change and air quality. Subsidies to fossil fuels, as well as taxes and levies unduly burdening electricity bills, should be avoided.

However, pricing should be complemented by planning elements, which can take various forms, including indicative targets, mandatory targets, standards.

The Paris Agreement and, in many respects, the most recent EU clean energy package may be considered as falling in the category of indicative planning. Although they do not set binding targets for individual states, policies are effectively informed by mechanisms, which establish some sort of control over the ambition, which is necessary to reach common goals.

Mandatory targets have proven, in certain cases, to be effective in stimulating and accelerating technology development. An example are the programs for the development of renewables implemented by several European countries in the recent past. Although limited in terms of cost efficiency, they have been able to boost the development of certain technologies and ultimately reduce their costs and make them competitive. Standards may be necessary to overcome behavioural and in general non-economic barriers and accelerate the phase out of inefficient technologies.

In any case planning should be flexible and include mechanisms allowing for adjustments over the years. The right blend of pricing and planning elements is very much dependent on the contexts. Great care in building consensus among stakeholders was widely and strongly recommended by participants.

5B) Unlocking the potential of electric vehicles in the power system

Chair: Alberto Pototschnig | Agency for Cooperation of Energy Regulators, Florence School of Regulation

Motivator: Edwin Edelenbos | Netbeheer Netherland

FSR Presenter: Swetha RaviKumar Bhagwat | Florence School of Regulation

The concept of electric vehicles (EVs) has been around since the beginning of the automotive industry. However, in recent years the interest in EVs has intensified. This interest is due to a confluence of factors: environmental concerns – mainly the air quality of the cities and climate change –, technological innovation in batteries, and fear about increases in oil price.

Here, EVs are understood as "plug-in electric vehicles" (PEVs), including plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (BEV). EVs are not limited to cars, but also include 2-wheelers, 3- wheelers, vans, light trucks, motorcycles and buses. Presently the major change is perceived to be occurring in the passenger car segment. Market penetration of electric vehicles will depend on many uncertain factors before it reaches a tipping point. The present trend appears to indicate a rapid increase in the coming years.

About one in every hundred cars sold today is powered by electricity. The yearly sales of EVs in the EU, considering both battery and plug-in hybrid, has increased from roughly 700 vehicles in 2010 to 149,500 in 2015. Globally, the threshold of 1 million electric cars on the road was exceeded in 2015, finishing with 1.26 million at the end of the year. Considering the automotive industry at large, the numbers may seem insignificant, but the trend indicates that the penetration of electric vehicles will increase rapidly in the coming years. All of this has pushed the automotive industry to innovate and has made e-mobility the new buzzword.

The rising number of electric vehicles has created concerns regarding its potential impact on the power system. The system may be put at risk due to significant growth in electricity consumption and the increase in the unpredictability of consumption patterns owing to vehicle charging. Yet, electric vehicles could become a solution rather than a problem by contributing significantly in offering flexibility while integrating variable renewables into the system. Apart from the system level benefits, permitting EVs to participate in the electricity markets would present new revenue generation opportunities for vehicle owners. This, in turn, would further improve the business case for EVs by reducing overall costs. Thus, in this context, EVs can be considered as a distributed energy resource (DER).

Going beyond the notion of EVs being just additional demand, the interaction of EVs with the electricity system can be broken down into 4 levels of engagement.

- V2G (Vehicle to Grid) – for ancillary services, peak shaving, voltage control, congestion management, and smart grid management.
- V2B (Vehicle to Buildings) – offers flexibility at the community level and smart building management.
- V2H (Vehicle to Homes) – offers back up resources for different levels of consumption.
- V2L (Vehicle to Load) – can be an off-grid resource for remote consumption.

However, the integration of EVs has several challenges, ranging from technical, planning and operational, policy and regulation. They are listed below.

Planning & Operation	• Charging infrastructure • Smart energy management systems • Coordination of charging infrastructure design and manufacturing segments
Technology	• Battery innovation (lifetime and costs) • Different charging speeds • Bi-directional charging infrastructure
Policy & Regulation	• Setting of standards for charging infrastructure and safety norms • Clear electric mobility policy to enable market participation • Attracting the right investments to activate the market. • Right incentives for early adoption of EVs • Pricing of EV charging and selling of electricity • Clarity on the role of EV when acting as storage in the market design

When these vehicles are idle or parked, they may be viewed as a distributed storage resource (similar to a stationary battery, with some additional limitations) that can be used to provide flexibility to the system.

However, the primary function of EVs is to provide a sustainable alternative for transportation. Thus, EVs can be considered an unreliable resource that is dependent on consumer behaviour and some external factors. Some examples of this dependence are limitations in the time of use of the EVs, requirements on the charging times, constraints related to the ownership of EVs, and availability of the charging infrastructure. Therefore, for EVs to become flexibility providers, an innovative regulatory framework would be required, and with the right economic signals, consumers' behaviour could be shaped to respond to the needs of the power system and to provide electricity services with economic value.

Distributed energy resources (DERs), whether distributed generation, storage, electric vehicles or demand response, are becoming ubiquitous in many power systems and the trend appears to be unstoppable. Direct regulation of this diversity of countless devices by direct regulation or control is a hopeless task. The alternative is to develop a comprehensive system of efficient economic signals, with sufficient spatial and temporal granularity to incentivise DERs to respond efficiently to the local and global system conditions at every moment in time. The particular case of DERs that we examine here are electric vehicles.

The questions debated during this session were the following:

1. How can the potential of electric vehicles be unlocked and monetised to provide services with economic value to the power system?
2. How relevant is the potential contribution of electric vehicles in the provision of the different types of services?
3. How should the aggregation of the services provided by electric vehicles be managed?
4. How to design and implement efficient economic signals (energy prices, network cost-reflective charges, and regulatory charges)?

The participants noted that unlocking the potential of EVs requires well designed tariffs that reflect energy cost and the state of network congestion at different levels. Regulatory sandboxes need to be developed to test the market design for charging and vehicle to grid services. It was also noted that where there is difficulty to price energy and network

granularity because of lack of single system operator for the whole interconnected system, EVs should offer their services on local markets and not on wholesale markets via aggregators.

Key insights based on ranking were:

- There is a need for well-designed tariffs that reflect energy cost and the state of network congestion at different levels, while encouraging charging using RES. This could be varied geographically and over time. For home charging a different solution will be needed.
- Regulation is important to set standards for charging infrastructure and set time differentiated charges which are essential to make the EVs use more economically attractive for consumers.
- Some initial (transitory) public intervention to build charging poles should be considered, as to break the chicken-egg situation and provide the needed critical mass for infrastructure planning.
- Municipalities should play a bigger role in EVs planning and regulation, e.g. locating charging stations + for facilitating integration with other public and private services (rail, bike-sharing etc) like in the Amsterdam model.
- Develop regulatory sandboxes to test market designs for charging and V2G (vehicle to grid) services.
- We need visibility on the charging points and the usage in order to plan network investment and operation accordingly
- Collaboration is needed between EV and energy storage stakeholders. Used EV batteries will have important second life functions in the form of stationary energy storage.
- Given the difficulty to price energy and network granularly because of the lack of a single system operator for the whole interconnected system, EVs should offer their services on local markets and not on wholesale markets via aggregators.

Summary by knowledge space chair Alberto Pototschnig | Agency for Cooperation of Energy Regulators, Florence School of Regulation

Many electricity systems around the world witness an increased penetration of renewable-based generation, aimed at addressing climate change. Most of this renewable-based electricity generation will be provided by technologies – such as wind and solar PV – which are inherently more variable, if not less predictable, than conventional generation. Such an increasing variability will have to be met by a greater flexibility of the electricity system, in terms of being able to absorb larger, more rapid swings in the output of the increasing share of renewables-based technologies.

Electric vehicles, while reducing the carbon footprint of the transport system if charged by low-carbon electricity, might also contribute to increasing the flexibility of the electricity system. In fact, (plug-in) electric vehicles can be a source of storage capacity, which can be harnessed to provide flexibility. When connected to the grid for (non-fast) charging, electric vehicles' batteries can provide the ultra-fast reactive response which may be difficult or costlier to procure from other sources. The technology to support vehicle-to-grid services is currently being developed…

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At the same time, the increasing penetration of electric vehicles requires, and has been accompanied by, their increasing performance in terms of range and recharging speed, so that they become a closer substitute for conventional vehicles. Fast plug-in charging, however, might poses challenges to the electricity system, as it might create high and highly variable load in areas – e.g. along the main highways or in town centres - where the electricity infrastructure is not ready to manage it, thus creating the need for investment.

Against this background, Knowledge Space 5B explored how the potential of electric vehicles could be harnessed to support decarbonisation and the challenges that this poses. Such a potential presupposes a greater penetration of electric vehicles.

The main conclusions of this Knowledge Space were related to policies and measures to promote the deployment of charging stations, infrastructure planning and tariff design.

With respect to the first aspect, the participants in the Knowledge Space advocated "well designed tariffs that reflect energy cost and the state of network congestion at different levels, while encouraging charging using [renewable energy sources]", even though it was not possible to identify ways in which the latter could be achieved. It was also recognised that tariffs "could be varied geographically and over time", while "for home charging a different solution will be needed". Therefore "regulation is important to set […] time differentiated charges which are essential to make the EVs use more economically attractive for consumers". More generally, it may be useful to "develop regulatory sandboxes to test market designs for charging and V2G (vehicle to grid) services".

With regard to the promotion of the development of a charging station network, which is essential to support the increasing penetration of electric vehicles, the participants in the Knowledge Space stressed the importance of ensuring "visibility [of] the charging points and the usage in order to plan network investment and operation accordingly", of "regulation […] to set standards for charging infrastructure" and of "some initial (transitory) public intervention to build charging poles […, so] as to break the chicken-egg situation and provide the needed critical mass for infrastructure planning". In this context "municipalities should play a bigger role in EVs planning and regulation, e.g. locating charging stations + for facilitating integration with other public and private services (rail, bike-sharing etc) like in the Amsterdam model".

Finally, with respect to the contribution that electric vehicles could provide to the flexibility of the electricity system, the Knowledge Space participants stressed that "collaboration is needed between EV and energy storage stakeholders. Used EV batteries will have important second life functions in the form of stationary energy storage" and that "given the difficulty to price energy and network granularly because of the lack of a single system operator for the whole interconnected system, EVs should offer their services on local markets and not on wholesale markets via aggregators".

6B) Challenges and opportunities of digitalisation for the electricity sector

Chair: Jean-Michel Glachant | Florence School of Regulation

Motivator: Emeline Spire | ELIA System Operator SA

FSR Presenter: Nicolò Rossetto | Florence School of Regulation

The energy sector is not immune to the digital wave that is deeply transforming our economies and societies. The declining cost of sensors and data storage devices, the improvement in data analytics and software, and better connectivity of energy assets – both on the generation and consumption side – are redrawing the physical limits of what producers and consumers of energy can do. By creating new opportunities as well as risks for the various stakeholders, this change in technology has the potential to undermine the way the sector has been organised in the past decades. It can also significantly affect the efficiency and effectiveness of public policies and the current regulatory framework.

However, it is important to avoid the unjustified hype that surrounds the topic. Companies, for instance, must identify appropriate business models to profit from new technologies. This is not always straightforward, as the case of the Blockchain shows. Companies are still struggling to understand how and where to apply successfully it in their business processes.

The digitalisation of the energy sector raises a series of economic and regulatory issues that deserve a careful investigation. The development and deployment of digital technologies dramatically increase the possibility to gather, store, transmit, analyse and combine a huge amount of data on the functioning of the power system. Combined with control devices, digital technologies allow remote and more sophisticated operation of the infrastructure and all the interconnected devices to the extent that some decisions become fully automated (think of smart contracts and artificial intelligence). Consequently, efficiency in the use of resources goes up and transaction costs go down. In turn, this provides room for a re-arrangement of the industry, with the possibility for new providers and intermediaries to emerge and eventually replace or marginalise the existing ones.

Digitalisation raises issues also in combination with the other two macro-trends that is possible to notice at the world level, i.e. decentralisation and decarbonisation. The key point here is to understand where the interaction between these three trends – the so-called “Three Ds” – will lead: Towards a more sustainable energy sector where energy demand is kept under control? Towards a more decentralised and democratic organisation of the energy sector where local communities and individuals are empowered?

Finally, digitalisation poses serious challenges in terms of privacy and data protection. With the growing relevance and amount of data produced and used, and with the growing number of devices digitally interconnected, risks associated with malicious behaviours inevitably increase. Thus, cybersecurity is becoming an indispensable activity that consumers, companies and public institutions cannot neglect. The key issues are depicted below.

Sector Organisation	Interactions with the other Two Ds	Privacy and Cybersecurity
• New business models • New intermediaries • Entry of technologyl companies in the energy sector • Interoperability • Marginalised role for asset owners	• Integration of intermittent RES and DER into the power system • More efficient use of resources • Empowerment of smaller market players and final customers	• Data ownership • Customer privacy and data protection • Responsibility for data management and data access • Data format and standards • Cybersecurity investment remuneration

Are energy utilities going to be "dumb pipes"?

Digitalisation implies the possibility to know in real-time the situation of the energy system with a high level of temporal and spatial resolution. It implies also the possibility to use that knowledge to take and implement decisions without suffering from significant transaction costs. In this context, the physical control of the assets is less important than in the past, while data and their efficient and effective use is a source of competitive advantage.

The traditional business model of energy utilities, both in monopolistic and deregulated markets, is put at risk by digitalisation. The ownership of generation, transmission and distribution assets are becoming less relevant than in the past. The same is true for the sale of electricity as a mere commodity. The direct interface with the customer, the availability of detailed consumption data and the ability to extrapolate useful information from those data is proving to be much more important as a source of value. The flexible use of the resources connected to the grid and the provision of a broader bundle of energy services to the final customer are now becoming key business models.

In addition, digitalisation allows bypassing the traditional interface represented by the meter at the connection point of the customer site with the public grid. The installation – behind the meter – of a digital device interconnected with the energy appliances and distributed generation units of the customer may offer services like demand-side management and access to peer to peer trading platforms. This opens the doors for new players, including 'start ups' and consumer technology companies like the GAFA, to enter the market and provide innovative services. In such a future, traditional energy utilities that own and manage assets for generation, transmission and distribution, may still be essential but not as "relevant" as they are today.

However, the future of the energy utilities is not yet set in stone, and they are not necessarily condemned to marginalisation. By looking at other industries that have been hit earlier by digitalisation, energy utilities have the possibility to react and innovate, thus preserving their relevance.

The questions debated during this session were the following:

1. Can established utilities react to this profound digitalisation change and preserve a viable business model? If so, in which way?
2. Will customers and the society at large be better off?
3. Do you see any special issue of privacy and cybersecurity?

During the discussion, digitalisation was recognized as an enabler for accelerating the provision of access to electricity and cross-sector integration. The first step to unlock its potential is the building of capacity and trust with consumers as well as the implementation of demonstration projects able to support its value proposition. This also requires developing a transitional regulation that is forward looking and considers the evolution of utilities due to digitalization.

Key insights based on ranking were:

1. Digital solutions can act as enabling tools in emerging economies and facilitate universal access to electricity through cost reduction, demand management and digital payment solutions.
2. Building of capacity and trust with the consumer as well as demonstrating the value proposition is needed as the first step towards unlocking the potential of digitalisation.
3. In many different regions of the world, new actors are entering power market through digitalisation and creating new relationships and markets (e.g., for local ancillary services).
4. Digitalisation requires a new and transitional regulation that is forward looking and consistent with the evolution of utilities.
5. There is a need for digitalisation as an enabler for cross-sector integration.
6. Regulators will have an important role to play in ensuring digitalization enters the distribution/retail segment, in particular the functionalities of smart meters.
7. Electric utilities can survive the digital wave, but they need to react fast and invest in better customer interfaces.
8. Cyber-security and data protection are an issue but it can be solved: energy companies and regulators are used to deal with privacy and security.

Summary by knowledge space chair Jean-Michel Glachant | Florence School of Regulation

The digital space is the one where all information about the world, the resources, the things, the life and the humans is transformed into a unified code easy to store, to reproduce, to transmit, to exchange, to combine and inject into device controllers and computing programmes using similar languages. This digitalisation has already become irreversible in several parts of the society and the economy; and it will, of course, take over the entire electricity sector: from generation, and generators, to consumption, and consumers, via all grids and markets – down to peer to peer, and up to transcontinental interconnectors.

The fact that the tech industry is itself dominated, at the world level, by a handful of giants, be they American or Chinese, is not a proof that the electricity sector will follow this highly concentrated model. It is very likely that the digital revolution, in the electricity sector, will open many doors to innovative countries and new players, enabling them to leapfrog up to the frontier of progress and achievement. Why?

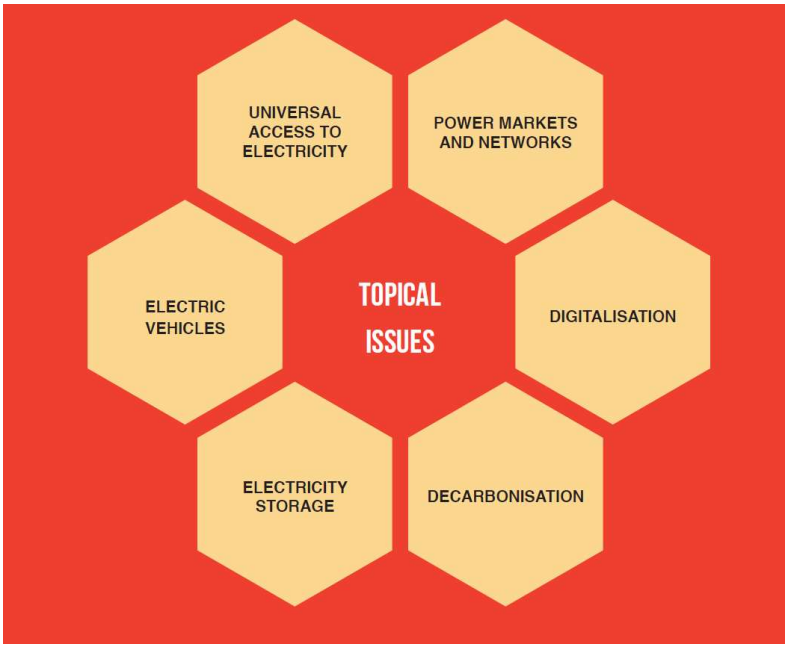
Two gateways frame the feasible digital paths for electricity. They are: 1) the way grids will be digitalised – both at the transmission and distribution level – and 2) the type of digitalisation of meters, end-use appliances and distributed generation units.

The today's unique combination of increased decentralisation of generation, pushed by renewable resources, with a single "common delivery loop", being the power grids, permits the power sector to build new and alternative models of digitalisation. The relatively low cost of digital innovation for trade, exchange, and coordination keeps the door open to many alternative innovations and entrants. Today's lack of harmonisation of new operating rules for "behind the meter" (the homes, appliances, cars, devices…, in a phrase, the "Internet of Things") also tempers the Tech Giants' appetite. However, this will not last forever. Days might be numbered.

Conclusion

4 days of intense interactions amongst 100 global experts at the first FSR Global Forum, brought about key learnings, which can power our collective dialogues and actions in the near future.

Under the theme of World Energy Transition, the issues addressed were:



Some of key learning from the forum were:

Digital powered discussions enable for quicker and easier knowledge exchange experience

- The unique format enabled experts to break down complex issues and debate with their contemporaries from across the world. The forum format was not just useful in sharing one's own knowledge and expertise but also in gaining a global perspective on the issues discussed.
- The use of digital tools to enable and conclude the various knowledge space discussions with multiple stakeholders was useful in acting as a medium of mapping and preserving the multitude of opinions generated at the discussions tables.
- Focused discussions amongst stakeholders from policy & regulation, academia, development organisations and industry yielded insights that can serve as a good starting point for further analysis.

Collective understanding and learnings can enable us to transition better, faster and more sustainably

- Energy transition could mean different things for different countries. Hence, it is important to take into account the social, political, economic and geographic particularities of any given country while planning its energy transition.
- The issues faced by the power sector today are complex, interrelated and one size does not fit all. Thus, there is a need for system level thinking that goes beyond topical silos to ensure holistic policymaking including regulatory frameworks, market design, and governance structure during the power sector transition.

- While the approach towards addressing certain issues such as energy access, regional markets vary in different parts of the world, issues arising from disruptive innovation such as electric vehicles, energy storage, decentralisation, decarbonisation and digitalisation are being figured out together. This further emphasised the need to think beyond the silo approach and move towards a more holistic understanding of the issues and their inter dependencies.
- While the need to analyze and plan for a sustainable energy future is urgent, the process of reform can become more efficient and effective by learning from each other's experiences. Which further emphasizes the need to actively engage all stakeholders in the formulating of stable regulatory and policy actions that enables and supports the energy transformation journey.

Some of the top insights generated after discussions from the 12 knowledge spaces at the forum were:

- Digital solutions can act as enabling tools in emerging economies in facilitating universal access to electricity through cost reduction, demand management and digital payment solutions (offering energy+ services).
- A well-functioning market and unbundled distribution/retail are preconditions for abolishing regulated tariffs. The process to achieve this should be gradual.
- Indicative planning is necessary, it shall set clear goals and comprehensive rules to the implementation, needs to involve all level of governance (e.g. state, regions, and local authorities) and timing.
- Encourage adaptive, interactive and consumer centric IDC (Integrated Distribution Company) to realise potential for electrification as they have access to more managerial financial and operational tools.
- Vulnerable/poor residential customers should be helped but not via a regulated retail tariff. They should be helped via other schemes financed, where possible, out of the energy sector.
- There is a need for well-designed tariffs that reflect energy cost and the state of network congestion at different levels, while encouraging charging using RES. This could be varied geographically and over time. For home charging a different solution will be needed.
- Centralised responsibility and coordination should be combined/conducted together with planning and investments from decentralized parties.
- Regulation is important to set standards for charging infrastructure and set time differentiated charges which are essential to make the EVs use more economically attractive for consumers.
- Regulators should allow storage providers to innovate and play in the wholesale and ancillary services markets, controlling for possible abuses of market power and manipulation.
- Rather than abolish regulation altogether, we need to move from a classical to a differentiated regulatory approach, valuing the different characteristics of electricity, e.g. reliability

Now more than ever, collective analysis and actions are needed for the sustainability of our shared environment – Planet Earth.

Let us get working together!

Thank you!

Annex

Additional insights, not digitally submitted

1B) **The role of regulated electricity tariffs in competitive retail markets**

- Regulated tariffs should be removed gradually. During the transition, residential customers should be involved and "educated" in order to avoid any socio-political backlash. Regulators should not forget to regulate wisely the other components of the final price (network charges and levies): if they do not, the success of the transition could be jeopardized.
- Electricity and energy in general should stop being an automatic cash machine for the government. And they will stop being that due to the growing "inter-fuel" competition allowed by electric vehicles and the fact that you can use electricity for several purposes.
- In smaller energy markets, retail liberalisation could be tricky and not deliver benefit to customers.
- The transition to energy as a service (no more energy as a commodity) will make the definition of tariffs more difficult.
- Moving to an elaborate tariff structure might be easier in emerging countries where a large portion of the consumers has only recently been connected to the grid and is not used to tariffs at all

3B) **Regulatory challenges of distribution networks with distributed resources**

- Network charges and green levies should be proportional, to a certain extent and especially in developed countries, to the maximum capacity of the connection/peak capacity demanded by the network user. This is because in those countries the grid is already there, and you want to promote decarbonisation (in developing countries where there is often no grid and reliability is poor other considerations might be more relevant).
- Local order books should be created by TSO and DSOs together to activate new potential suppliers of flexibility. Coordination and deployment of the digital layer are key challenges.

4A) **Establishing priorities for regional power market integration in emerging economies**

- Regional agreement on electrification/integration ahead of national development no longer makes sense; with technological developments such as cost-effective wind/solar, economy of scale from regional market is not as big of an issue as it used to be.

***4B)* The role of indicative planning in the ongoing economy electrification process**

- In certain cases, relying on command and control makes a lot of sense, as it is the case of the promotion of energy efficiency. When doing this, clear key performance indicators should be defined.

***5B)* Unlocking the potential of electric vehicles in the power system**

- With the growth number of EVs, charges for the energy and the network capacity used by EVs should become cost-reflective in order to provide efficient signals, keep costs down, and avoid unfair distortions/excessive cross-subsidisation. These charges should be technology neutral.
- Aggregators could be good in offering an intermediation service to EV owners, but their business model should respect the topology of the grid. More in general, we need an entity that coordinates the physical flows on the grid and ensure the security and stability of the system. Local platforms could play an important role when EV penetration rises.
- First tackle the need for visibility on charging points and usage of the network in order to plan network investment, then enhance network capacity

***6B)* Challenges and opportunities of digitalisation for the electricity sector**

- Customer interfaces are essential to make digitalisation useful to help the energy transition, either by automating reactions to dynamic pricing or to nudging customers by showing the performance of their neighbors/peers.
- Digitalisation as an enabler to integration of sectors, therefore joint planning/operation & regulatory processes needed

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