Final report

1.1 Project details

Project title	Ydelse og pålidelighed af solcellesystemer – Dansk deltagelse i IEA PVPS Task 13
Project identification (program abbrev. and file)	EUDP Journalnr.: 64014-0519
Name of the programme which has funded the project	EUDP
Project managing company/institution (name and address)	SiCon, J N Vinthersvej 5, 3460 Birkerød
Project partners	SiCon
CVR (central business register)	28950071
Date for submission	5/4-2018

1.2 Short description of project objective and results

The objective of the project is to ensure that Danish research institutions and companies active in development, installation and operation of PV systems, are kept informed on the latest research results, -topics, and trends within the area of Performance and Reliability of Photovoltaic Systems.
SiCon has been a very active member of the working group and contributed as activity leader in subtask 1.1, responsible for data acquisition and analysis by use of a questionnaire distributed among task members on current practices related to addressing of uncertainty factors in PV financial models. SiCon also have been very active research and content contributor and one of three lead authors for a comprehensive report on Technical Assumptions used in PV financial modelling including dissemination hereof in Danish and international conferences and papers.

Dansk

Formålet med projektet har været, at sikre at danske forskningsinstitutioner og virksomheder der er aktive indenfor udvikling, installation og drift af solcelleinstallationer, er blevet orienteret om de nyeste forskningsresultater, -emner og -tendenser indenfor temaet: Ydelse og pålidelighed af solcellesystemer.
SiCon har været et aktivt medlem af arbejdsgruppen of har som aktivitetsleder i subtask 1.1. bidraget med bl.a. udarbejdelse og analyse af et spørgeskema om den aktuelle praksis ift. håndtering af usikkerheder og tekniske parametre i de finansielle modeller der i dag anvendes. SiCon har også bidraget med ny forskning og været indholdsleverandør til en omfattende rapport om Technical Assumptions used in PV financial modelling og har bidraget til videre formidling af disse resultater i artikler og konferencepræsentationer både i Danmark og internationalt.

1.3 Executive summary

1.4 Project objectives

The objective of the project has been to ensure that Danish research institutions and companies active in the development, installation and operation of Photovoltaic systems, have been kept informed on the latest scientific research and trends within the topic of *Performance and Reliability of Photovoltaic Systems*.

1.5 Project results and dissemination of results

The project participation includes active participation in all international Task meetings.

Early in the project it was decided, that SiCon should contribute as work package activity leader in the subtask 1.1 group dealing with financial analysis of PV system and performance and risk assessment.

SiCon has been presenting project status and progress at the following meetings:

- 12_Leoben_Meeting 2015
- 13_Alice Springs_Meeting 2015
- 14_ Bolzano Meeting 2016
- 15_Albuquerque Meeting 2016
- 16_Lugano Meeting 2017
- 17_Cologne Meeting_2017

One of the first substantial tasks has been design, development, distribution and analysis of data collected in a questionnaire on current practices in relation to risk assessment and technical parameters used in PV financial model.

Another substantial research contribution has been development of a methodology for handling technical and financial risks in PV financial models. Today such risks are addressed with exclusive focus on the uncertainty in year-to-year irradiation and uncertainty in a few other technical parameters. In addition, these uncertainties must be represented in terms of standard deviations of a normal distribution in order to be included in an add-on financial uncertainty analysis. In contrast, the methodology developed by SiCon in this project can handle any number of uncertainty factors included financial (interest, tax rate, depth ratio etc.) and also is capable of handling uncertainty distributions that may not be normal distributed.

Also meetings with a number of Danish companies that have a general interest in the addressed topics have been conducted. Among the companies and institutions have been DTU-Fotonik, Emazys, Aalborg University, GreenGo Energy, EnergiMidt, PA Energy, European Energy and the Danish PV Association.

An abstract was prepared by SiCon and handed in to the European PV conference in Munich and was accepted for an oral presentation and also nominated among the 21 best abstracts for the conference in general which resulted in an invitation to prepare a paper for a special edition of Progress in Photovoltaics.

A significant effort have been devoted to development of research results and authoring and editing contribution to the report *Technical Assumptions Used in PV Financial Models - Review of Current Practices and Recommendations* that was published in May 2017. Also in relation to this report a good deal of further dissemination work was generated at international conferences and a webinar.

Finally SiCon was contributing by resources and planning activities to the national conference on PV and solar activities that was held in January 2018 at the headquarter of the Danish Industry Association.

Of more general character, a total of 9 high quality reports has been generated during the overall task 13 program:

1. Review of Failures of Photovoltaic Modules. Report IEA-PVPS T13-01:2014

2. Analytical Monitoring of Grid-connected Photovoltaic Systems - Good Practices for Monitoring and Performance Analysis. Report IEA-PVPS T13-03: 2014

3. Characterisation of Performance of Thin-film Photovoltaic Technologies. Report IEA-PVPS T13-02:2014

4. Modelling Acceleration Based on Outdoor Stress Conditions for PV Module Testing. Report IEA-PVPS T13-04: 2014.

5. Analysis of Long-Term Performance of PV Systems. Report IEA-PVPS T13-05:2014

6. PV Performance Modeling Methods and Practices: Report IEA PVPS T13-06_2017

7. Improving Efficiency of PV Systems Using Statistical Performance Monitoring: Report IEA-PVPS T13-07 2017

8. Technical Assumptions Used in PV Financial Models: Report IEA PVPS T13-08_2017

9. Assessment of Photovoltaic Module Failures in the Field: Report IEA PVPS T13-09_2017

Also a range of workshops has been executed to further disseminate the work and results of the task 13:

07_2015_Intersolar Munich

08_PV Modelling & Monitoring Workshop_October 2015

09_Workshop on Performance and Reliability_Bozen

10_PV Modelling and Monitoring Workshop_Freiburg

11_SAYURI-PV 2016 Japan

12_2017_Modelling Workshop_Lugano

13_2017_Intersolar Munich

14_2017_EUPVSEC Amsterdam

1.6 Utilization of project results

Besides meeting with various stakeholders, the main utilisation of the project results can be seen from the papers and conference contributions provided under this project.

Project papers:

Jan Vedde et al. *Technical Assumptions Used in PV Financial Models - Review and Analysis*. 32nd EU-PVSEC June 21-25 2016, Munich, Germany.

Vedde J. et al. Technical Assumptions Used in PV Financial Models. Invited for submission for Progress in Photovoltaics (2016).

Mauricio Richter, **Jan Vedde** et al. *Technical Assumptions Used in PV Financial Models - Review of Current Practices and Recommendations*. IEA PVPS Task 13, Report IEA-PVPS T13-08:2017, May 2017.

Project presentations:

Jan Vedde: *Subtask 1: Economic of PV System Performance and Reliability*. Presentation at IEA PVPS Task 13 meeting in Albuquerque. 27-29 september 2016.

Jan Vedde: *Subtask 1: Economics of PV System Performance and Reliability*. Presentation at IEA PVPS Task 13 meeting in Lugano. 27-29 march 2017.

Mike Green (M.G. Lightning Electrical Engineering), Mauricio Richter (3E), **Jan Vedde** (SiCon): *Mitigating Financial Risks in a PV Investment*. Webinar organised by Leonardo ENERGY on July 5th 2017 with the title "Technical Assumptions Used in PV Financial Models: Review of Current Practices and Recommendations"

Jan Vedde: Oral presentation at 32 EU PVSEC: 7DO.14.4 *Technical Assumptions Used in PV Financial Models*.

Jan Vedde: *Ydelse og pålidelighed. Dansk deltagelse i IEA PVPS Task13* samt Store solcelleanlæg for en projektudvikler. To præsentationer ved solcellekonference om Danmarks arbejde i IEA PVPS, afholdt ved Tekniq i Glostrup den 18 april 2016.

1.7 Project conclusion and perspective

The active project participation and contribution to this IEA PVPS task has been considered a success for both Danish stakeholders and the IEA program in general. Important learning in within a range of technical topics has been addressed within this task as is evident from the list of reports and workshops that has been result of this workgroup.

This report has been disseminated to a range of Danish stakeholders and contributed to further activity and projects being developed and supported by the Task 13 input.

Also the active Danish contribution representing an important voice of industry experience and relevance (seen as complementary to a more university based research contribution) with knowledge on both relevant materials science topics (silicon feedstock, crystal growth, wafering, cell manufacturing, glass manufacturing and coating) and utility scale project development and financing has been highly acknowledge and appreciated.

Annex

Relevant links:
http://www.iea-pvps.org/index.php?id=128