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OPERATIONAL EXPERIENCE AND ECONOMICS
OPERATIONAL COSTS AND THEIR INFLUENCE ON LCOE OF PV PLANTS
EXPERIENCE AND OUTLOOK ON OPERATIONAL COSTS FOR SMALL TO MEDIUM PV PLANTS IN SWITZERLAND FROM A POINT OF VIEW OF AN INDEPENDENT POWER PRODUCER

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ABSTRACT: Operational costs of PV plants become more relevant for levelized costs of electricity (LCOE) with decreasing upfront costs for PV systems. This is true due to the shift of the balance in shares of LCOE for the two main components of LCOE capital costs and operational costs. Understanding and optimizing operational costs is therefor essential for further reduction of LCOE for future PV plants. This work analyses true operational costs for small to medium (30…250 kWp) PV plants over a period of time of five years in terms of most relevant components as well as absolute numbers and gives an outlook on possible future developments of operational costs.
The share of operational costs in the LCOE rose from 17% to 29% in the observed period of time, although absolute numbers of operational costs were reduced by around 15%. This is mainly due to the fast reduction of capital costs of about 55%. While the trend for the capital costs seems to be given with PV system price learning curves, the main components of operational costs show different potentials for cost reduction.

Keywords: LCOE, operational costs, maintenance and operation

1 PURPOSE OF THE WORK

Levelized costs of electricity (LCOE) basically consist of capital costs, including discount rates, and operational costs. While capital costs are dominated by upfront costs of the PV system, operational costs not only consist of maintenance costs, but also insurance, surveillance of performance as well as different fees due to utilities and authorities and others.

PV system costs are very well documented, especially module and inverter costs, described by the well-known cost learning curves. They are not further investigated in this work but are base to the LCOE calculations.

This paper focuses on the operational costs. **Operational costs have not been analysed as thoroughly as system (capital) costs so far.** This is partly due to the fact that until recently, the capital costs have had a far larger share in LCOE than the operational costs, but also because focus has been laid more on technical improvements in the PV systems.

2 APPROACH

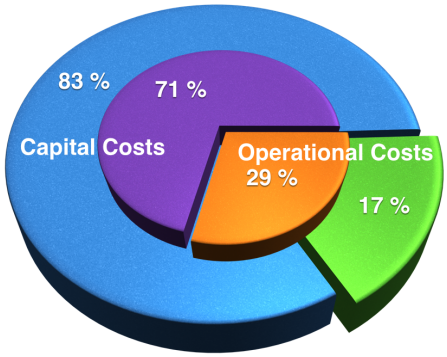
As an independent power producer (IPP) the Swiss company Zurichsee Solarstrom AG (ZSSAG) operates several small to medium PV plants in Switzerland. The existing data on operational costs over the last five years is analysed identifying the most important components in terms of absolute and relative numbers. The development of the identified components over time are compared and rated. Correlations to technical and economical developments as well as requirements for approvals needed for authorities and other parties involved are established.

Finally an outlook on possible development of the components for operational costs and the influence on LCOE of PV plants is given.

3 RESULTS

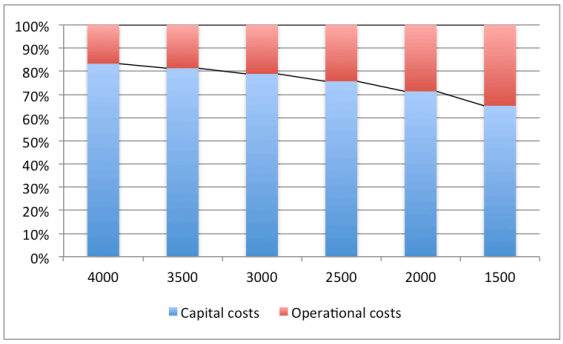
3.1 OPERATIONAL + CAPITAL COSTS = LCOE

With only small improvements in operational costs over time horizon of the data analyzed the share of the operational costs on LCOE for newly built PV plants strongly increased.



The graph shows the share of operational costs on LCOE for PV plants realized in 2009 with true operational costs of around 7 Rp/kWh (partially corrected with time value of components) with 17% and for PV plants realized 2014 with **operational costs** of around 6 Rp/kWh **making up for 29% of LCOE**. The size of the pie is proportional to absolute costs (capital costs + operational costs). In other words, the LCOE have been reduced by almost 50% during this period of time, while operational costs have only been reduced a little above 15%, capital costs have been reduced by more than 55%.

Calculated constant operational costs of 6 Rp/kWh make up for 9% up to 24% of the LCOE of small to medium PV plants, where the time is represented by PV system costs in CHF/kWp.



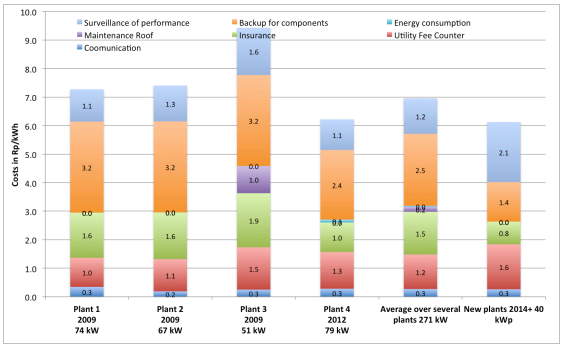
3.2 MAIN COMPONENTS OF OPERATIONAL COSTS

Main components in the analyzed data of operational costs are **backups for replacement of components**, especially inverters. It makes up for almost one 35% of the operational costs at point of time of calculation. This is of course strongly dependent on material costs of inverters, which show a decrease in time. This part of operational costs has to be recalculated on a periodic base.

Insurance costs also make up for a large part of the operational costs analyzed, in the data analyzed for about 19.5%. Insurance fees strongly depend on PV system costs. Reduction in PV system costs (learning curve PV) can be stronger than reductions for internal calculations of insurance companies. This makes a new evaluation of insurances for existing PV plants necessary.

Fees, requirements and certifications for grid connection and authorities can lead to necessary and unwanted adaptions of layouts in small to medium PV plants. In Switzerland, PV plants with a nominal power between 30 … 50 kWp are very difficult to realize due to additional certifications needed and rent of power meters from utilities. This components can make up between 15…20% of operational costs.

Surveillance of performance and remote maintenance have been constantly developed by PV industry and allow for a faster and more precise detection of faults in PV systems. They make up for another 15…20% of operational costs. Clustering in surveillance by specialized companies has to be exploited even more thoroughly for optimized costs.



3.3 SCHEDULED AND EVENT-BASED MAINTENANCE

Regularly returning operational costs can be taken into account for LCOE calculations easily, although some have to be adapted over time, because assumptions are no longer valid.

Influence of event-based operational costs (i.e. module, inverter or installation failure) can be reduced by maintenance and insurance contracts. Case handling is either over-insured or has to be taken into account when occurring, adding to LCOE. Quality assurance of PV installations is absolutely essential to keep this component in affordable dimensions. Clustering of several PV plants in operating organizations helps distribute risk of occurrence and therefore costs.

4 CONCLUSIONS

- Reduction in operational costs cannot keep up with reduction in PV system costs.
- Generalized calculations of operational costs are no longer applicable, due to higher share of operational costs in LCOE in comparison to upfront costs of PV systems. Project specific costs have to be calculated in order to obtain valid LCOE.
- In order to calculate LCOE correctly and minimize operational costs, a periodic re-evaluation of relevant components has to be made, especially for technical components and services such as inverter replacements and insurance fees. On time of realization valid operational costs are not applicable over full life cycle of PV plants.
- Influence of single components of operational costs, for example energy meter renting, can be so strong that they influence the system layout. This leads to a band of PV plant sizes which are very challenging to realize economically.
- Offers for services may vary strongly, a tender for different components of operational costs, such as insurances, certifications and others will lead to reductions in LCOE.

5 OUTLOOK

Focus of power producers, planers and operators should shift more from PV system costs (capital costs) to operational costs in order to optimize LCOE. To raise awareness and understanding, more detailed analysis of operational costs and development is needed on a broad database.

While insurance costs and savings for replacement of components such as inverters show clear tendencies to decrease, surveillance of energy production stays on a more or less constant level and other components such as fees and requirements for grid connection tend to become more restraining and cost intensive. Utilities and authorities are coming up with new requirements and restrictions, partly due to higher penetration of PV in the grids, partly due to a slow reaction to the fast deployment of PV (time lag).

WORK IN PROGRESS

Additional comparison between different offers and costs at the same point of time (spread across the values) as well as best available products and services at different points of time (timeline) are visualized based on the analyzed data.

The evaluated data is expanded by the available data for operational costs of PV plants realized 2014/15 by IPP ZSSAG.

Swiss specific facts influencing operational costs given by the database are identified in order to make the results found more generally applicable.