IEAGHG Information Paper: 2016-IP13; Comparing the Costs of Electricity Supply

The comparison of costs of different low carbon technology options in the USA seems to have sparked something of a media debate but underlying the headlines there are issues of relevance when comparing apples and pears as is often done by both politicians and the media.

The standard comparator for comparing the costs of electric city generation is the metric is the levelised cost of electricity or (LCOE.)

The definition of LCOE is: The levelised cost of electricity (LCOE) is a measure of a power source which attempts to compare different methods of electricity generation on a comparable basis.

In our cost studies we feel comfortable using LCOE to compare, comparable technologies;i.e. different coal based and gas fired power cycles with and without ccs. We would be comfortable stretching this to another base load technology nuclear. But as an organisation we have not strayed into using LCOE to compare, base load power plants with variable renewable electric sources like wind or solar.

In IEAGHG's opinion the best way to compare different power generation technologies is to model a range of combinations of technologies in the context of a real power system, with variable power demand. This however is more difficult, it is more country-specific and it does not result in simple "best technology" charts such as those included in a recent report by GCCSI report on *"The costs of CCS and other low-carbon technologies in the United States: 2015 update"*, See https://www.globalccsinstitute.com/publications/costs-ccs-and-other-low-carbon-technologies-2015-update. However one must accept that such comparisons are simple, and provide just the sort of messages that policy makers like to hear and can relate too.

We also note that sometimes extra costs are added to LCOE charts to account for "system costs" of renewables such as extra back-up generation capacity and increased transmission requirements. It should however be noted that these costs are not always easy to calculate and they can sometimes be negative. For example in many hot countries the peak power demand is during the daytime in summer (for air conditioning), which is also the time when solar PV generates most of its power. This means that per MWh generated, solar PV reduces the requirement for other peak generating capacity more than a "baseload" generation technology does. In the UK, where peak power demand is in winter, it is the opposite and solar PV would have a positive back-up generation system cost.

IEAGHG is not alone in this interpretation of the suitability of LCOE. The Energy Information Administration (EIA) in its analyses separates "dispatchable" and "non-dispatchable "sources in its LCOE calculations[1]. The EIA has stated that "caution should be used when comparing them (dispatchable" and non-dispatchable sources) to one another." In a article it goes on to say that dispatchable plants "whose output can be varied to follow demand" (e.g., coal, natural gas, nuclear, etc.) are more valuable than wind turbines "whose operation is tied to the availability of an intermittent resource." I guess the issue here lies around the word "value", which is you are looking at it from a grid perspective and a supplier of energy to a client reliability would be more valuable than intermittency. However from a climate/political perspective renewable electricity might be of more value despite its issues of intermittency.

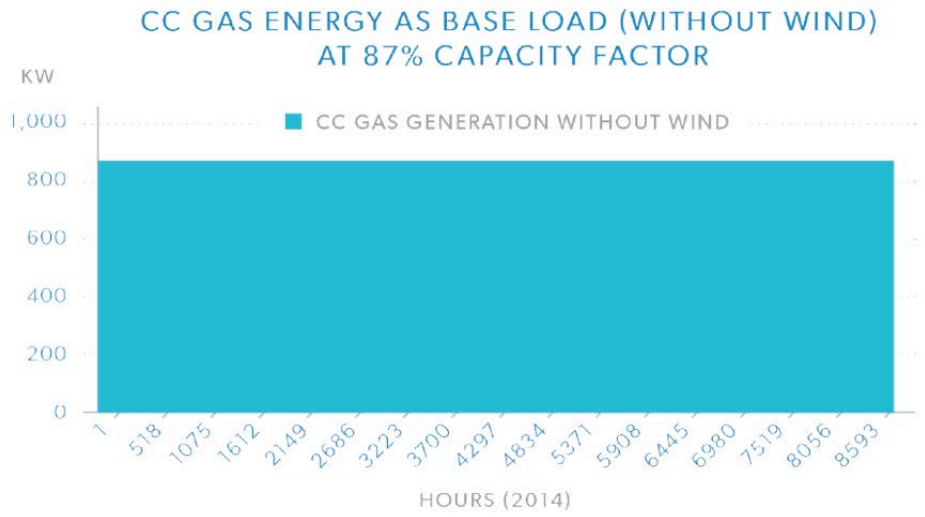
The Institute of Energy Research (IER) in the USA has recently published a report entitled; The Levelized Cost of Electricity from Existing Generation Sources. See

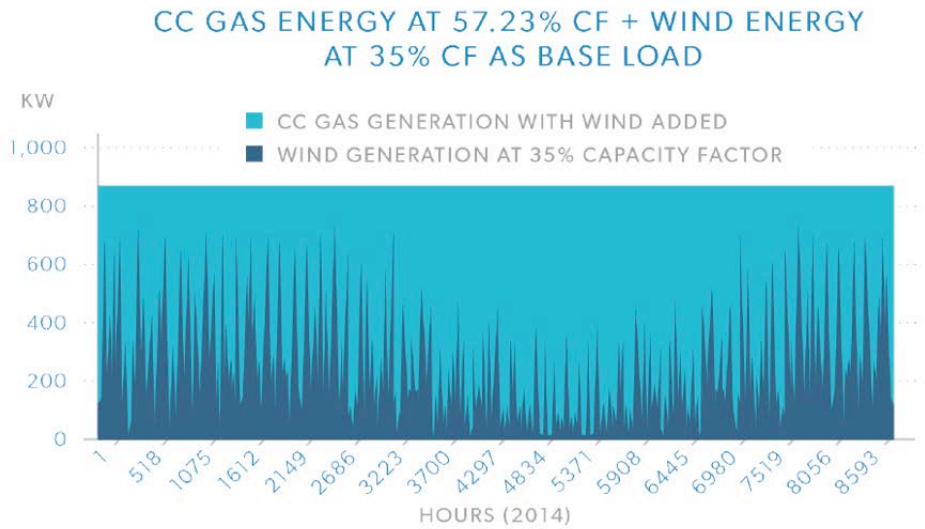
[1] U.S. Energy Information Administration, Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2015, June 2015, pp. 1–2, http://www.eia.gov/forecasts/aeo/pdf/electricity_generation.pdf.

http://instituteforenergyresearch.org/wp-content/uploads/2015/06/ier_lcoe_2015.pdf. This report compares the costs of electricity from existing plants in the USA with new build plant as calculated by the EIA.

In this report IER introduced the concept of the "imposed costs" i.e. those costs created by intermittent resources. The report estimated those "imposed costs" to be $30/MWh on dispatchable generation from natural gas plants. In this case the "imposed costs" were defined by the example *If a power grid consists of only combined cycle natural gas plants the natural gas fleet is needed for those times when wind output is low or zero,[but it has to back down to accommodate the intermittent wind generation. In other words, its production is crowded out by the intermittent wind generation. Lower production from the same capital-intense facility is the source of "imposed costs"—wind generation significantly raises the LCOE of the dispatchable resources on the system. By decreasing a reliable power plant's run time without also reducing its fixed costs, wind power makes it more expensive to generate electricity from existing and new dispatchable resources*.

The scenario IER modelled is shown in the figure below. In this scenario new wind production causes the natural gas fleet's capacity factor to drop from 87 percent to below 60 percent. The "imposed cost" of wind power in this scenario they state is nearly $30/MWh





The IER then continue to say that, when the imposed costs of intermittent resources are taken into account, the LCOE of wind is not competitive with other new sources (highlighted in red with imposed costs included).. This is illustrated in the table below taken from their report.

Generator Type	LCOE EXISTING as found in FERC Form 1 (EIA fleet avg CF) 2012 $/MWh	LCOE NEW (EIA) as adjusted by this report (EIA best case CF) 2012 $/MWh	LCOE NEW (EIA) as adjusted by this report (EIA fleet avg CF) 2012 $/MWh
Dispatchable Full-Time-Capable Resources			
Conventional Coal[1, 3]	38.4	78.1	96.8
Conventional Combined Cycle Gas (CC gas)[3]	48.9	74.0	73.2
Nuclear[3]	29.6	93.8	90.2
Hydro (seasonal)	34.2	82.4	115.6
Dispatchable Peaking Resources			
Conventional Combustion Turbine Gas (CT gas)[2]	142.8	139.6	361.6
Intermittent Resources – as used in practice			
Wind including cost imposed on CC gas	N/A	88.3 **+ other costs***	106.8 **+ other costs***

Summary

This issue of "imposed costs" is a related by somewhat different principle of "system costs" we introduced earlier. However taking the two together it is clear that a simple LCOE comparison does not demonstrate the full costs of different base load and variable electricity sources. The only real way to do this is to look at the costs from a "system perspective" as more and more grids are becoming complex system with more than one type of electricity production system in the mix. Any system based approach must also take into account issues such as: grid strengthening to bring renewable electricity to the user, feed in tariffs and grid allocations for different options and storage needs.

It is also true to say that none of the cost examples quoted include CCS, which will increase the costs of coal and natural gas fired plants. The objective of this note was not to try and compare the costs of CCS options with other low carbon options. However it is noted that proponents of some low carbon technology options do just that using LCOE as the measure of comparison. The objective of this note therefore was to raise a warning that policy makers should be cautious of comparing apples with pears based on LCOE analyses. What they should be doing is looking at the technology from a "system perspective" and asking modellers to identify the most cost effective suite of options to minimise the cost of electricity to consumers whilst maintain full grid capacity to meet varying demand on the grid.

John Gale
06/06/2016