Levelized Cost of Consumed Electricity

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Executive summary

1. Motivations underlying the research

Profitability of renewables energies is in general appraised through the concept of levelized cost of electricity (LCOE). It is usually computed as a discounted average cost that ignores the intermittency of the generated electricity. Nevertheless, ignoring intermittency and reasoning on average values gives a disproportionate advantage to renewable sources and can lead to taking wrong decisions. The same problem applies to the grid parity which is another tool used to assess renewables' profitability. Indeed, using such methodologies, the Energy Information Administration reports that solar photovoltaic (PV) has already obtained grid parity in several places. However, the LCOEs obtained cannot be compared directly with those of carbonized electricity sources as solar PV electricity generation is intermittent and cannot be used in isolation.

This study attempts to fill this gap by proposing a new method to compute the average cost of renewables that accounts for intermittency and flexibility options provided by smart meters and batteries. As our focus is on residential electricity consumers, we introduce a new metric: levelized cost of consumed electricity (LCOCE). Under various scenarios, we calculate the LCOCE using an economic model that allows a household (a residential electricity consumer) to optimize its electricity consumption as well as grid feed-ins and electricity stored given varying electricity tariffs, weather conditions (solar irradiance), and devices used.

Our approach is novel because it accounts for (i) location-specific (United Kingdom (UK) and Hong Kong (HK)) and dwelling-specific (flat and house) behaviour of the household that optimizes its electricity consumption; (ii) uncertainty in solar irradiation both within the day and seasons; (iii) variations in tariff rates; and (iv) cost of acquisition and installation of flexible smart devices in the smart grid, including smart meters, batteries, and so on.

2. A short account of the research performed

Computation of LCOCE necessitates three different types of data: (i) discount rate, relative risk aversion coefficient, and system lifetime; (ii) investment, maintenance and operation costs; and (iii) data on electricity generation and consumption. To obtain 'optimal' electricity generation and consumption decisions, we construct an optimization model and calibrate it on two sets of data: observed data on a UK house and simulated data on an apartment in a high-rise building in HK. We consider two different types of dwelling as a single house is more representative of

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Welsh homes while a flat in a high-rise building is the typical type of dwelling in HK. We also consider different solar PV installations depending on the location as we seek to appraise the cost of the most standard one for each type of dwelling. Following this, we derive the optimal electricity consumption, solar generation, storage and purchases (sales) from (to) the grid for the UK and HK cases.

The two cases that we apply the LCOCE approach to clearly demonstrate the two opposed consequences of intermittency for the cost of the electricity consumption that are accounted for in the LCOCE, but not in the LCOE. For HK, the additional cost of the backup (storage, smart meter, and electricity purchase) that needs to be used when no electricity is generated explains why the LCOCE is higher than the LCOE (as the LCOE of solar electricity does not account for such backups) for systems *that include solar panels*. On the contrary, in the UK, the opportunity to sell the excess power to the grid, that is accounted for in the LCOCE (and not in the LCOE), generates a sufficiently large gain to prevail on the previous effect, except when there is storage. The different conclusions for each country are driven by the low electricity tariff in HK which limits the gains from selling excess electricity to the grid.

3. Main conclusions and policy implications of the work

This paper makes a clear point about the proper calculation of the cost of solar PV panels that can be complemented with devices, such as a smart meter and a battery, at the household level. Our method makes several improvements in that it accounts for the intermittency at daily and seasonal levels, electricity tariff variations, optimal household electricity consumption behaviour as well as the cost of complementary technologies such as smart meters and batteries.

We observe that accounting for intermittency reduces the cost of solar consumption for the dwelling in the UK while it increases it for the high-rise building apartment in HK. These outcomes stress the importance of computing costs depending on the location, which implies not only specific weather conditions, but also specific types of dwelling, consumption habits, as well as electricity tariffs.

With the rising generation of solar power at the household level and the rising use of batteries and smart meters, a more accurate measure of a weighted average cost of electricity consumption is crucial for analysing the economic value of investing in smart grids, and, accordingly, for expanding smart communities. A more accurate calculation of the weighted average cost of electricity consumption is also informative for policymakers when deciding on policies to promote further investment in home renewable energy systems. In particular, computing the LCOCEs for specific types of systems can allow them to determine a more accurate amount of financial support for the households.