УДК 811.111:620.97

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Renewable Solar Energy: Hydroelectricity, Wind and Solar Power

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Renewable sources account for rapidly growing shares of power generation in most parts of the world. Globally, running water is still the dominant renewable source of electricity in terms of generation, but the sum of solar PV and wind power could, according to some projections, grow already in the late 2020s or early 2030s. Global hydro power generation increased by an average of 2.4 % per year between 1990 and 2015 [1]. Growth was highly uneven across countries and regions. Whereas Chinese generation increased by more than 9 % per year, OECD area generation was up by a mere 0.6 % per year [2].

Hydro has the advantage of being dispatchable, i.e., adjustable to accommodate fluctuations in demand. In a global warming conscious world, hydro should therefore have a bright future. However, hydro generation has levelled out, and is expected to play only a supporting role in reducing greenhouse gas emissions, for three main reasons; the best resources close to demand centres have in many cases already been developed, hydro generation costs have not declined along with other renewable generation costs, and finally, large-scale hydro power projects have become increasingly controversial due to their social and environmental impact.

In cost terms, large-scale hydro compares well. But whereas the costs of solar PV and wind have declined in recent years, those of hydro have gone up. This development is likely to continue. Learning curve analysis suggests that solar PV and offshore wind have significant remaining potential for cost reductions. Hydro is a mature technology with little potential left. On the contrary, as hydro developers are forced towards lower quality resources further away from demand centres, unit costs may increase further.

Wind and solar photovoltaic power have been the renewable energy growth stories “par excellence” in recent years. About two thirds of total capacity is utility scale, along with that made up of factory, office and residential rooftop panels. Global onshore wind capacity increased from 116 GW to 416 GW for 11 years, implying an average growth of 18 % per year [3]. Global offshore wind is still at 19.3 GW or 4 % of total wind capacity, a small sibling in the family of renewable power technologies, but a growth of 33% per year between 2008 and 2017 suggests a potential for significant market capture. Solar photovoltaic and wind generation capacity account for 5.1 % and 8.5 %, respectively in global total generation capacity as of 2017 [1].

The reasons for the rapid growth in wind and solar photovoltaic generation since 2010 are government support and falling costs. They are highly interconnected in that the support has stimulated technology development, allowed for economies of scale, attracted more actors to the playing field and boosted competition. Now governments are reassessing, modifying and in some cases winding down support arrangements. The feed-in tariffs, tax breaks and other incentives that are available have become fiscally burdensome, and in some cases created electricity supply-demand imbalances, calling for power system optimisation and better regulation, rather than continued propped-up growth in zero marginal cost electricity supply. The consequences for wind and solar photovoltaic remain to be seen, but few observers envisage long-term setbacks for either technology, rather a natural moderation of growth rates.

The standard metric for comparing power generation costs is the socalled levelized cost of electricity (LCOE), which means the sum of investment costs, operating and maintenance costs, fuel and carbon costs (if relevant) and financial costs over the lifetime of a power plant, divided by anticipated output and discounted to present day values. Competitiveness in LCOE terms is not the only variable relevant for investment decisions – there are cost items that are not captured by the LCOE, and some technologies have more flexibility to generate when prices are favourable than others. Relative LCOE developments are nevertheless key signposts to the future shape of the power sector.

The wind and solar photovoltaic LCOE reductions over the last decade or so, and expectations of more of the same, have turned outlooks for power sector decarbonisation even in the most fossil fuel reliant regions, which used to be outlier scenarios, into baseline forecasts.

LCOE estimates vary significantly, depending on underlying assumptions, and are typically presented as ranges to account for differences in national and site-specific cost drivers, but most recent overviews show well-located onshore wind power plants as the cheapest of all options, and utility-scale solar photovoltaic plants to be competitive with most new coal and gas plants. And whereas the capital and operational costs of fossil fuels are flat, and those of nuclear and large-scale hydro plants are up, those of new renewable electricity are still pointing down. The pace of cost declines has abated, but the learning curve rule of thumb, saying that costs drop by 20 % for every doubling of capacity, suggests possibilities of additional declines in double digit territory, especially for solar photovoltaic.

Recent power auction prices convey the same message. Bid rounds have been won at prices below recent published average LCOE estimates, suggesting expectations of favourable electricity price, carbon price and/or cost developments between now and the time of commissioning, and probably that bidders consider they have exit options if these expectations are not met. Renewable power players' growing preparedness to take on "merchant" risk has been visible in recent offshore wind bid rounds. Offshore wind typically enjoys more stable wind conditions allowing for higher capacity factors, and represents an answer to the growing "Not in My Backyard" reservations against onshore wind.

The electricity price impacts of increasing shares of electricity available at zero marginal costs, in total supply, have prompted calls for regulatory reform and new power sector business models. There are fears of increased price volatility around depressed levels disincentivising investments in services that are crucial for uninterrupted supply. Unless the current mis-match between price signals, power plant dispatching principles and system long-term needs are handled, it could conceivably derail or at least slow the ongoing de-carbonization of electricity supply.

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