OVERVIEW OF IEA PVPS TASK 11 – PV HYBRID SYSTEMS WITHIN MINIGRIDS

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1 Overview and Background

The International Energy Agency Photovoltaic Power System (PVPS) Executive Committee has authorized Task 11: "*PV Hybrid Systems within Mini-grids*" for the period 2006-2011. The Task builds on the work on PV hybrid systems undertaken in PVPS Task 3 and currently includes expert participants from 13 IEA countries.

A particular focus is the operation of PV within mini-grids (defined as the interconnection of small, modular generation sources to ac distribution systems). These mini-grids are powered by a combination of PV and other electricity sources, they typically supply multiple users, and they may be interconnected with (or be part of) the distribution grid of the local electric utility. This raises issues of system control and coordination, sustainability and the role of local electric utilities in different jurisdictions.

This paper briefly reviews the goals and objectives of Task 11 and then gives an overview of the new work performed since the last report presented at the 4th European PV Hybrid and Mini-grid Conference in 2008 [4].

2 Scope and Objectives

The scope of Task 11 is PV based hybrid electricity generators with a focus on mini-grid systems. The main *goal* of Task 11 is to promote PV technology as a technically viable and economically competitive energy source in mini-grids. It aims to improve the knowledge-base of PV hybrid mini-grids and reduce barriers to market penetration of these systems. Specific objectives to meet this goal are to:

i) define application domains for PV hybrid mini-grids and identify the factors - technical, economic, social, and environmental – that lead to successful and sustainable applications,

ii) provide recommendations on design approaches (system architecture,

generation types, control strategies) to achieve high penetration of PV as a means to improve the quality, reliability and economics of electrification systems such as mini-grids;

iii) assess the potential of technologies to be mixed with PV for hybridisation; and,

iv) compile and disseminate best-practices on PV hybrid power systems.

3 Approach and Work Plan

Task 11 activities address both technical and non-technical issues that affect the market penetration and uptake of PV hybrid systems. Technical issues include

- design methodologies for PV hybrid mini-grid systems,
- control and interconnection of mini-grids, and
- increasing the energy contribution of PV versus fossil fuel generators within hybrid systems.

These form the bulk of the work in Task 11. Non-technical issues pertain to the social, economic and environmental conditions through which these systems become sustainable.

The principal results of Task 11's work will be presented in a series of technical reports which will be freely available on the IEA PVPS web-sites [2, 3]. In addition, results are disseminated in papers and presentations at conferences and workshops. While some of the results will be of interest to experts and researchers in the field, the primary objective is to provide expert information about PV hybrid systems and mini-grids to a broader audience of system integrators, electric utility personnel, rural development specialists, and energy policy developers who need up-to-date summary information about this technology and its potential to meet future electrical energy needs.

4 Design practices for PV hybrid mini-grids

Current design practices for PV hybrid systems are increasingly based on software tools. These tools replace "paper and pencil" calculations and often embed design guidelines and rules that were previously incorporated in manuals and other

reference documents. Task 11 completed a survey and analysis of software design and simulation tools used by Task 11 participants, which considers availability, applicability, and quality [5]. This was followed by a workshop on software design and simulation tools at the 23rd European PVSEC in September 2008 that brought together tool users and tool developers to discuss user needs and future development plans [6]. This work is summarized in two Task 11 reports. The first, to be published in 2010, provides guidelines on the selection and use of existing software design and simulation tools for PV hybrid systems. The second, due for publication in 2011, will focus on needs for future software based design tools.

Even the best design tools capture only some of the complexity of a PV hybrid system design. Much still depends on the skill and experience of the system designer. Task 11 is preparing a report on best design practices for PV hybrid systems that incorporates the lessons learnt from prior system designs by its expert participants. The final version of this report will be published by 2011.

5 Control of PV hybrid mini-grids

Task 11 has examined current PV hybrid mini-grid system architectures and has classified them for purposes of studying control techniques for voltage and frequency stability within mini-grids. The classification is based on which ac power sources in the mini-grid perform the “grid forming” function to set the mini-grid frequency and voltage. Each control class has been evaluated for its capabilities and its applicability to particular mini-grid applications [7].

Task 11 is also evaluating supervisory control strategies for the dispatch of generation sources and controllable loads within mini-grids. Several candidate control strategies have been defined and these will be compared using a simulation model which incorporates, where possible, actual data (e.g. load profiles, insolation) from existing systems. Relative performance of the control strategies will be

evaluated using performance indicators being developed by Task 11 to allow easy comparison of PV hybrid system performance [8].

A key requirement in many mini-grid control strategies is communication among the generation sources and other system components. This may be fast communication for power sharing and system stability or slower communication for supervisory control. Task 11 has prepared a report, to be published in 2010, which surveys existing data communication practices in mini-grid systems and makes the case for development and adoption of standard open protocols for data communications in PV hybrid systems.

Another key requirement in many mini-grid control strategies is an energy storage system to balance power supply with power demand in the mini-grid. Task 11 has evaluated the role of energy storage in mini-grid stability, determined the requirements of the energy storage system, and determined the ability of different energy storage technologies to meet these requirements [9].

The final control topic considered by Task 11 is parallel (interconnected) operation of the mini-grid with the central grid. It is gathering data on applicable interconnection regulations and standards in Asia, Europe, and North America and on the architecture and performance of existing interconnected mini-grids. Data on design standards for power quality in existing autonomous mini-grids is also being collected to determine if power quality in mini-grids is generally compatible with central grids. A report summarizing the data and presenting design and operational recommendations on grid connection of PV hybrid mini-grids will be published in 2011.

6. Sustainability Conditions

A case-study approach is used to study the social, economic and environmental conditions required for sustainable operation of PV hybrid mini-grids [10]. Twelve PV hybrid systems from 6 countries were selected as candidate case studies from 36 system descriptions submitted by Task 11 countries. The systems have a worldwide

spread, with varying architectures, power ratings, and data availability. A questionnaire has been developed to gather data on the social, economic, and environmental aspects of each system. However, it has become clear that all the necessary case study data is rarely available, making it difficult to perform a comparative assessment across systems.

Other methods and sources of data will be used to supplement the case study techniques. For example, as part of the study of the environmental sustainability of PV hybrids, simulation programs are being employed to demonstrate and quantify the lower green-house gas emissions that are produced by a PV-diesel hybrid mini-grid as compared to a conventional diesel-only mini-grid.

7. Conclusion

IEA PVPS Task 11 is in the last two years of its Work Plan, focusing on delivering reports that will provide usable, up-to-date information to its target audience. The multi-national and multi-organizational composition of its team of expert participants allows the development of unbiased and authoritative summaries and analyses of current practices and issues in PV-hybrid and mini-grid system design.

Reports will be freely available on the IEA PVPS web-site once the review and approval process is complete and Task 11 seeks other opportunities to disseminate its results to interested parties.

8. References

[1] IEA web-site: http://www.iea.org/

[2] IEA PVPS web-site: http://www.iea-pvps.org/

[3] IEA PVPS Task 11 web-site: http://www.iea-pvps-task11.org/

[4] K. Mauch, "Current State of the Art in PV Hybrid Mini-Grids – Early Results from IEA PVPS Task 11", 4th European PV-Hybrid and Mini-Grid Conference, May 2008

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[6] IEA PVPS Task 11, "Presentations from *Valencia Workshop on Software Tools for PV Hybrid Design and Simulation",* September 2008*,* *http://www.iea-pvps-task11.org/id39.htm*

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[8] A. Swingler, et. al., “A pragmatic performance reporting approach for describing PV Hybrid systems within Mini-Grids: Work in progress from IEA’s PVPS Task 11 Act. 31”, 5th European PV-Hybrid and Mini-Grid Conference, April 2010.

[9] B. Espinar and D. Meyer, “Energy Storage for Mini-Grid Stabilization”, 5th European PV-Hybrid and Mini-Grid Conference, April 2010.

[10] J.-C. Marcel, “IEA PVPS Task 11 (Hybrid System within Mini-Grid) Sub Task 40: Sustainability Conditions”, 4th European PV-Hybrid and Mini-Grid Conference, May 2008.