

INTERNATIONAL RENEWABLE ENERGY AGENCY

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Note of the Director-General

**Supporting the power sector transformation:
From targets to implementation****I. Introduction**

1. In response to Members' requests, IRENA has significantly strengthened its activities in support of power sector transformation. This note provides an overview of recent trends and insights into the sector.

2. Globally, hydropower, wind and solar power generation technology installations are increasing in comparison to conventional power generation capacity installations. In 2015, solar PV additional installed capacity is projected to reach 55 GW, the largest capacity addition of any power generation technology. As a consequence, global power generation from renewable energy is rising by around one percentage point per year and has reached 23% in 2014. This trend is expected to continue with wind power and solar photovoltaics accounting for the majority of growth, and driven by economics, public health concerns, energy security considerations and climate change mitigation policies.

3. The addition of variable renewable energy (VRE) from wind and solar resources is changing three broad principles that have been governing the power sector for the last century. These principles include:

a. "Variable renewable energy changing the paradigm that supply will adjust to variable demand."

4. Thermal power generation units are dispatchable – that is, their output can be adjusted to demand. However, this is less so the case for VRE, notably for solar PV and wind as they require flexible electricity systems. Therefore, interconnectors, smart grid technologies, storage and electrification of the transport and building sector will become increasingly important to enhance flexibility. "Power will no longer flow only from centralised power stations to passive consumers."

5. The scalability of solar PV and wind is allowing new stakeholders, including individual households, to actively participate in the power sector. Distribution networks will no longer be passive, but will actively manage power flows at a local level. System operators will require different procedures to adapt to the new conditions and to guarantee reliability and security in the electricity supply.

b. “Liberalised electricity markets minimise the supply costs for the consumer through competition based on marginal cost of generation.”

6. Solar and wind power generation have minimal marginal costs, which is changing the price dynamics and ultimately the economic viability of traditional business models used by conventional power stations. Simultaneously, there is increasing need for flexible capacity to ensure generation at all times. These developments require changes to existing market procedures governing the order of power generation across the different plants, as well as the utility business models.

7. At the same time, advances in information and communication technology are enabling a more refined operation of the generation, grid and consumer sectors of the electricity system by reducing total system costs and introduces higher flexibility into the system. Thus, facilitating the integration of higher shares of VRE.

8. As the share of VRE grows, traditional planning approaches, standards, codes and regulations, including system planning, design and operation practices, markets and business development, need to be revisited to ensure smooth operation.

II. What are the trends in VRE deployment?

9. There are a number of countries operating power systems of around 100% renewables. The vast majority of power for these systems is produced by hydropower. The share of other VRE types in these countries is generally much lower, with wind accounting for 3% and solar PV accounting for 1% of global power generation. Some countries have reached much higher shares of VRE in electricity generation. Spain and Germany have attained an annual share of 22% and 16% in 2014 respectively, but have occasional daily penetration levels of more than 70%. Certain smaller countries or regions have reached much higher VRE percentages, for example Denmark and Ireland have reached penetration levels of more than 50% wind over sustained periods of time. Some islands like Tokelau in the South Pacific Ocean, Samsø Island in Denmark, or Kodiak Island in Alaska have attained penetration levels of 100% VRE using storage or interconnectors for balancing. IRENA is currently assisting, among others, Antigua and Barbuda, the Cook Islands, Kiribati and Samoa with planning a transition to high VRE shares, for some of them of up to 100%.

10. Looking ahead, IRENA’s renewable energy roadmap, REmap 2030, has shown that policy makers are underestimating the forthcoming growth of VRE, and that the global VRE share can grow from 4% in 2014 to almost 20% by 2030, with some countries well above 20%. Towards this global goal, most countries can learn from the experiences of frontrunner countries that have shown that this is technically feasible, with some countries continuing their plans for additional growth in renewable energy use.

III. What are the key challenges for power sector transformation?

11. IRENA’s report, *Adapting Renewable Energy Policies to Dynamic Market Conditions*, identifies the key challenges that arise from rapidly changing renewable energy markets and which are faced by policy makers. These challenges include: accounting for rapidly falling renewable generation costs, addressing tax/rate-payer burdens, accounting for renewable energy’s cost competitiveness, and integrating variable renewable power. For each of the challenges, the report analyses innovative policy solutions that are being implemented or proposed. Furthermore, the report serves as the basis for in-depth analysis of policy adaptation measures, including design of renewable energy auctions and measures to integrate greater shares of VRE in the electricity sector.

12. Long-term energy planning is another key area that can support the power sector transformation. IRENA’s recent publication titled *Addressing Variable Renewable Energy in Long-term Planning (AVRIL) For Emerging Economies*, showcases best practices in the long-term scenario planning methodologies that account for the specific characteristics of renewables. The analysis highlights the

importance of good planning practices. AVRIL affirms the experience of front runner countries where planning has been critical for the successful transition to a renewables-based energy system.

13. For a successful deployment of advanced technologies and implementation of new operational practices for the integration of VRE into electricity grids, it is essential that all parties adhere to the same rules to ensure adequate functioning of the electricity system. In support of this, IRENA is preparing a new study on best practices in grid codes and regulations for integration of variable renewables. Well-designed and -implemented grid codes will require generators to use the best-available-technologies and thus will push the development of new targeted technology solutions. Grid connection codes are also stimulating renewable energy technology developers to advance their designs to ensure that production units can provide grid support services. IRENA's analysis shows that technical requirements for the connection of VRE generators, such as those contained in grid codes, have developed rapidly in countries that already have relatively high shares of wind and solar PV in their power systems.

14. Other challenges are related to the protocols and market designs governing power systems. Solar and wind power will affect the operation and order in which different power generation units are called upon to satisfy demand. This may also result in more complex dispatch schedules and create more dynamic pricing across time and space. Nodal pricing of supply or smaller balancing areas are responses to such issues. There is also the possibility that consumer prices can become more variable, thus creating an incentive for demand response.

15. Renewable power generation is also allowing for more self-production by consumers through rooftop solar PV or small wind turbines. Self-production will affect revenue collection by system operators for grid maintenance and operation, and new investments in grid capacity are needed in order to alleviate grid bottlenecks. Consequently, new finance schemes will have to be developed to ensure that network operators have sufficient funding to maintain and operate the grid infrastructure.

16. *The Age of Renewable Power*, a new IRENA report released in October 2015, aims to assist countries in addressing these challenges systematically through the development of their own national roadmaps. The study identifies 20 measures to integrate VRE and also highlights lessons learned by countries already pursuing a power system transformation. The report shows that for the successful selection and introduction of measures for VRE integration, policy makers must ensure that data collection and energy planning tools are in place, examine existing flexibility options, and secure human capacity to develop and adapt technologies to local conditions.

IV. How does IRENA plan to assist Members in addressing the challenges to transform their power sector using renewable energy?

17. The power sector transformation is ongoing. The transition pace and ambition level varies from country to country and the measures need to be adapted to the specific conditions of the power system. Some of the specifics include the size of the power system; interconnections with neighbouring systems; whether generators are connected to transmission or distributions systems; characteristics of conventional generators; geographical distribution of VRE generators; energy policies; power market size; established operational practices; and the institutional frameworks allowing for both flexible generation and demand.

18. In some countries, many of these measures are already in place and there are opportunities for an international exchange of experiences, identification of best practices and learning. Consequently, the G7 and the G20 asked IRENA in June and October 2015 to evaluate the most effective options to support the integration of VRE and to create a platform to “discuss with grid planners, transmission and distribution system operators and grid regulators their experiences” and extend “analysis to a broader

range of countries”¹. IRENA’s activities will also support its Members to develop national roadmaps for achieving power sector transformation, as pledged by the members of the Clean Energy Ministerial.

19. The aim of IRENA’s activities is twofold. First, IRENA will provide policy makers with methods and tools that can be applied at a national level to guide their power sector transformation. This toolkit will be designed such that they take country-specific characteristics into consideration. Second, IRENA will track progress on the implementation of grid integration measures and how they correspond to the specific country conditions. These activities will facilitate the dialogue between policy makers who set targets and the utilities responsible for power system management at a national and regional level.

20. To support countries, IRENA will apply and strengthen its toolkit for power sector transformation. This toolkit already includes tools for the assessments of renewable energy integration potential in long-term planning, smart grid cost-benefit analysis, grid investment assessment, evaluation methods for smart grid demonstration projects, systemic value assessment of electricity storage systems for renewables, and the implementing good practices for designing and implementing grid codes for VRE.

21. New methods and tools will include an analysis of the benefits of using industry standard economic dispatch models for long-term planning of power systems with high shares of VRE in selected regions. Moreover strategies for better integration of and operational constraints identified by stationary and dynamic grid studies in long-term energy plans will be developed, for both centralised grids and mini-grids. IRENA will also analyse topics such as electric vehicle programmes, the role of interconnectors, and national energy storage systems as flexibility measures.

22. Against a backdrop of changing ownership structures in the energy sector and the rising share of VRE, IRENA will also continue its policy analysis focusing particularly on adaptation measures to cope with evolving market conditions.

23. IRENA’s work will also include on-the-ground advice on regulations through the Regulatory Empowerment Project to the development of Power Sector Transition Plans (PSTPs) for islands and small power systems. Upon request, support will be provided to individual Members in the development of the analytical work necessary to support the transition of their power sector to large shares of renewable energy, work that has so far focused on islands but that can be broadened to larger grids.

24. Since renewable energy grid integration strategies are specific for each individual country, it is not possible for IRENA to apply these guidelines, methods, and tools to all Members. IRENA will therefore develop a new platform to exchange best practices and explore the possibility of linking its power sector transformation activities to other projects and institutions. Four possible strategies are:

- Engage Members in the application of existing tools and identify other tools that are needed. For example, more detailed roadmaps could be developed on electric vehicle integration into the grid, pumped hydro, thermal storage, and reports could be written on inverters, transformers, etc.;
- Advisory services to individual Members – a deep dive for a select number of countries, with more detailed analyses of pathways for renewable energy grid integration. The insights from such select studies could subsequently be generalised and shared with all IRENA Members;

¹ G20 Toolkit of Voluntary Options for Renewable Energy Deployment, http://www.irena.org/documentdownloads/Pressrelease/G20_Toolkit.pdf

- Strengthen the power sector transformation component of REmap. The existing expert network can be used to create country taskforces that develop new activities are guided by IRENA guidelines and methodologies. Country engagement would be essential. Such a programme could benefit from country secondments to the IRENA Secretariat to strengthen its analytical capacity;
- Guide the work of financing institutions such as the World Bank and regional banks. In this case, IRENA would act as a technical advisor to generation and infrastructure projects in emerging and developing countries.

25. In all cases, IRENA would operate as a knowledge hub where practical lessons are collected and shared. It will be important to couple the technical analysis with activities in the areas of: regulation and enabling policy framework design, new business models, interregional cooperation, and capacity building.

V. Guiding questions

- What are the ways in which to balance the exchange of best practices, methodology development and country technical assistance?
- How can IRENA further strengthen and prioritise its work on market design, economics and enabling policy frameworks for power sector transformation?
- What are the provisions necessary to bolster international dialogue and ensure the complementarity of initiatives between IRENA and other stakeholders?