SURVEY OF OPERATION AND MAINTENANCE COSTS OF PV PLANTS IN SWITZERLAND

F.P. Baumgartner[1], O. Maier[1], D. Schär[1], D. Sanchez[2], P. Toggweiler[3]
[1] ZHAW, Zurich University of Applied Sciences, SoE, Institute of Energy Systems and Fluid Engineering, Technikumstrasse 9, CH-8401 Winterthur, Switzerland, www.zhaw.ch/~bauf
*phone: +41 (0) 58 934 7292; e-mail: bauf@zhaw.ch
[2] ZHAW INE, Switzerland; www.ine.zhaw.ch
[3] Basler & Hofmann AG Zurich, Switzerland, www.baslerhofmann.ch

ABSTRACT: With worldwide prices of photovoltaic (PV) modules having dropped below € 0.6 /W_p nowadays, the relevance of operation & maintenance costs (OMCs) relative to other costs of a photovoltaic plant increased to more than 20% up to 40% of the total costs over the whole operation period of the plant. Moreover, the level of knowledge concerning OMCs is limited among PV plant operators either of their own plants or about other reference plants of the same category in the field. In Switzerland a previous OMCs analysis was conducted in 2008. This knowledge is needed to getter information to set the federal feed-in tariff for PV electricity. These federal tariff rates related to the most economic PV plants have to be subject to a regular review according to the Swiss electricity law. This paper analyses the survey done in 2014 with overall OMCs found between 3 and 13Rp/kWh, as an average value of the related nominal plant power category with a high variance within one group. Over 80% of the produced electricity of the analysed grid connected PV plants shows OMCs below 5Rp/kWh. The data collected from web based polling's and expert interviews covering 48MW nominal power, or 4.4% of the total installed PV power in Switzerland in 2014. The main cost drivers of OMCs are identified to be monitoring, site visits and metering for PV plants below 100kW nominal power. Larger plants are dominated by inverter related replacement costs of about 1Rp/kWh up to values of about 2.1Rp/kW for smaller plants. Furthermore, priorities on reduction of OMCs are suggested, mostly thanks to reducing the labour cost due to services of a person's directly at the PV plant site. Reference OMCs costs of about 3Rp/kWh for today's new 10kW sized plants should be achievable for an optimized PV system setup with significantly reduced site visits.

Keywords: Maintenance, OMC, cost reduction, Grid-Connected, Performance, PV Market, PV System, Utilities; feed-in tariffs

1 INTRODUCTION

Today both, the share of PV module costs and the total cost of OMCs generates almost the same costs over the whole plant operation period [1, 4]. The Swiss Federal Office of Energy SFOE is responsible to adapt the federal Swiss PV feed-in tariffs (KEV Kostengerechte Einspeise Vergütung) on a regularly base, according to the present energy law (Art. 3e, Abs. 1 EnV, SR 730.01).

The last survey of the OMCs conducted for the SFOE back in 2008 found OMCs from 5 to 10 Rp/kWh based on the analyses of 36 PV plants in Switzerland [2]. For example about 2.5Rp/kWh average OMCs was accounted for replacement costs of modules and inverters for PV plants below 10kW. Other publications in the same year provided total OMCs of 76Fr per installed kW each year. This annual value corresponds to about 1% of investment costs of a 70kW plant and corresponds to even 16 Rp/kWh as OMCs in 2008 [3].

Seven years later some of the most cost efficient new PV plants in Switzerland show total production costs very close to this former 2008 OMCs.

Thus the authors performed the second OMCs survey in 2014, co-financed by the SFOE due to the fact that progress in technology and markets might also reduce significantly the OMCs and thus the adaption of feed-in tariffs could be reflected [2].

In this paper we report about the method and the results of this recent 2014 OMCs survey. An assessment of the findings relative to reported values for example the 2008 findings are discussed and the most important cost drivers of today's OMCs in Switzerland are identified.

2 METHOD OF COLLECTING THE DATA

In total 278 PV plants were analysed in 2014, which accounts for 4.4% of all PV installations in Switzerland. Starting with a web based online poll, a limited quality of consistence was found based on 31 feedbacks. In total, only about half of all this collected data could be taken into account for detailed analyses of OMCs drivers.

Moreover, targeted professionals were interviewed, like PV plant operators also from utilities, plant designer and installers. Thus comprehensible data sets could be obtained on typical plant sizes and categories of each interview partner. By the comparison of the different professional respondent a better understanding of the cost drivers and how they are managed could be found.

Only 20% of the analysed plants are older than 5 years. Besides the above poll data, plausibility checks are performed based on maintenance contracts from service companies [5].

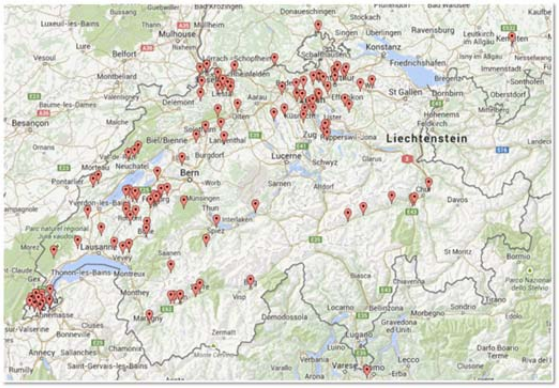


Figure 1: Sites of the analysed grid connected PV plants

The data set was selected to cover almost a broad variety of power categories from small 10kW to MW green field PV installations. Also flat roof, inclined roof or in the roof integrated PV systems were taken into account as shown in Fig. 3.

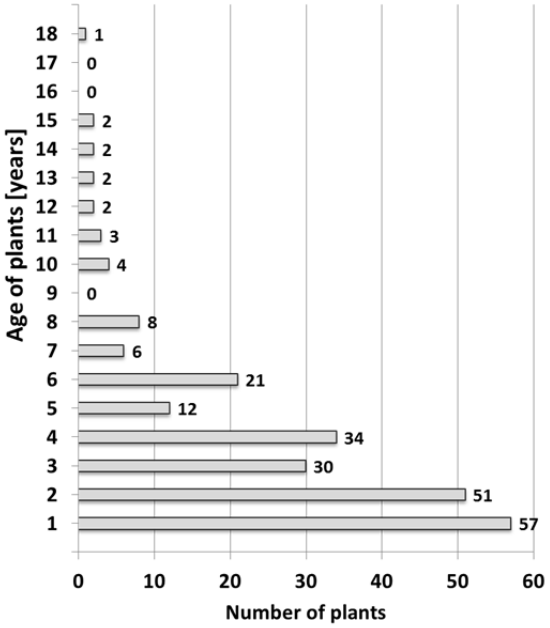
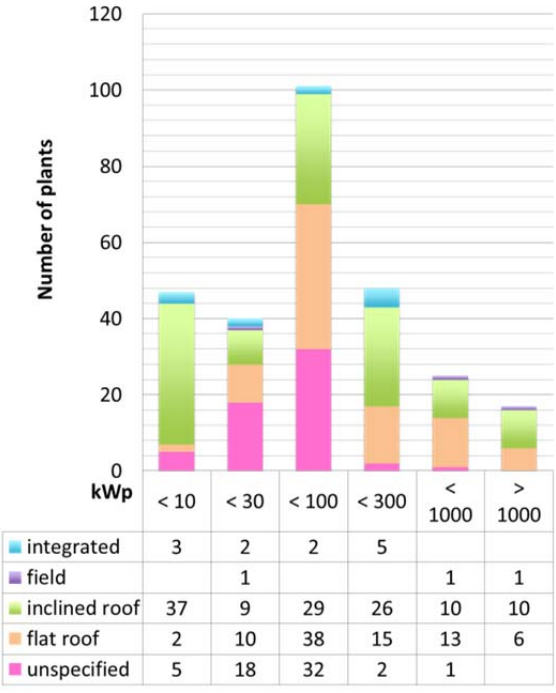


Figure 2: Age of plants, with 20% of the analysed systems is older than 5 years (data from expert interviews).



kWp	< 10	< 30	< 100	< 300	< 1000	> 1000
integrated	3	2	2	5		
field		1			1	1
inclined roof	37	9	29	26	10	10
flat roof	2	10	38	15	13	6
unspecified	5	18	32	2	1	

Figure 3: Power category and numbers of plants by each type of construction of the overall analysed 278 PV plants in 2014.

The following types of OMCs were taken into account, replacement of inverter and modules, cleaning, service and control visits, electricity metering, certification of origin, monitoring, insurance (damages, elementary, liability), administration, rent of the roof, VAT, dismantling, OMCs transformer and switching station for large plants. All financing costs, taxes on profit and capital, expenses on green roof services, risk incurrence here a not accounted to belong to the OCMs.

3 RESULTS

About 80% of the energy is produced by the analysed PV plants coming along with OMCs of 5 Ct. / kWh and lower.(Fig. 4) Respectively, 95% reported OMCs ≤ 7 Ct. / kWh and 99.9% with OMCs ≤ 14 Ct. / kWh. The very low values in the range of 2 to 3 Rp/kWh belongs mainly to new large scale plants and thus have to be confirmed in the next years and longer operation periods.

Small PV plants below 10kW showed the highest reported OMCs in average of 12.7Rp/kWh together with a high variance as shown in Fig. 5. The larger the plant, the lower are the OMCs per kWh. MW scale installations are below 3Rp/kWh OMCs dominated by the inverter service or replacement costs of about 1.1 Rp/kWh. Inverter OMCs are expected to be only about 20% of total OMCs for PV plants below 30kW. Due to the fact that 80% of the analysed plants are younger than 5 years (Fig. 2) very few respondent reported the actual replacement of the inverter.

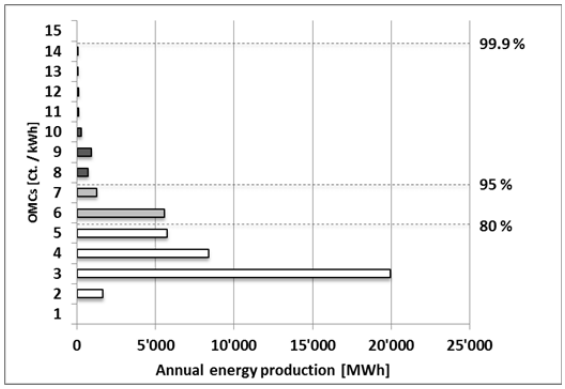


Figure 4: Distribution of the annual energy production in function of the OMCs of the plant (255 plants with a total of 44.6 GWh annual productions evaluated in the plot).

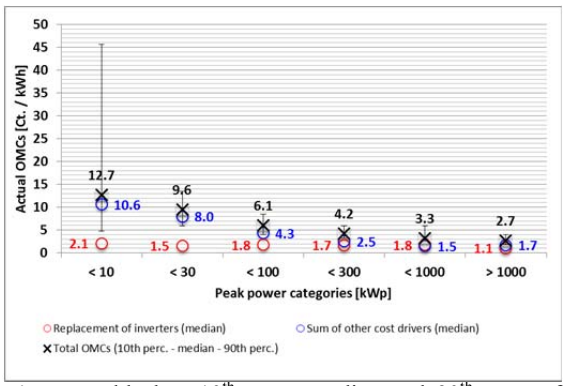


Figure 5: black – 10th perc., median and 90th perc. of actual total OMCs in Ct. / kWh, by power category (214 plants evaluated in total in the plot); red – median of costs of inverters replacement in Ct. / kWh; blue – median of the sum of all other cost drivers but inverters replacement in Ct. / kWh.

Small plants show a large variability in OMCs, which reflects both the variability of the value of the costs as well as the variability of occurrence of the reported specific cost drivers at a given plant.

As reported in [7] about 32% of the service calls of PV plants originate from the inverter in residential plants and even 46% in large commercial power plants in the US.

Due the fact, that the main part of the here analysed PV power plants is younger than four years the average lifetime of inverters and thus the related OMCs are based on the assumption that a replacement of the inverter have to be done after 13 years operation time.

Extending service life to 20 years costs today leading manufactures offer a 10kW inverter today of about 1400€ some of them with included labour cost for the replacement in the field which account for about over 20 years of about 7€cents/kWh or about 5€cents/kWh for a final total operation period of 30 years due to the once replaced inverter.

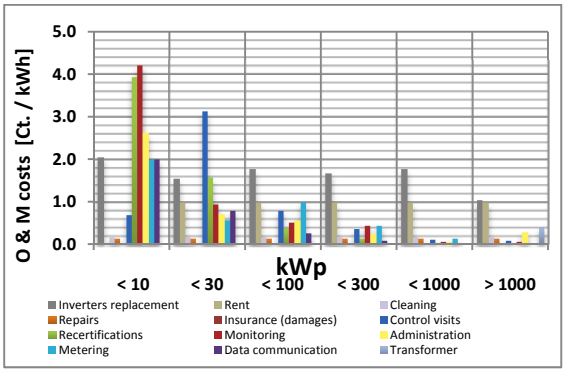


Figure 6: Contribution of each cost driver to the OMCs as the median of the costs per kWh produced PV electricity reported for each cost driver by power category of plants (plants that do not report costs or do report costs of zero for a specific cost driver are not taken into account).

Analysing the individual cost categories it was found that in small installations monitoring and electricity meter are the dominate cost drivers.

Recently, Swissolar the association of the PV companies in Switzerland pointed out that some of the distribution grid operators offers an annual charge fee of up to 600 SFr and higher for a course meter, mandatory for PV plants larger 30kW [8]. Thus the course meter will account for 2Rp/kWh of a 30.5kW plant which is about 10% of the feed-in tariff. They suggest increasing the level from 30kW to 100kW where the installation of the high costly course meter becomes obligatory. In Fig. 7 the average reported metering costs in the survey was at 9.6Rp/kWh for PV plants between 30kW and 100kW nominal power.

The most efficient OMCs reduction is expected to be realized by mostly lowering the frequency of visits at the site. This is to be applied to reducing the number of cleaning, and visual inspections. Only 3% of the plants were cleaned in the last four years. This should be realated to measured significant losses in for example the performance ratio.

Special for very small systems monitoring service costs should be reduced to a minimum to reach low OMCs. Market survey on PV monitoring systems are also offered by several technical magazines and could be helpful for the final customer [9]

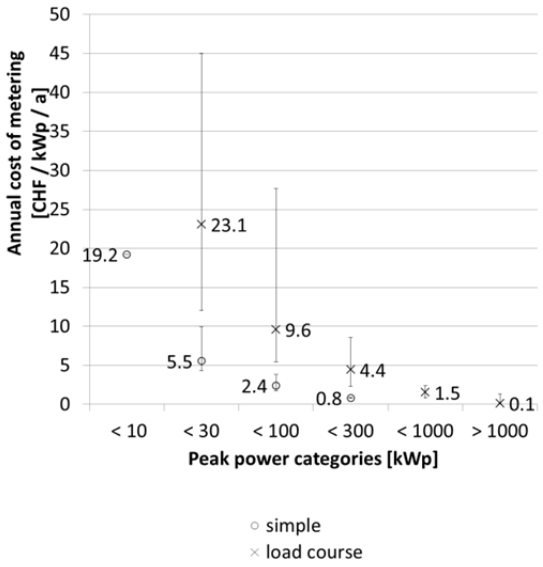


Figure 7: Costs of metering, for new plants > 30kVA metering with load course is mandatory

Actual estimation of the authors drawn from interpreting the present survey 2014 and other market information conclude that today a reference 10kW PV plant could reach 6Rp/kWh. Assuming an annual relative price increase of 1% of OMCs about 40% of the total costs belong to OMCs over a plant operation period of 25 years, including the 30% investment cost subsidy in Switzerland. Thus the total OMCs are higher than the PV module costs of the plant.

4 CONCLUSION AND OUTLOOK

Average OMCs of 12.7Rp/kWh for small and about 3Rp/kWh for MW plants was found in this 2014 survey. About 80% of PV power is produced today with OMCs of lower than 5 Ct/kWh. This is similar to the previous OMCs survey back in 2008 with values of 10 to 5 Rp/kWh.

For large plants, replacement of inverters becomes the most important cost driver in the 2014 survey. For smaller plants monitoring, visual visits at the plant site and metering are the cost drivers.

Thus, some of the reported OMCs of plants below 30kW, in operation since several years, reaching values of about half the value of the todays federal feed-in tariffs.

Further analyses of the here identified OMCs cost drivers will lead to needed improvement of the cost share in close cooperation with the professionals active in this field in Switzerland.

ACKNOWLEDGEMENTS

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REFERENCES

[1] A. Jäger-Waldau, Conference Technical Programme Chairman, Closing Session, 29th EUPVSEC, Amsterdam (2014), Closing Session

[2] P. Toggweiler et. al., Operation and Maintenance costs of photovoltaic plants in Switzerland, Swiss Federal Office of Energy SFOE, Photovoltaic Research Program, 2008, BFE-No 102070 / 152575; see also talk at the 13th Swiss PV Conf. 16th March 2015, http://www.swissolar.ch/fileadmin/user_upload/Tagungen/PV-Tagung_2015/6.1_Resultate_der_BFE-Studie_zu_den_Betriebskosten_bei_PV-Anlagen_P_Toggweiler.pdf

[3] A. Kirchner et al, Vergütungssätze für Strom aus erneuerbaren Energiequellen nach der Energie-verordnung; Prognos AG, Basel, Document, 31-6691 published 16.4.2008, page 77

[4] Sandia National Laboratories: O&M Workshop about O&M-Cost with PV, 2013

[5] O. Maier, Operation & Maintenance Costs of Photovoltaic Power Plants: a Swiss Benchmark and Outlook, Diploma of Advanced Studies in Management of Renewable Energies, University of St. Gallen (REM-HSG), Dec 2014

[6] NREL costs of PV electricity production; Aug 2013; http://www.nrel.gov/analysis/tech_lcoe_re_cost_est.html

[7] M. Anderson, Sun Systems Technology, at 2014 Sandia PV Reliability, Operation & Maintanence Workshop, May 7, 2014; http://de.slideshare.net/sandiaecis/03-sun-systemtech om perspective

[7] J. T. Klise et al; *Solar PV O&M Standards and Best Practices – Existing Gaps and Improvement Efforts;* SAND2014-19432; Printed Nov 2014;

[8] D. Stickelberger; talk at the 13th Swiss PV Conf. 16th March 2015; http://www.swissolar.ch/ fileadmin/user_upload/Tagungen/PV-Tagung_2015/2.3_Photovoltaikmarkt_Schweiz_neue_Herausforderungen_und_Chancen_D_Stickelberger.pdf

[9] Market survey of PV monitoring solutions, Sept 2015; www.pv-magazine.de