The Cost and Value of Renewable Energy: Revisiting Electricity Economics

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See footnotes at end of text.

COP21 concluded in Paris late last year, with an agreement that was broadly hailed as a diplomatic triumph. And renewable energy (RE) is the grand winner. Many countries had already announced ahead of COP21 that they were transitioning their power systems to 100% RE by 2050, and even earlier if possible. Market data indicate that the trend is already underway, with 60% of capacity additions being RE last year according to IRENA. The IEA, in its annual RE Medium-Term Market Report, projects additions of 700 GW of RE over the next five years. The most important reason for the growing market trend is the RE cost decline in many parts of the world due to sustained technology progress, improved financing conditions and aggressive expansion in emerging markets. This is all happening at a time of low oil prices, so this time it seems that RE are here to stay.

If this trend continues, this is indeed very good news, as it implies that the decarbonisation of the power system needed to implement the Paris agreement may not be so costly for the economies and may not need subsidies. But is this really true? Concerns are increasingly being voiced on the costs induced by the growing RE penetration, the so-called “hidden costs”.

What is the right cost metric?- The equipment cost decline has been spectacular in the last couple of years. The MESIA’s MENA Solar Outlook 2015 reports that “installation cost of utility-scale solar PV power plants have fallen from roughly $7 000/kW in 2008 to less than $1 500/kW in 2014”. However, it is now well known, even to non-energy experts, that the initial investment cost is not a good measure to assess the competitive positioning of RE technologies and indicate whether they will deliver electricity at an affordable price to consumers. The “capital cost” metric does not capture the fact that RE generating plants usually operate less hours than a conventional plant, and therefore cannot be used to compare different power generating technologies.

Comparison is usually done based on the levelized cost of electricity (LCOE). LCOE is the per-kWh cost of building and operating a generating plant over its financial life. Key inputs to calculating LCOE include capital costs, fuel costs, fixed and variable operations and maintenance (O&M) costs, financing costs, and utilization rate for each plant type. It is a convenient metric to compare different power generating technologies, as it allows comparison of plants with different cost structures and utilisation rates. LCOE can also be regarded as the minimum cost at which electricity must be sold in order for a project to break-even.

The declining trend has been as steep for RE LCOE as for capital cost, with declines of 66% for PV and 30% for wind in the last five years. In some cases, the LCOE is even lower than the price offered by conventional power plants—this is when grid parity is reached. In January 2015, the tender for the second phase of Mohammed bin Rashid Solar Park in Dubai was awarded to the lowest bidder for US$0.06 per kWh for a 25-year fixed contract, which was then the lowest solar price ever achieved worldwide[1]. Lower LCOE prices have been reported since then in the U.S. and in Germany.

The fallacy of LCOE- LCOE analysis has shortcomings and comparing technologies using that metric is misleading, as shown by Joskow[2]. The use of LCOE is flawed because it treats all kWh supplied as an homogeneous product with a single price. Specifically, traditional levelized cost comparisons fail to take account of the fact that the value of electricity supplied is time and location specific. Moreover, the LCOE metric does not take into account that electricity supplied by conventional plants and by RE plants is not the same product. Since the output of wind and solar PV is driven by natural processes, there is no guarantee that it will be available when the consumer needs it, whereas electricity from conventional power plants can, most of the time, be produced on demand. A kWh produced from conventional power plants is firm, one by RE is uncertain. LCOE ignore the costs of backing up intermittent renewables and of the networks required to integrate them.

Grid integration costs- Integrating wind and solar power or other variable RE into power systems causes costs elsewhere in the system. Examples include distribution and transmission networks, short-term balancing services, provision of firm reserve capacity, a different temporal structure of net electricity demand, and more cycling and ramping of conventional plants. These costs are often called “hidden costs” or “grid integration costs”. Typically, “integration costs” are of three types: grid costs, balancing costs and the “adequacy costs” or “utilization effect on conventional power plants”. There is no agreement on whether the third type should be accounted as part of integration costs; it is discussed in the next section on merit-order effects. Integration costs will vary substantially according to the amount of penetration of variable RE, the power system structure and its flexibility. The flexibility of a power system is its ability to cope with the stress resulting from sudden and unpredictable variations in availability, which is characteristic of renewable energy. Grid integration costs can vary from zero (or even negative when the production of RE matches perfectly the demand profile) to estimated values of around $15/MWh[3].

The merit order effect- RE penetration affects the revenues and margins of conventional power plants by lowering average wholesale electricity prices and peak prices and by reducing the volume of electricity produced by thermal plants. Wholesale prices fluctuate between zero when renewables are at the margin (or even negative when low demand coincides with a very high level of wind for instance) and the variable cost of fossil fuel-fired plant when the latter are at the margin.

In a merit order based on marginal cost, RE plants will be dispatched first as they have a zero marginal cost. As the RE capacity increases, conventional fossil fuel power plants move to the right of the merit order curve and their utilisation is substantially reduced. In Spain, effective operations of CCGT fell from over 4000 hours in 2008 to less than 1000 hours in 2014. Not only they do not recover their fixed investment costs[4], but also they risk being decommissioned if they run too few hours to cover their fixed O&M. However, those plants are needed to provide the system flexibility required to integrate a high level of RE. An issue for electricity systems is how to provide adequate compensation for this flexibility. Capacity mechanisms have been introduced in some European countries to remunerate that flexibility and avoid conventional power plant closure. However, capacity payments tend to create an oversupply of power generating capacity, further depressing prices. This affects negatively both the value of RE and of conventional plants.

System costs- As emerges from the discussion above, there is a complex and intricate relationship between prices, RE costs/values and conventional plant profitability. A high level of RE capacity tends to depress wholesale electricity prices. This implies lower revenues for conventional plants, which tend to be decommissioned or mothballed. This in turn reduces power system reliability and flexibility, which decreases the ability of the power system to integrate a high level of renewables. This vicious circle needs to be broken to find an economic equilibrium that optimises the RE contribution. What is needed is a holistic approach to power system analysis and planning.

The metric needed is an approach that integrates all these costs and derived effects of the RE penetration to determine the optimal mix of plants to meet electricity demand at lowest cost, while satisfying the climate change and other policy objectives. This is the “total system cost” approach which focuses on the total cost of the power system, rather than trying to allocate some of the cost components to specific technologies, or part of the power system, in order to be able to compare the technologies on the basis of LCOE.

Planning the future power system needs to integrate the flexibility requirements, but flexibility requirements also need to be incorporated in operating decisions. The power system does not always operate as planned. Extreme weather, unanticipated outages and other factors can result in the system operating outside of planned conditions. Generally, the system is robust enough to handle most departures without problems. For more severe departures from planned conditions, the re-dispatch of generating resources is a major tool for the system operators. Although the prevailing thinking is that RE plants run whenever available, curtailing existing variable RE units for reliability reasons could be helpful at times; but it adversely impacts the economic performance of such resources and is politically challenging. There are suggestions that RE could provide ancillary services and contribute to market balancing, mimicking conventional generation, but the cost may be high and it would affect RE market value. Building RE capacity to remain idle while waiting to back each other up and provide flexibility as needed is difficult to justify economically. The long-run challenge is to put in place market arrangements—both market design and operating practices-- that recognize the value of flexibility, by remunerating flexible plants adequately, and guarantee sufficient revenues for investment to take place without permanent state intervention.

The “system cost” approach provides the right metric to measure RE costs and market value, but it is a little complicated for the layman. Either we need to better educate the public, or design a simple metric that everybody can understand.

Footnotes:

[1] Source IRENA Press Release April 8, 2015- Cost-Breakthroughs Make Solar and Wind the UAE's Most Competitive Energy Sources

[2] Joskow, Paul. "Comparing the Costs of intermittent and dispatchable electricity generation technologies", MIT-CEEPR Working Paper (revised February 2011). A short version appears in the *American Economic Review Papers and Proceedings 2011,* 101(3):238-241, May 2011.

[3] Some estimates are given as % of LCOE, with a range of 10-40%

[4] In general, CCGT plants were financed on the assumption that plants would operate around 4,000–5,000 hours a year (46–57 % load factor).

IAEE/Affiliate Master Calendar of Events

(Note: All conferences are presented in English unless otherwise noted)

Date	Event, Event Title and Language	Location	Supporting Organization(s)	Contact
2016				
April 24-26	9th NAEE/IAEE International Conference *Energizing Emerging Economies: Role of Natural Gas & Renewables for a Sustainable Energy Market and Economic Development*	Abuja, Nigeria	NAEE NAEE/IAEE	Wumi Iledare *wumi.iledare@yahoo.com*
June 19-22	39th IAEE International Conference *Energy: Expectations and Uncertainty Challenges for Analysis, Decisions and Policy*	Bergen, Norway	NAEE	Olvar Bergland *olvar.bergland@umb.no*
August 28-31	1st IAEE Eurasian Conference *Energy Economics Emerging from the Caspian Region: Challenges and Opportunities*	Baku, Azerbaijan	TRAEE	Gurkan Kumbaroglu *gurkank@boun.edu.tr*
September 21-22	11th BIEE Academic Conference *Innovation and Disruption: The Energy Sector in Transition*	Oxford, UK	BIEE	BIEE Administration *conference @biee.org*
October 23-26	34th USAEE/IAEE North American Conference *Implications of North American Energy Self-Sufficiency:*	Tulsa, OK, USA	USAEE	David Williams *usaee@usaee.org*
2017				
June 18-21	40th IAEE International Conference *Meeting the Energy Demands of Emerging Economic Powers: Implications for Energy And Environmental Markets*	Singapore	OAEE/IAEE	Tony Owen *esiado@nus.edu.sg*
September 3-6	15th IAEE European Conference *Heading Towards Sustainability Energy Systems: by Evolution or Revolution?*	Vienna, Austria	AAEE/IAEE	Reinhard Haas *haas@eeg.tuwien.ac.at*
2018				
June 10-13	41st IAEE International Conference *Security of Supply, Sustainability and Affordability: Assessing the Trade-offs Of Energy Policy*	Groningen, The Netherlands	BAEE/IAEE	Machiel Mulder *machiel.mulder@rug.nl*
September 19-21	12th BIEE Academic Conference *Theme to be Announced*	Oxford, UK	BIEE	BIEE Administration *conference @biee.org*
2019				
May 26-29	42nd IAEE International Conference *Local Energy, Global Markets*	Montreal, Canada	CAEE/IAEE	Pierre-Olivier Pineau *pierre-olivier.pineau@hec.ca*
August 25-28	16th IAEE European Conference *Energy Challenges for the Next Decade: The Way Ahead Towards a Competitive, Secure and Sustainable Energy System*	Ljubljana, Slovenia	SAEE/IAEE	Nevenka Hrovatin *nevenka.hrovatin@ef.uni-lj.si*