IRENA
International Renewable Energy Agency

21 April 2016

INTERNATIONAL RENEWABLE ENERGY AGENCY
Eleventh meeting of the Council
Abu Dhabi, 24 – 25 May 2016

Note of the Director-General

Cost Reduction Potential in Solar and Wind Technologies

I. Introduction

1. The rapid growth of solar photovoltaic (PV), particularly distributed PV, and wind power technologies is fundamentally changing a century-old paradigm of large centralised power stations producing and transporting electricity over transmission lines and local distribution networks to costumers. Instead, the majority of solar PV and even wind power systems are connected to distribution networks or medium voltage lines and are distributed closer to the consumer. In the case of solar PV they are often on the rooftops of the consumers themselves. For example, in South Australia, 25% of all households have a solar PV system. The distributed nature of solar PV also provides an impetus for the development of off-grid and mini-grid systems to support rural electrification.

2. In 2015, solar photovoltaics reached a pivotal point when projects worldwide were able to produce electricity from utility-scale solar photovoltaic projects for less than USD 0.10kWh, although the average often still remains above USD 0.10/kWh. The future is even brighter, as tenders and auctions for future delivery from 2017 onwards are being signed at between USD 0.04 to USD 0.06/kWh in regions with excellent solar resources. Rooftop solar PV systems provide households in a number of countries with cheaper electricity than if the electricity was bought from the grid, and innovative solutions like solar lights and solar home systems are providing affordable electricity to unelectrified regions in Africa and Asia.

3. At the same time, onshore wind is now one of the cheapest sources of new generation capacity, with a global average cost of USD 0.06/kWh in 2015. Concentrating solar power (CSP) and offshore wind are in the infancy of their deployment (CSP installed capacity at the end of 2015 was 5 GW and that of offshore wind 12 GW), nevertheless, these technologies are already attractive in some markets and costs are continuing to fall.

II. Highlights of the cost reduction potentials for solar and wind

4. IRENA's work, including the second edition of IRENA's global renewable energy roadmap REmap, shows opportunities for rapid growth for both solar PV and wind power technologies. The installed capacity of solar PV could increase from around 225 GW to 1760 GW, and wind power capacity could increase from around 400 GW to 1990 GW.

5. Based on these deployment levels, IRENA has analysed the installed cost reduction potentials for solar and wind power technologies. The average levelised cost of electricity (LCOE) for utility scale PV could decrease by between 42% to 45% in 2025 compared to 2015 levels. For CSP, by 2025 the

LCOE of both parabolic through and solar tower technologies will decrease by about 35% driven by lower capital investment costs. Historically, the investment costs of onshore wind power have declined by 6% and LCOE by 9% every time global installed capacity has doubled. Rapid and ongoing technology improvements, such as improved designs, larger turbines, higher hub heights and rotor diameters, mean that today's wind turbines can have double the capacity factor for the same wind resource than earlier turbines. In addition, a more rapid shift to today's best available technology in a number of markets could help reduce LCOE's.

6. Offshore wind is in its early stages compared to onshore wind, and the next generation of advanced large offshore wind turbines, as well as reduced costs for foundations and more efficient project development practices, could reduce the LCOE of offshore wind by 30% to 40% by 2025.

III. The impact of solar PV and wind power on the electricity sector

7. Besides the positive economic impacts of an increased deployment of solar PV and wind power, the integration of higher shares of variable renewable energy has many implications.

8. From a technical perspective, distributed renewable power generation reduces reliance on transmission networks in grid-connected systems by satisfying demand locally. However, upgrades of distribution networks and investments in flexible generation may be required if the production from high shares of solar PV and wind power generation exceeds local demand. Furthermore, operational procedures to manage power flows need to be adjusted. For off-grid systems, solar PV systems need to be matched with other renewable power generation technologies, innovative control systems, electricity storage systems or accompanied by diesel generators to ensure uninterrupted provisions of electricity at night.

9. From an institutional perspective, solar PV and wind power are also changing the ownership structure of the electricity system in both liberalised and vertically integrated electricity systems. Households, farmers, and local communities can invest in solar PV and wind power, and become generators and consumers at the same time. Also, industrial manufacturers are increasingly investing in renewable power generation capacity to satisfy their electricity demand from their own resources. Simultaneously, the localised production of electricity is changing the role of the distribution network operators, which suddenly have to accommodate electricity flows from the consumer back into the transmission network. The active role of consumers is creating new business models and ways of operating and managing the grid. For rooftop systems, the leasing model is becoming increasingly popular. Furthermore, virtual power plants and virtual communities of solar PV owners are emerging which are pooling resources or sharing electricity generation using the existing grid.

10. Solar PV and wind power are also changing the investment models and financial flows for utility-scale projects. Traditionally, utilities with centralised power stations and large grid infrastructures were seen as long term but reliable investment opportunities with steady rates of return. Operational expenditures were minimised, and fluctuations in fossil fuel prices could be passed on to the consumer.

The distributed nature and up-front cost requirements of solar PV are creating new financing instruments, such as project bundling, crowd funding, yieldcos and green bonds.[1]

11. From a policy perspective, the rapid decline of solar PV costs in the electricity sector has important implications. On the one hand, policy makers should allow for long-term planning and targets to facilitate a predictable business environment and an agile set of policies to support this long-term vision. On the other hand, policies should also allow for cost tracking and be sensitive to the dynamics in the business environment. In this context, countries have been increasingly adopting market-based mechanisms such as renewable energy auctions to support deployment and are considering new policies to guide the impact of self-consumption on the management and operation of power systems.

IV. Changing drivers of cost reduction have important policy implications

12. Equipment cost reductions remain an important driver of overall cost reductions in the future. However, with today's low equipment costs, particularly for solar PV and to a lesser extent for wind turbines, cost reduction opportunities in absolute terms will increasingly also hinge on non-equipment factors, including:

- Balance-of-project costs (i.e. the costs not related to solar PV modules and wind turbines).
- Operations and maintenance (O&M). These can represent one-quarter of wind power electricity costs.
- Finance costs. The weighted average cost of capital has a strong influence on the cost of electricity given the low or non-existent fuels costs of RE technologies.

13. This is a significant change from the experience in 2008/2009, when equipment cost reductions were a key driver in reducing costs and improving competiveness. This has important implications for policy makers, as existing policies will need to be adjusted and new ones implemented to ensure the drivers of these cost areas are adequately addressed. Given the increased number of stakeholders involved in the balance-of-project, O&M and financing costs; as well as the increased number of policy levers and regulations affecting their levels, unlocking these cost reductions may prove challenging without integrated, forward-looking policies. In reality, this means that in some countries current policy frameworks are not conducive and may require adjustment to achieve the most efficient level of these costs. A key opportunity exists in the significant cost differentials between countries for solar and wind power technologies. There exist, notably for solar PV, significant cost reductions that can be achieved by accelerating the rate of convergence in costs to "efficient" levels.

14. Although solar PV and wind power are commercially available and economically attractive in the electricity sector, there is still room to further improve solar technologies. Consequently, deployment policies stimulating market pull and business engagement need to go hand in hand with technology and

[1] Yieldcos are companies that hold already developed renewable energy assets for the income stream generated from their revenues. By transferring or selling renewable projects to these yieldcos, it frees up project developers capital for additional projects. Green bonds are bonds that are issued to fund sustainable or "green" activities although certain criteria must be respected.

innovation policies to support continuous research, development and demonstration. This includes a combination of basic and applied research for applications outside the electricity sector, and instruments that create long-term demand for solar PV deployment in buildings, the transport sector, agriculture or manufacturing, including supported niche market formation and promoted industrial coordination.

15. Also, policies to support solar PV and wind power deployment should consider the macro- and socio-economic development in these end-use sectors, such as the impact that these technologies may have on jobs and productive uses in rural areas. As deployment becomes more diverse, policies should also consider how to ensure the creation of local value chains from project initiation to operation and maintenance, and recycling of installed solar PV panels and wind turbines.

Questions for discussion

- What are the current experiences and future expectations for solar PV development and deployment in IRENA's Member states, and how does this affect policy development?
- Which potential impacts of solar PV are expected to occur within and beyond of the electricity sector, and how can IRENA assist countries in preparing for these impacts?
- How can IRENA most effectively support and accelerate the development and deployment of solar PV technologies within and beyond the electricity sector?
- Which policies have helped Member States drive down costs to efficient levels?
- How are Member States adapting their policy frameworks to unlock cost reductions in an era of low equipment costs, notably for solar PV modules and to a lesser extent wind turbines?
- Which challenges are Member States facing in collecting detailed cost data to allow an examination of "efficient" levels of costs for individual project components given structural and economic differences between countries and in order to identify cost reduction potentials?
- Which plans do Member States have for unlocking the low-hanging fruit of cost differentials between countries, with policies that drive down costs to "efficient" levels (taking into account structural differences)?
- What additional analysis would be most beneficial to Member States in understanding cost reduction opportunities until 2025? Should IRENA focus on high level global analyses that identify cost differentials and reduction potentials? Regional deep dives that seek to identify the reasons for cost differentials and how to reduce them? New analysis of how to reduce financing and O&M costs?

Suggested reading

Power point: Corporate sourcing of renewables – IRENA cost analysis

Renewable power generation costs in 2014 - Executive summary

Technology brief – Wind Power