THE ECONOMICS OF PROSUMAGE: QUANTIFICATION OF BUSINESS OPPORTUNITIES IN GERMANY, CALIFORNIA, AUSTRALIA, INDIA, AND SOUTH AFRICA

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Overview

A triangle of trends comprised of technological innovation, digitalization and climate change is currently forcing the electricity sector globally to undergo dramatic changes. The affordability of solar and storage technologies has forged the "pro-sum-age"-paradigm: PROduction + conSUMption + storAGE (Green, 2016). Prosumage has become an economical option in many electricity systems. The materialization and further development of this situation not only poses interesting opportunities for home and business owners as investors but has also affects utilities and grid operators (Rickerson et al., 2014).
A prosumer is the operator of an electricity-generating asset who consumes at least part of the produced electricity directly without any usage of the grid. ProsumAGE adds storage to this concept which allows the operator to store the energy e.g. when the supply exceeds the current demand to shift demand from a later point in time forward.
Grid parity, an essential concept when talking about prosumage, describes the point in time when the present value of long-term revenues (earnings and savings) of an electricity-generating asset equals the long-term costs of buying electricity from the grid. (EPIA, 2011) It is the crucial condition for the profitability of self-consumption of electricity and therefore for the potential use of storage.
The objective of this paper is to provide a quantitative assessment of business opportunities in prosumage. Since prosumage can be very broad, this paper will only examine a prosumage system comprised of photovoltaic (PV) generation and battery storage. We assess opportunities for the development of prosumage in five distinct legislations and energy systems.

Methods

To analyze possible business cases for prosumage the first step is to collect qualitative and quantitative data regarding grid parity in the different locations i.e. LCOE-values (Levelized Cost of Electricity) as a function of PV-system size, as well as electricity retail prices and feed-in prices, should they exist in the observed regulatory framework.

$$\mathrm{LCOE} = \frac{\mathrm{PCI} + \sum_{t=1}^{N} \frac{\mathrm{AO}}{(1+\mathrm{DR})^t}}{\sum_{t=1}^{N} \frac{\mathrm{GP} * (1-\mathrm{SDR})^t}{(1+\mathrm{DR})^t}}$$

Formula for calculating the LCOE

Parameters

PCI	Project cost minus tax credit or grant	GP	Generated power
AO	Annual operations cost	DR	Discount rate
N	Number of years of operation	SDR	System degradation rate

We define LCOE as the price of a unit of electricity produced by a power generating asset. To calculate the LCOE, all costs of the power generating asset over its lifetime are considered and divided through the total amount of energy produced over the same period. In case of a rooftop PV system, this comprises the initial investment as well as maintenance costs divided by the generated electricity which depends mainly on plant size and insolation profiles. Both have to be discounted with the costs of capital (Branker et al., 2011).
In addition to the cost of supplying electricity via a PV-system of a certain size the demand profiles as well as the PV-production profiles for representative households at each of the chosen locations have to be studied.

To be able to evaluate the profitability of storage systems the production and demand profiles of the representative households have to be matched. This makes a calculation of the potential for storage use for all conceivable combinations of differently sized PV and storage systems possible. With additional data on storage capacity prices in differently sized systems a calculation of LCOS (Levelized Cost of Storage), that means storage costs of a stored kilowatt hour over the lifetime of the storage is possible. Finally, with this data the Internal Rate of Return can be optimized considering different PV- and storage system sizes.
The case studies are chosen such that they cover a broad spectrum of regulatory situations, geography, and energy systems as well as economic environments.
As this paper aims to analyze the viability of prosumage for an individual investor, we do not consider system effects, i.e. the role of prosumage for total system costs (see Green, 2016), nor distributional issues.

Preliminary Results

We chose Germany, California, Australia, India and South Africa to cover a broad spectrum of geographic, infrastructural and political conditions. Germany and California represent large-scale, highly interconnected energy systems, with high penetration of solar PV and increasing privately owned storage. Both countries have set similar renewables standards (~ 50% share by 2030), but California has a significantly higher solar intensity (EEI, 2016; Fraunhofer, 2016). Australia is probably the most interesting developed country for prosumage due to its low population density and favorable insolation profiles across the country. India's government has set 100 GW and 40 GW of grid-connected and rooftop solar PV respectively as a goal for 2022 (IEA, 2015) as it needs both grid-connected and off-grid electricity. Thus, India might see the fastest increase of prosumage. South Africa too, has ambitious plans for PV development and excellent natural conditions, although the economic case for prosumage is not yet evident, given highly subsidized retail prices and ongoing investments into coal and nuclear power. The sharp decline in prices for PV components and the simultaneous rise of retail prices lead to grid parity in an increasing number of places (IEA, 2014). Still, many scientific publications state much higher costs for PV systems than actual installation costs, often up to three years prior.

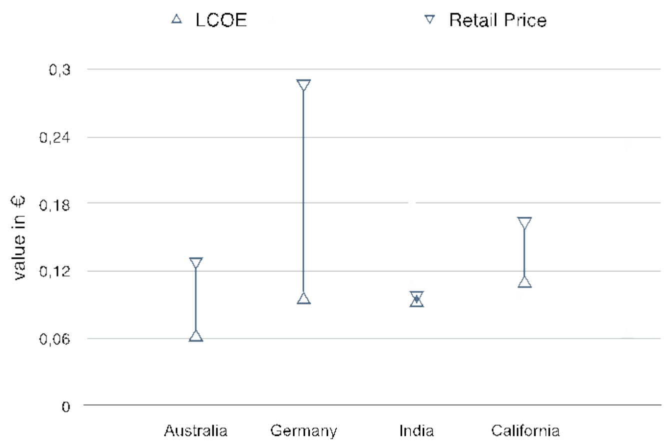

Figure 1: LCOE of PV vs Price of Electricity in selected places

Figure 1 shows preliminary results comparing the levelized costs of electricity of decentrally generated electricity from PV installations and the average retail price. The conditions for investments into own generation and storage differ significantly between the countries, and thus can't be generalized. The cost of capital can outweigh efficiency gains and per unit cost reductions (such as in India), whereas a stable institutional environment is worth a lot (case of Germany so far).

Conclusions

The findings of the proposed paper will not only include relevant data on LCOE and the state of grid parity but also on the viability of PV-prosumage for various insolation and demand profiles as well as regulatory and economic environments. The paper will also determine if and how storage systems can be profitable in a grid parity environment, which has been reached for prosumers using PV in many countries over the world. Another question that will be answered with the gathered data is if prosumage is still profitable without refinancing mechanisms such as feed-in tariffs or net metering.

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