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Opportunities to Accelerate Smart Grid Deployment through Innovative Market Design

A discussion document prepared for the workshop and high-level panel discussion, “Intelligent market design – boosting global smart grid deployment,” organized by International Smart Grid Action Network (ISGAN) and the Swedish Smart Grid Forum in conjunction with the 9th Clean Energy Ministerial (CEM), 24 May 2018.

Background

A draft version of this document was prepared for the workshop and high-level panel discussion, “Intelligent market design – boosting global smart grid deployment,” organized by International Smart Grid Action Network (ISGAN) and the Swedish Smart Grid Forum as an official side-event to the 9th Clean Energy Ministerial (CEM) in Malmö and Copenhagen, 23-24 May 2018. The draft functioned as a guidance document for the interactive dialogue during the workshop and following high-level panel discussion. The outcome and recommendations from these events has been included as separate sections in this document. Moreover, comments received during these dialogues has resulted in some minor changes of the draft version (highlighted in gray). To stimulate a continued in-depth policy discussion defining priority actions to advance the market design agenda, this final version of the document will be communicated to CEM9 participants together with a short summary of the outcome from the workshop and high level panel.

Disclaimer

This document has been prepared by representatives from the organizers based on relevant position papers and studies from, for example, ISGAN, IEA, and IRENA as well as individual feedback from ISGAN national experts and the Swedish Smart Grid Forum representatives. The views, findings, and opinions expressed in this document do not necessarily state or reflect the policies or positions of any of ISGAN’s participants or their sponsoring governments or organizations.

Opportunities to Accelerate Smart Grid Deployment through Innovative Market Design

Smart grid technologies and practices are key building block for advancing power system integration and transformation, in support of more competitive and innovative lower-carbon economies. This document frames the main principles for an efficient electricity market design capable of managing opportunities and challenges of accelerating smart grid deployment, addressing both the local/decentralized and the regional/interconnected level. One objective is to clarify the pivotal role of market design for smart grid deployment. Another is to identify market design principles that can be applied in a wide range of circumstances to support the key function that smart grid plays to accelerate power system integration and transformation supporting the transition towards competitive and innovative low carbon economy.

Smart grid captures a range of advanced information, sensing, communications, controls and energy technologies, resulting in an electric power system that can intelligently integrate the actions of all connected users – from power generators to electricity consumers to those who do both. Smart grid solutions are also found across the entire electrical system, from the high voltage transmission grid, through the distribution grid (local grid), and finally at consumer level.

Electricity system challenges and global trends

The transformation of our energy systems to meet energy and climate policy objectives is one of the most challenging missions of our time. To facilitate the move towards lower-carbon economies while sustaining economic growth and maintaining system reliability, electricity markets will need to go through transformational changes. For example, the challenge of integrating variable renewable energy sources (RES) calls for a consistent yet flexible electricity and energy market framework that acknowledges that the current just-in-time mode of electricity production will increasingly be complemented, if not replaced in some locales, by a “harvesting” mode of electricity generation. Older market rules and structures need to be modernized and better matched with clean energy policies and opportunities provided by innovative technology solutions, while ensuring a secure electricity supply. Furthermore, in many countries, there is growing need to modernize an increasingly ageing electrical infrastructure and at the same time there is flat or declining demand. In others, there is rapidly growing demand for electricity, connecting more and more people to power systems with growing expectations for a prominent level and high reliability of energy services. Together, these trends highlight the potentially pivotal role of smart grid solutions as a vehicle to manage infrastructure investments more cost efficiently.

Accelerating the deployment of new smart grid technologies will enable a broader, faster, and more cost-effective utilization of a range of clean energy technologies and increase energy efficiency on all levels in the energy system, substantially transforming how electricity systems are planned, operated and controlled. Electricity market design must be able to adapt to this changing environment to a considerable extent determined by five major global trends[1]:

- *Decarbonization* – the move from systems based primarily on high-carbon, fossil fuel-based power sources to much more energy-efficient systems powered mostly – and someday, exclusively, by a broad range of lower-carbon sources. With faster changes in system conditions, largely caused by weather patterns, market solutions need to be ”faster”, enabling response closer to real time;

- *Decentralization* – the transition from centralized power plants and control to an increasingly complex mix of centralized and decentralized power generation (e.g. rooftop solar photovoltaics, energy storage) and distributed controls including also flexible loads, storage and self-production.

[1] These trends are highlighted as a base for ISGAN´s (International Smart Grid Action Network) Strategic Work Plan for its second term, March 2017 through February 2021.

With novel market solutions “local markets” may occur providing opportunities amongst prosumers to trade at the local level;

- *Integration* – the trend toward more integrated electricity markets and greater interconnection of previously independent grids and/or power markets along with the broader perspective of, more integrated energy systems including sector coupling with transport, heating and cooling. With larger markets including cross-border trade the available transmission capacity need to be clearly defined to maximize the use of existing infrastructure:

- *Digitalization* –the trend toward more of ubiquitous information and communication technologies (ICT) and data applications (modern sensors, automatic control and encrypted communication, and solid-state technologies etc.). With these novel technologies opportunities to facilitate a fair market access and increased transparency of operation procedures will increase.

- *Inclusion / accessibility for all* – increasing demand for sustainable, affordable and accessible energy for everyone including increased electrification (e.g., of industrial processes and transport) and challenges related to global urbanization. To fulfil these demands the capability of demand-side-resources and synergies with other energy carriers and infrastructure will become increasingly important.

Smart grid deployment and the importance of efficient market design

Good governance is needed to assure that market rules adapt to meet future challenges. Therefore, there is a need for novel solutions in market design. Energy policy and power sector regulation must work in co-ordination and be adapted to the new reality, while considering the specific characteristics of each power market, such as its institutional arrangements, grid development, electrification characteristics and renewables penetration. For instance, priorities in emerging economies may be determined by rapid growth in demand, while developed countries face challenges related to aging infrastructure and flat or declining demand.

Power system integration and transformation presents increasingly complex policy challenges, which will require a combination of new initiatives, regulations, standards, strategies, and business models to make use of emerging opportunities provided by smart grid solutions. These are to be found across the entire electrical system, from the high voltage transmission grid, through the local grid, and finally to households. However, to meet national challenges, different approaches and priorities may be needed, and there is no generic or one-size fits all solution. At the same time, there are generally applicable findings from experiences that can be adapted more broadly to make local implementation faster and more efficient. In other words, an emerging body of best practices is increasingly available.

The key role of policy maker and regulators

Although many different approaches are possible to meet the challenges that power grids are facing, policymakers and regulators have a key role to play in developing both coherent and innovative market design supporting the transition towards clean sustainable solutions and, at the same time, provide reliable electricity at least cost to consumers.

- Decentralisation and the growing penetration of RES are bound to transform the power sector. While some challenges remain, favourable policies and regulations can bridge the gap and avoid technology lock-ins that prevent the achievement of a suitable low-carbon path. These policies include those that reduce barriers, promote investment, create a fair and level playing field and ensure the long-term financial viability of the power system[2].

- Competitive markets are important tools, but they must be supplemented by appropriate policy incentives to ensure an effective transition to lower-carbon power at least cost[3];

[2] Adapting Market Design to High Shares of Variable Renewable Energy, IRENA 2017
[3] Re-powering Markets, Market design and regulation during the transition to low-carbon power systems, IEA 2016

- For investors and owners of grid infrastructures, a clear regulatory framework will, in all scenarios, make long-term investment decisions less risky and help incentivize investment in smart grid solutions to deal with appropriate grid operation challenges.

Leveraging a variety of stakeholders and roles

An increased need for flexibility service providers

As electricity generation from variable RES grows, and end-use consumption patterns become increasingly complex, the electricity system needs to become more responsive. New storage technologies and demand response options in industry and smart buildings can provide solutions. In most cases, this will require enhancements to certain market rules, including lowering barriers for new market entrants, acknowledging that the specific properties of power systems as well as the characteristics of electricity demand differs from country to country and system to system.

- To support operation of transmission and local grids, new market solutions safeguarding the use of available assets for flexible response need to be developed, for example through strategies for demand response and integration of embedded generation, energy storage systems (ESS) and power-to-x[4] solutions This development will in several cases also challenges the prevailing role of local network operators;

- New utility practices and services will be needed to increase the potential for use of flexibility assets throughout the system, especially through the coordinated use of flexibility for system balancing and congestion management.

- Improving short-term power markets or, depending on market structure, shifting operational decisions closer to real-time, can enhance the use of flexibility resources and improve system operation[5].

Impact of new market actors and consumer empowerment

Rapid developments in information and communication technology are facilitating the introduction of new market solutions, creating new business opportunities for decentralized renewable energy resources and flexibility services. The dynamic will contribute to crucial changes in the way todays electricity consumers participate in different markets, not only as end-users, but also as producers (prosumers) or “flexibility service providers” (e.g. from demand response or local storage facilities)[6].

- The implementation of Automatic Metering Infrastructure (AMI) is an important prerequisite in many circumstances to increase consumer and prosumers empowerment and active market participation, including aggregation of flexible resources[7].

- Improved data handling and accuracy including privacy, management of big data and data protection issues are also pivotal for customers’ and end-users’ trust.

- The development and uptake of innovative and attractive services based on, for example, smart appliances, internet of things (IOT), energy management applications, and similar, can be bolstered for both existing and new market participants by a common set of communications standards adopted throughout the market chain, from individual appliances/equipment up to market interfaces.

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[4] Power-to-x refers to different possibilities such as power-to-gas or power-to-heat to manage changes in capacity needs.
[5] See, for example, “Clean Restructuring: Design Elements for Low-Carbon Wholesale Markets and Beyond,” 21st Century Power Partnership, 2016 or The Power of Transformation – Wind, Sun and Economics of Flexible Power Systems, IEA 2014
[6] ISGAN Smart Grid Casebook Spotlight on Customer engagement and empowerment, 2017, provides an international approach and lessons learned in Customer Engagement and Empowerment, to be downloaded from **www.iea-isgan.org**
[7] ISGAN AMI Casebook, Spotlight on Advanced Metering Infrastructure provides an international approach and lessons learned in relation to the potential costs and benefits of advanced metering infrastructure (AMI), and the associated business cases for investments. to be downloaded from **www.iea-isgan.org**

- The development of peer-to-peer (transactive) market mechanisms between energy producers and end-users at small scale, supported by distributed ledger technologies like Blockchain and smart contracts, might challenge prevailing market rules and regulation.

A growing market for local energy systems and microgrids

Microgrids are either established off-grid networks or grid-connected with the ability to disconnect from the traditional grid to operate autonomously. Grid-connected microgrids can strengthen grid resilience and help mitigate grid disturbances as well as function as a grid resource for faster system response and recovery. Growing electricity demand, especially in developing countries, and the ambitions to provide energy access for all, taking both energy security and affordability into account, are increasing the potential for local energy systems and off-grid microgrids. Local energy schemes are diverse in their aims and configuration; while some business models can be replicated elsewhere, the potential system benefits of local solutions will be determined by the prevailing physical system characteristics, consumer behaviour, market design, and other localized circumstances.

- It is possible for the centralized grid and microgrids to support each other in a way that is beneficial for all stakeholders. However, there are still several technical and policy-related issues to be resolved with respect to grid and microgrid integration.

- Clear regulation and adherence to relevant technical requirements will increase the potential for a microgrid to become a long-term solution including, for example, local energy networks that have potential for future interconnection and interaction with the central grid. Good planning, appropriate requirements and clear regulations for microgrids limit the risk of stranded assets and enable better business cases for the involved stakeholders[8].

- In industrialized countries the growth of local energy systems may challenge prevailing regulatory arrangements for networks and the wider system including regulatory safeguards that system costs and benefits are fairly and equitably shared. Concerns have been expressed that more cost-effective microgrid and off-grid solutions will allow formation of distinct local energy systems with the ability to completely disconnect from the larger power grid, which might result in increased tariffs for the remaining customers, thus increasing their incentive to invest in the same solutions, leading to even more disconnections (and so on).

Energy system integration and interaction

Increased system complexity calls for closer interaction, coordinated planning and advanced analytical tools

Irrespective of the differences in size and complexity of electricity markets, a common vision for market transformation and related aspects of market integration will benefit from integrated energy resource planning and grid integration studies. Market integration both between various levels, such as emerging local energy markets and wholesale markets, and market coupling between system and countries/regions are important aspects to be considered. This calls for novel solutions facilitating coordinated network planning and information exchange as well as new analytical tools.

- Although market solutions and grid structure vary substantially throughout the world, ensuring that smart grid systems can function effectively within different grid environments requires modelling complex electricity systems, including transmission level, substations, primary and secondary distribution (i.e. local grids), and increasingly storage as well as power-to-x. This holistic approach provides a unified view of the system together with planning capabilities

- With increasingly complex electricity systems, an ever-closer cooperation between system operators will be required to avoid increased system vulnerability. The technical and non-technical

[8] ISGAN discussion paper, The role and interaction of microgrids and centralized grids in developing modern power systems, Jonas Tjäder, Susanne Ackeby, ISGAN Annex 6, 2016, to be downloaded from www.iea-isgan.org

solutions required for a closer interaction between transmission system operators and distribution system operators (distribution network operators) are very similar in most cases, making exchange of experiences and best practice a key area for cooperation[9].

- Despite the increase in distributed energy resources and self-production, transmission remains a cost-efficient means to ensure the integration of high shares of wind and solar power. In addition, the transmission grid remains essential to secure electricity supply.

A broader energy system perspective amplified by cyber-physical systems

The long-term and sustainable planning of the future electricity system will require a broad and holistic approach. Seeking synergies between the electricity network and other energy-carriers and infrastructures, (including gas grids and storage, heating and cooling systems, and e-mobility) can provide new sources of value. Rapid developments in information and communication technology and the increasing importance of Cyber-Physical Systems will amplify the benefits that can be gained from this broader systems perspective.

- New models for market design and network operation through smart grid solutions that enable more efficient use of resources and improved network resilience needs to be developed and there appropriate harmonized. Important considerations are opportunities provided through, for example, real-time monitoring and control, integration of ICT, microgrid concepts, and cost-effective energy storage solutions.

- Opportunities of cyber-physical systems, for example merging physical and digital elements of the electricity system, include proactive maintenance at lower cost, lessening outage in time and number as well as facilitating aggregation and use of storage for flexibility purposes.

- Across this landscape of change, it is crucial for policymakers to understand the possible synergies within the energy sector and between the energy sector and industry in a circular, interconnected economy. This is a global challenge that requires strong international cooperation and systems views in which know-how and best practice from around the world can be shared.

[9] Key challenges in relation to TSO-DSO interaction are presented in ISGAN discussion paper TSO-DSO interaction: An Overview of current interaction between transmission and distribution system operators and an assessment of their cooperation in Smart Grids, Annex 6 2014, to be downloaded from www.iea-isgan.org

About ISGAN

ISGAN (International Smart Grid Action Network) is an initiative of the Clean Energy Ministerial (CEM) and an IEA Technology Collaboration Programme (TCP) with the vision to accelerate progress on key aspects of smart grid policy, technology, and related standards through voluntary participation by governments in specific projects and programs. The present ISGAN membership includes countries responsible for more than 80% of the global GHG emissions and promoters of more than 90% of clean energy technologies investments.

As the only global government-to-government initiative for sharing information, best practices, and competence on smart grid ISGAN helps to identify solutions to accelerate smart grid deployment, enable replication of proven ideas, and support greater national ambition in developing and deploying smart grids. ISGAN focuses its activities on those aspects of smart grids where governments have regulatory authority and expertise.

Read more: **www.iea-isgan.org**

About Swedish Smart Grid Forum

The Swedish Smart Grid Forum is an initiative of the Swedish Government. The objective is to strengthen the capability and capacity for smart grid solutions for the future, in Sweden and globally.

The mission of the Swedish Smart Grid Forum is to develop dialogue and enable actions towards a smarter grid. It provides a platform for stakeholders that want to contribute and be part of the development of the future grid. The Forum is led by the Minister for Policy Coordination and Energy, Mr. Ibrahim Baylan, together with a steering group consisting of a wide range of stakeholders, both authorities, academia and industry. The Forum also works closely with the Swedish Energy Agency.

Read more: **www.swedishsmartgrid.se/in-english/**