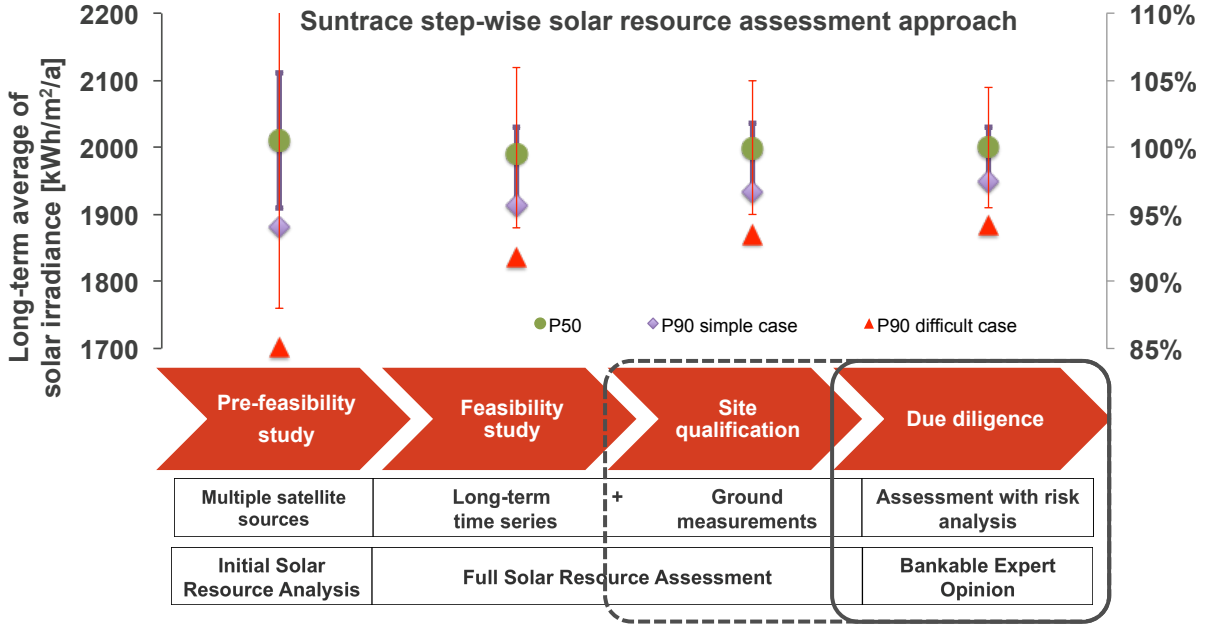
Bankable Expert Opinion on Solar Resource & Meteorological Conditions

for due diligence of solar power projects

Well-proven site-specific solar resource assessment is an essential factor during due diligence assessment of large-scale solar power projects. For bankable expert opinions on meteorological conditions, usually data with a lower uncertainty and lower probability are required to satisfy conservative approaches from banks and lenders. In addition to P50 Typical Meteorological Year (TMY), Meteorological years (MY) based on more conservative approaches are required to assess the risk of lower solar radiation values. For this purpose typically either the P70 or P90 data sets are derived. These represent yearly datasets for which values would be exceeded in 70 % or 90 % of the times respectively for any given year.



Analysis is done progressively in greater depth with each step, resulting in reduced uncertainty of solar radiation.

Bankable Expert Opinion on Solar Resource and Meteorological Conditions focuses on detailed site assessment, quality check and analysis of all available solar radiation and meteorological data. Direct Normal Irradiance (DNI) is key solar resource component for Concentrating Solar Power (CSP) plants and Global Horizontal Irradiance (GHI) for Photovoltaic (PV) power plants. The typical aim of such a bankable expert opinion is to give a bankable long-term solar radiation value with a corresponding data set in at least hourly time resolution (TMY representing P50 value), along with the expected uncertainty of solar radiation. The approach followed by Suntrace in performing a bankable expert opinion is based on the methodology described in Meyer (2010)[1].

Availability of ground-based measurements is crucial at this stage of project development. However, if ground-based measurements are not available at site in question, measurements from nearby sites can also be used. Site-specific satellite-derived solar radiation data covering at least 15 years are used for assessment. Various aspects of solar radiation such as long-term annual average, frequency distribution, monthly averages, inter-annual variability, uncertainty, etc. are analyzed in details with great care. TMYs that are based only on satellite data may have significantly different characteristics than those based on ground-measured data. Due to their inherent characteristics, satellite-derived solar radiation data (especially DNI) generally differ from ground-measured solar radiation data with respect to the occurrence of instantaneous values, averaged values, frequency distribution and representativity. Adjustment of satellite-derived solar radiation data to ground-measured data can help reducing such differences. Suntrace has developed methods like Schumann et al. (2011)[2] and

[1] Meyer, R. (2010): Recommendations for Bankable Meteorological Site Assessments for Solar Thermal Power Plants. Proc. of the SolarPACES Symp., Perpignon, Sep. 2010.

[2] Schumann, K., Beyer, H.G., Chhatbar, K., Meyer, R. 2011. Improving satellite-derived solar resource analysis with parallel ground-based measurements. Proc. of the ISES Solar World Congress, Aug. 30 - Sep. 1, 2011, Kassel, Germany.

Mieslinger et al. (2014)[3] for adjustment of satellite-derived data to ground-measured data. The advantage of using Mieslinger et al. (2014)[3] is that the bias of resulting adjusted-satellite-derived data with respect to ground-measured data tends to be almost zero. Depending on the region, the duration and quality of the satellite-derived and ground-measured data, the uncertainty of long-term averages can be reduced below 5% for DNI and below 4% for GHI by using this adjustment method.

TMYs are created from the adjusted satellite-derived solar radiation data following the method of Hoyer-Klick et al. (2009)[4]. Our TMYs represent the long-term monthly average of solar radiation as close as possible. One of the main features of our TMYs is that they represent a realistic frequency distribution of solar radiation, which is an important factor in designing solar power plants especially solar thermal power plants. For risk assessment multiple years, adjusted to site-specific characteristics based on ground-measured data consisting of several good and bad years are provided so that performance simulation can be based on these multiple years. In addition P70, P90 or any other PXY values could also be derived from multiple years of data, which are usually used as basis to calculate the financial base case for a project.

Scope

- recommendation and processing of order for site specific satellite data (>10 years) from third party,
- quality check of satellite-derived solar radiation data,
- detailed quality check of available ground-measured data,
- inter-comparison of available meteorological measurements with overlapping satellite-based time-series,
- adjustment of the satellite time series following Mieslinger et al. (2014)[3] with further improvements to minimize the bias with measurements,
- analysis and improvement of solar radiation frequency distribution (annual duration curves),
- analysis of the combined data set,
- detailed analysis of uncertainty,
- determination of long-term annual average of solar radiation expected at the site,
- determination of uncertainty of the long-term annual average of solar radiation,
- determination of inter-annual variability of solar radiation,
- determination of the typical annual cycle of solar radiation,
- determination of variation of monthly average values of solar radiation over multiple years.

Deliverables

- Official double-checked report (minimum 30 pages) describing the applied methodology and summarizing all relevant results,
- 1 TMY data set (P50 case) representing long-term annual average in 60 minutes time resolution,
- 1 MY data set representing P70 or P90 case in 60 minute time resolution, expected due to the uncertainty of solar radiation determined for the specific site,
- 1 MY data set representing P70 or P90 case in 60 minute time resolution, expected due to the uncertainty **and** inter-annual variability as determined for the specific site,
- Multiple year data set from the site-specific adjusted satellite data covering at least 10 years.
- optional: on request higher time-resolutions down to 1 min can be created at additional costs.
- optional: instead or in addition of P70 or P90 data sets representing any other probability can be supplied (PXY).

In early stage project development less detailed studies usually are sufficient. For description of our Solar Resources Assessments for Pre-feasibility Studies or Project Feasibility or Meteorological Stations optimized for solar energy applications, please contact us at meteo@suntrace.de or +49 – 40 767 9638-0.

[3] Mieslinger, T., Chhatbar, K., Ament, F & Meyer, R. 2014. A New Method for Fusion of Measured and Model-derived Solar Radiation Time-series. Energy Procedia, Vol. 48, Pages 1617-1626.
[4] Hoyer, Carsten, Fred Hustig, Marko Schwandt, and Richard Meyer. 2009. 'Characteristic Meteorological Years from Ground and Satellite Data'. In Proceedings of SolarPACES 2009. Berlin, Germany.