29th European Photovoltaic Solar Energy Conference and Exhibition,
Amsterdam, the Netherlands, 22-26 September 2014

UPDATE OF THE DUTCH PV SPECIFIC YIELD FOR DETERMINATION OF PV CONTRIBUTION TO RENEWABLE ENERGY PRODUCTION: 25% MORE ENERGY!

Wilfried G.J.H.M. van Sark[1], Lex Bosselaar[2], Pierre Gerrissen[3], Kendall Esmeijer[1],
Panagiotis Moraitis[1], Menno van den Donker[4], Gerjan Emsbroek[5]
[1]Utrecht University, Copernicus Institute of Sustainable Development, Heidelberglaan 2, 3584 CS Utrecht,
the Netherlands, T: +31 30 253 7611, E: w.g.j.h.m.vansark@uu.nl;
[2]Netherlands Enterprise Agency, P.O. Box 8242□3503 RE Utrecht, the Netherlands;
[3]SolarCare, Achillesstraat 128, 4818 BP Breda, the Netherlands;
[4]Solar Energy Application Centre (SEAC), High Tech Campus 5, Eindhoven, The Netherlands;
[5]CertiQ, Postbus 718, 6800 AS Arnhem, the Netherlands

ABSTRACT: Statistics Netherlands (CBS) annually publishes the contribution of renewables to the Dutch electricity supply, by following a national protocol. The amount of electricity generated by photovoltaic (PV) technology is calculated from the average installed capacity in a particular year multiplied by a specific yield value of 700 kWh per kWp installed. It was generally recognized by market stakeholders that this value was too low. Therefore a study was performed that should lead to an updated value that would be support by the market stakeholders. From several data sources PV performance data was collected, for the years 2012 and 2013, and an expert meeting was organized to come to a common advice to CBS. Consensus among the experts was reached on a specific yield of 875 kWh/kWp, to be used from 2011 onwards. This constitutes a **25% increase** with respect to the old value.
Keywords: PV performance, specific yield, PV market

1 INTRODUCTION

Statistics Netherlands (CBS) annually publishes the amount of installed capacity of photovoltaic systems. Most systems installed in the Netherlands do not benefit from a feed-in tariff; therefore there is no centralized data on actual production. To come to production data, CBS collects information on the installed capacity by sending out questionnaires to suppliers of PV systems. The amount of PV generated electricity is calculated from the installed capacity following a national protocol on monitoring of renewable energy [1]. In this protocol methods are described how to determine the amount of renewable energy for each technology, e.g. wind, biomass, solar thermal, solar PV, hydropower. This methodology may become relevant for other countries where a large proportion of the PV-systems is installed where net metering is in force in stead of a feed in tariff system.

Presently, the amount of PV generated electricity is determined using a full-load-hours model, i.e., the average capacity of a particular is multiplied with 700 h. This value has been determined based on historical data [2] and estimations on the specific annual yield of PV systems. The protocol has being renewed in 2014, for all renewable energy technologies. Regarding PV, several stakeholders in the market have argued that the value of 700 h, or rather the specific yield 700 kWh per kWp installed, was too low. In their opinion, recent technology improvements have led to much higher values. In addition, specific yields to be used in Dutch investment subsidy schemes for systems larger than 15 kWp were increased to 850 kWh/kWp. This prompted a research to develop a new estimate for the specific yield that should be used in the updated version of the protocol.

In the past decades the growth of the photovoltaic (PV) systems market in the Netherlands has shown various steps, as is illustrated in Fig. 1. The present installed capacity is 722 MWp. Using the present specific yield value, this would lead to an electricity production by PV of 380.5 million kWh.

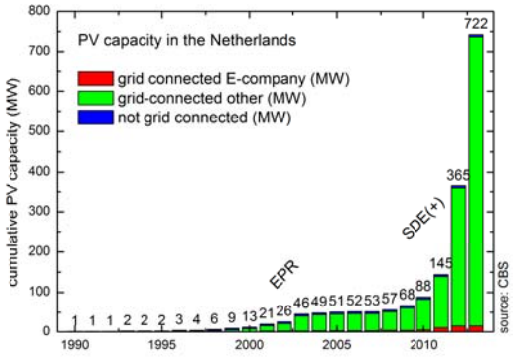

Figure 1. Development of cumulative installed PV capacity in the Netherlands (data source: CBS [3]).

2 METHODOLOGY

The collection of PV performance data was performed using several data sources for the years 2012 and 2013. We used Internet sources solarlog, and zonnestroomopbrengst.eu, as well as data from an installer. For 2012 total analyzed capacity was 2.36 MWp (~6.5% of total installed capacity in the Netherlands in 2012); for 2013 this was 11.6 MWp (~1.6% of total installed capacity in the Netherlands in 2013). Data were then presented at an expert workshop and discussed with the aim to reach consensus on a new value for specific yield that would be usable for the coming years.

Table I: Overview of data collection (A=solarlog, B=zonnestroomopbrengst.eu, C=SolarCare)

Data source	2012 (# systems)	2013 (systems)	accuracy	totals
A	322	728	unknown	day
B	222	-	unknown	month
C	90	809	2%	day
Total	2.4 MWp	11.6 MWp		

3 RESULTS

3.1 2012

The distribution of annual yields is shown in Fig. 2, using a bin size of 50 kWh/kWp. The average yield is determined to be 877±137 kWp. About 23% of the systems has a specific yield between 900 and 950 kWh/kWp. Figures 3 and 4 show the tilt and orientation of the systems. The tilt angle is not always optimal, i.e., the optimal angle in the Netherlands is between 35 and 40 degrees. Quite a number of systems are installed at an angle of 20 degrees, which is due to a specific support system design in which a compromise was found between optimal tilt and minimal ballast. Most of the systems are oriented well: due South at 180±30 degrees.

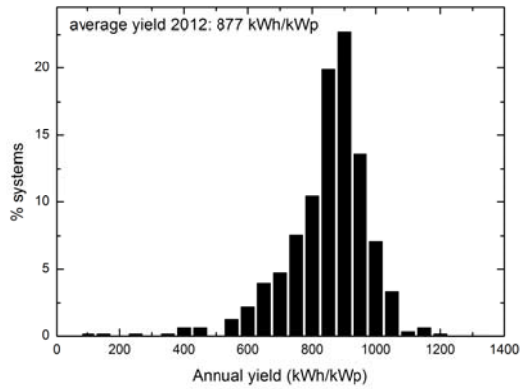

Figure 2. Yield distribution in 2012 in the Netherlands.

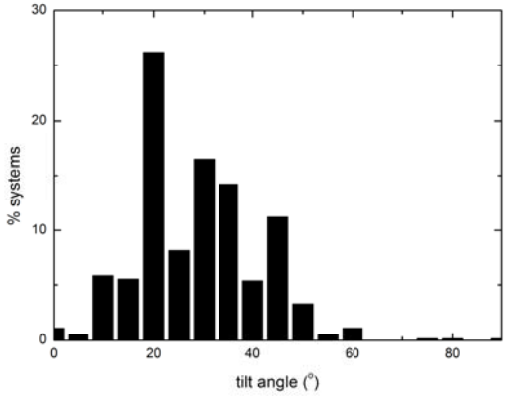

Figure 3. Distribution of tilt angles.

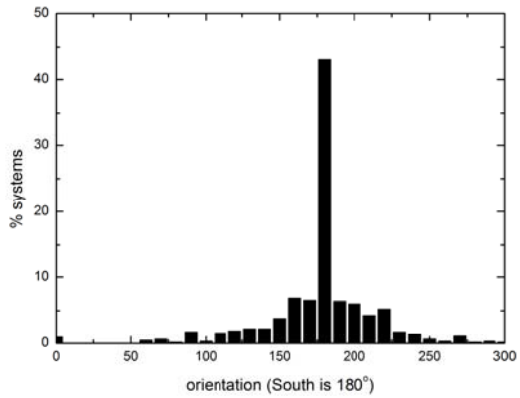

Figure 4. Distribution of orientations.

Analysis of separate data sources A, B, and C revealed only minor difference in the average yield of 883, 866, and 880 kWh/kWp, respectively.

A geographical analysis revealed that even for a country as small as the Netherlands, yield variations could be as large as 16%, see Fig. 5.

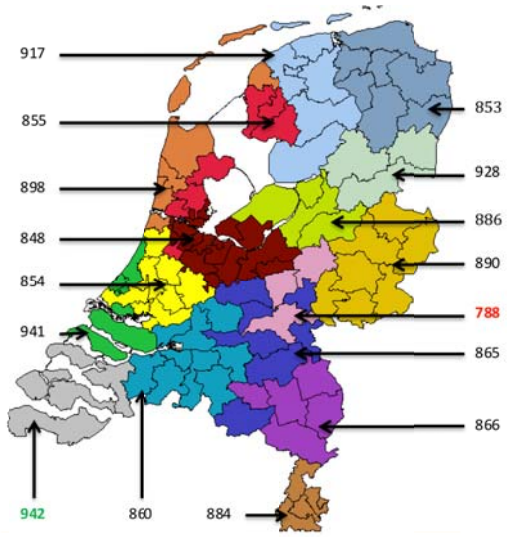

Figure 5. Variation of yield in 2012 in the Netherlands.

3.2 2013

The yield data for 2013 showed an average of 878 kWh/kWp for the whole dataset, and 874 and 886 kWh/kWp for data source A and C, respectively. Figure 6 shows the distribution of yield of data source A, at a bin size of 20 kWh/kWp.

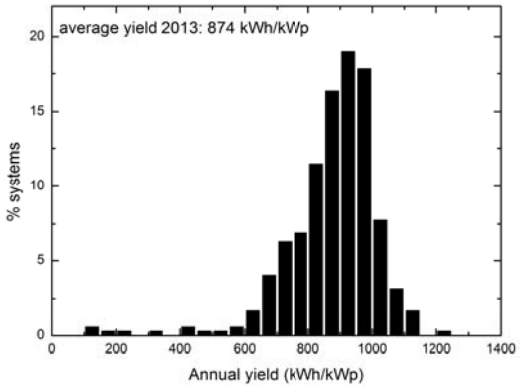

Figure 6. Yield distribution in 2013 in the Netherlands (source A).

3.3 Irradiation

Data from the Royal Netherlands Meteorological Institute show that the average irradiation did not change much in 2012 and 2013. In 2012 the annual irradiation was 1036.2 kWh/m^2/year, while that of 2013 was 1044.9 kWh/m^2/year. Therefore, considering the spread in the annual yield data, it is concluded that the yields can be considered to be equal.

4 CONCLUSION

Based on the results presented above, and the expert's opinion shared in the workshop meeting, a consensus was reached on a new specific annual yield value of 875 kWh/kWp. Also, it was agreed that this value should be used from 2011 onwards. Earlier studies indeed showed that 2011 yields were similar to 2012 and 2013 yields as shown here [4,5].

CBS has recently stated in her annual report on renewable energy in the Netherlands 2013, that the advice will indeed be used in future annual reports [6].

The consequence is that apparently suddenly, the amount of electricity generated by PV has increased by 25%. Thus, the annual amount in 2013 will be 475.6 million kWh, which accounts for 0.5% of the total electricity supply. Note, that on sunny days in spring, PV may account 5% to the national electricity supply.

5 DISCUSSION

As the geographical variation of yield is substantial (Fig. 5), it may be questionable to use only one specific yield value for the whole country. However, CBS will not change their calculation methodology. An approach in which geographical variation would be maintained is to use one specific value for the performance ratio [7], from which an annual yield per region or province can be calculated. A well performing system shows a performance ratio value of 0.85. Table II shows calculated yields, using actual irradiation sums for 2011, 2012 and 2013, as well as for a nominal year, which is based on a 30-year average. Comparison with the actual yield values shows that using performance ratio indeed may be an alternative method. However, the choice of the specific value of the performance ratio must be validated.

Table II: Calculated yield using performance ratio of 0.85, compared to actual yield

year	annual irradiation kWh/m^2	calculated yield kWh/kWp	yield kWh/kWp
2011	1056.7	898.2	-
2012	1036.2	880.8	877
2013	1044.9	888.2	878
nominal	1024.8	871.1	

6 ACKNOWLEDGEMENTS

We would like to thank Netherlands Enterprise Agency (RVO) for financial support.

7 REFERENCES

[1] Protocol Monitoring Renewable Energy, AgentschapNL, 2010.

[2] A.C. de Keizer, E. Ter Horst, E.C. Molenbroek, W.G.J.H.M. van Sark, *Evaluating 5-years performance monitoring of 1 MW building integrated PV project in Nieuwland, Amersfoort, the Netherlands.* Proceedings of the 22nd European Photovoltaic Solar Energy Conference, 2007, pp. 2960-2965.

[3] CBS Statline, http://statline.cbs.nl/statweb/, last access date 25/09/2014.

[4] K.B.D. Esmeijer, W.G.J.H.M. van Sark, *Statistical analysis of PV performance using publically available data in the Netherlands*, Proceedings of the 28th European Photovoltaic Solar Energy Conference (Eds. A. Mine, A. Jäger-Waldau, P. Helm), WIP-Renewable Energies, Munich, Germany, 2013, pp. 4024-4027.

[5] P. Moraitis, W.G.J.H.M. van Sark, *Operational performance of grid-connected PV systems,* Conference Record of the 40th IEEE Photovoltaic Specialists Conference, Denver, CO, USA, 2014, (in press).

[6] CBS, Hernieuwbare Energie in Nederland 2013, 2014.

[7] N.H. Reich, B. Mueller, A. Armbruster, W.G.J.H.M. van Sark, K. Kiefer, Ch. Reise, *Performance Ratio Revisited: is PR> 90% Realistic?,* Progress in Photovoltaics: Research and Applications 20 (2012) 717-726.