IRENA
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Note of the Director-General

IRENA's Work on Power Sector Transformation

I. Introduction

1. In IRENA's institutional publication, *REthinking Energy* (released in September 2014), the case was made that the power sector transformation has already started. Renewables have accounted for more than half of net capacity additions in the global power sector since 2011; new installed capacity of renewables is greater than that of fossil and nuclear power combined. Furthermore, IRENA's latest report on *Renewable Power Generation Costs* (released in January 2015) shows that cost-competitiveness of renewable power generation has moved beyond Europe, North America and island States to countries in Africa, Asia, and Latin America.

2. IRENA's *renewable energy roadmap* (REmap 2030) also shows that the potential for renewable energy power generation extends beyond existing national plans. The market for solar photovoltaics and wind power are already growing more rapidly than many experts predicted only a few years ago. Furthermore, large economies like China and India have increased their renewable energy targets. For example, India has increased its target for solar photovoltaics from 20 GW in 2022 to 100 GW in 2022. As a result, the share of renewable energy power generation could grow from 22% in 2013 to more than 45% of global annual power generation in 2030. The growth for power generation from solar photovoltaics and wind power – the so-called variable renewable energy – is even more drastic increasing from around 3% in 2013 to almost 20% in 2030.

3. During the 5th Assembly, Ministers and Heads of Delegations discussed national experiences with power sector transformation. Many concluded that IRENA should continue to analyse in more detail the market, legal and regulatory, management and technology aspects of grid integration of high shares of variable renewables. Furthermore, they suggested to convene experts and policy makers around specific policy, operation, and technology issues to facilitate the exchange of experiences and best practices. They also made a strong case for the importance of integration at all levels, including the role of regional and inter-regional interconnectors to facilitate market integration.

4. IRENA's current knowledge framework on power sector transformation includes methodologies to support the long-term planning of power sectors, both nationally and through regional planning, to assist in choosing and scheduling different renewable energy grid integration options, including energy storage, to plan mini-grid projects, and to assess the current status and future options for the integration of renewable power generation in island grids. Based on the discussions during the Ministerial Roundtable, IRENA is now examining options to extend the knowledge framework for renewable energy grid integration and transformation, and steps to translate this knowledge framework into action.

II. Power sector transformation: Long-term planning versus Immediate Challenges

5. Several countries are already managing grid systems with more than 20% of annual power consumption produced by variable renewables. Furthermore, a number of countries have implemented innovative approaches combing new mini-grid, electricity storage, and renewable energy technologies to provide reliable and cheap electricity options for rural areas disconnected from the main grid. However, the future electricity system design is still not evident as solutions have to be tailored to current and future power system characteristics and may contain a mixture of technological, economic, and regulatory measures depending on local circumstances.

6. IRENA's technology roadmap on renewable energy grid integration provides a framework to assess the sequence of activities needed to come to appropriate renewable energy grid integration solutions. This sequence of steps includes an assessment of the current and future flexibility available in the power sector, an assessment of the performance, costs and investment needs associated with different transmission, distribution, smart grid and electricity storage options, as well as the collection of data to support renewable energy grid integration measures.

7. With growing electricity demand in most countries in the world, it is evident that long-term planning of the power generation mix is one of the first and most effective tools to ensure cost-effective power systems based on renewable power generation. IRENA's activities under the *Clean Energy Corridors* pave the way for regional planning through the identification of renewable power development zones, the development of enabling regulatory frameworks, and assessment of finance models, whilst the *Addressing Variable Renewables in Long-Term Planning (AVRIL)* project supports Member countries in enhancing the quality of energy planning with higher shares of variable renewable power generation.

8. There are, however, a number of countries that already experience local difficulties in keeping up with the stream of renewable power generation projects in the pipeline. In this respect, IRENA is examining sound regulatory frameworks for variable renewable energy integration and is mapping appropriate grid codes based on international standards in the countries that are successfully integrating high shares of variable renewables, whilst at the same time mapping opportunities for implementation in other countries.

9. Some of the most concrete cases of power sector transformation can be found in island States, where – due to the limited size of the grids – solar photovoltaics and some wind turbines can result in renewable power generation shares beyond 50%. IRENA's *grid stability assessment methodology* is helping island States to understand the limits of their existing grids and identify opportunities, including energy storage, for the future design and operation of their networks.

10. Energy access is also a key area where advances in mini-grid technologies, including control systems and storage, can make an immediate difference by providing cheap and reliable electricity access and changing the livelihoods of 1.3 billion people. IRENA's status and outlook reports on off-grid renewable energy technologies combined with the insights on policy and finance barriers from IRENA's *International Off-grid Renewable Energy Conference (IOREC)* are providing concrete ways forward.

III. Electricity storage for renewable energy

11. Energy storage is one of the options available to facilitate and accelerate a power sector transformation. In particular, advanced electricity storage options are changing a century old paradigm in which generators and grid operators have been concerned with matching generation and demand at all time. This development is of particular interest for renewable power generation, because it addresses some of the immediate concerns associated with some forms of renewable power generation, such as

their reliance on seasonal and daily variability of natural resources, their location-specific dependency in some cases, and their potential impacts on power reliability and adequacy.

12. The most mature and widely applied electricity storage technology is pumped hydro storage. In many countries, pumped hydro stations have been built to store cheap electricity produced from baseload plants at night, and release this electricity when demand and electricity prices are high during the day. However, there are some geographical restrictions and these technologies have a relatively low efficiency of around 70%-80%.

13. Beyond the power sector, lead acid batteries has been the dominant technology to store electricity in cars or as back-up capacity in factories and households. Traditionally, lead acid batteries have been relatively cheap, but their limited efficiency and life time made them less suitable for the integration of renewables. IRENA's report *Battery Storage for Renewables* (released in January 2015) examines the relative recent developments in battery storage systems for consumer electronics and electric vehicles, which has led to a surge in development activities in so-called "advanced battery storage systems" to support the integration of renewables in the power sector. Furthermore, flywheel technologies, adiabatic compressed air energy storage (CAES), supercapacitors, and superconducting magnetic energy storage systems (SMES) are electricity storage technologies that are used to support the integration of renewables into the power sector.

14. IRENA's *Technology Roadmap on Electricity Storage* proposes 14 action areas in five priority areas where concerted action from the different stakeholders can ensure that electricity storage systems can live up to expectations and support a power sector transformation. The roadmap concludes that electricity storage systems are not a prerequisite for continued growth of renewable power generation in most cases. However, they will certainly facilitate the short-term transition from diesel generators to renewable power generation in isolated electricity systems on islands and in remote areas. Furthermore, it is important to note that electricity storage systems introduced at any level in the power sector – consumer, distribution, transmission, generation, or in the form of electric vehicles or productive use – will impact system operations in both the short- and long-term and will have a positive effects on the integration and transition towards renewables. A better understanding of these consequences – through the 14 action items – is needed to guide both renewable energy policies as well as electricity storage policies.

15. One of the most immediate priority areas for action – including an international platform to facilitate financing – is electricity storage systems deployed in islands and mini-grids to facilitate a transition from diesel generators to renewable power generation. Other actions include international cooperation on studies for pumped hydro stations, and a methodology to provide systemic value assessments for electricity storage. Furthermore, the declining costs of rooftop solar PV systems combined with advanced electricity storage systems can create a situation in which utilities' models to recuperate expenditure for maintaining and managing the grid need to be revisited. As a consequence, policy makers and regulators need to start today to create regulatory frameworks that ensure that any electricity storage systems for self-consumption will also be able to support the grid. Such a regulatory framework will require methods and procedures that allow for aggregation, support for technology developments for control systems and software, and procedures to deal with (data) ownership.

IV. Supporting international cooperation among countries

16. It is clear that the power sector is at a cross point with most signs pointing to renewable power generation as the way forward. There is growing evidence and experience in renewable energy grid integration practices, and new technologies are available to ease and facilitate a transition towards more flexible and distributed power systems. However, this pathway may still be new to countries, so leadership and international cooperation is key to ensure a smooth and effective power sector transition.

17. The need for international cooperation is not limited to the technological challenges, but also requires changes and innovation in institutional structures governing the power sectors and finance models providing capital for grid infrastructure development and generation capacity. Consequently, policy makers will have to work hand in hand with regulators, utilities and other stakeholders to make this transition happen. IRENA's technology roadmaps provides some guidance on where more international cooperation activities are needed, but many of these activities will require input and leadership from other stakeholders located within the Member countries.

18. With IRENA's activities on power sector transformation coming to conclusion in the next couple of months, it is important to receive feedback on how existing activities can be translated into concrete action at a country level and where more work is needed to provide support to policy makers.

V. Guiding questions

- Does the current portfolio of activities on power sector transformation cover the knowledge needs, or are there specific areas, such as demand side management or dispatch models, where more technical studies or methodological development is needed? Should the scope of some activities, like the grid stability assessment methodology for islands, be extended to larger power systems?

- How can IRENA most effectively provide technical assistance in the implementation of the methodologies and guidelines on power sector transformation in IRENA Members? How can IRENA most effectively engage with the relevant stakeholders, and to what extent should IRENA engage with local utilities?

- In what areas of international cooperation activities should IRENA take a leading role? How can IRENA ensure complementarity with the activities of other international and regional organisations, and how can IRENA add value to existing cooperation frameworks?