

PV Hybrids in Mini-Grids: New IEA PVPS Task 11

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Presentation Plan

- Task 11 scope, work plan and participants
- Report on early stage activities and results

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Task 11 Scope



IEA INTERNATIONAL ENERGY AGENCY

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Autonomous



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IEA PVPS Task 11 work plan

Subtask 10: Design Issues

Activity 11: Current architecture: state of the art & trends Activity12: Design Methodology and Tools Activity 13: Best Practices

Subtask 20: Control Issues

Activity 21: Mini-grid Stability
Activity 22: Communication
Activity 23: High level control, supervisory control
Activity 24: Storage
Activity 25: Interconnection and island issues

Subtask 30: PV Penetration in Mini-Grids

Activity 31: Performance indicators Activity 32: Strategies for energy management

Subtask 40: Sustainability

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Activity 41: Social and political framework Activity 42: Financial and economic issues Activity 43: Environmental considerations



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Task 11 Participants

Country	Participating Organizations
AUSTRALIA	Industry
AUSTRIA	Industry
CANADA	Industry, Government Agency
FRANCE	Industry, Research Institute
GERMANY	Industry, Research Institute
JAPAN	Industry, Research Institute
ITALY	Research Institute
KOREA	University
NORWAY	Industry
SPAIN	Industry, Research Institute, University
SWITZERLAND	Industry



Early Activities and Results

- Initial activities focus on assessing and documenting current technology and design practices for PV hybrids and mini-grids.
- Assessment is by surveys of participant experts, literature review, and by case studies.

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Design Software

- Activity 12 (Design Methodology and Tools) has surveyed Task 11 Participants on PV hybrid design tools (software programs). Survey topics:
 - Tool availability (generally available or proprietary) and cost,
 - Tool characteristics, features and application area (e.g. feasibility analysis, system sizing and design, simulation, mini-grid design)
 - Characteristics and quality of user interface and documentation
- Responses on over 20 software programs.
- Final outcome will be a report providing an overview of available software tools and guidelines for selection and use. A workshop for users and developers of design tools to discuss next generation tools is planned for 2008.





Mini-grid control

- Subtask 20 has examined current PV hybrid minigrid system architectures and has classified them into four categories for further study
- Classification is based on which ac power sources in the mini-grid perform the "grid forming master" function to control the mini-grid frequency and voltage.
- For each category, Subtask 20 is studying the following issues
 - Grid forming control techniques
 - Power sharing among ac sources
 - Control of PV generation
 - Demand side management techniques to manage loads and limit fuel consumption
 - Connection of the mini-grid to an external grid

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Single fixed master architecture



• Typical for relatively small PV/battery systems combined with a back-up generator which is not used very often.

• The battery inverter is unidirectional and is the single grid forming unit powering the minigrid.

•The engine generator and the PV arrays are connected on the DC bus of the battery.



Single changing master architecture



• In this configuration, the engine generator is connected on the AC bus. This is more energy efficient than configuration 1 if the fuel contribution to the energy mix is significant.

• Usually, bi-directional battery inverters are used, which allow battery charging from the AC side.

• The minigrid voltage is controlled by the battery inverter most of the time or by the engine generator when it operates.

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Pomelo, Indonesia 24 kWp PV, 20 kWhr battery, 125 KVA genset





Multimaster – genset dominated architecture • This configuration



• This configuration is typical for large mini-grid systems in which PV supplements fossil fuel generation. At least one engine generator is operating as the grid forming master at all times.

 No storage is required but a short-term battery system (eg. 10 minutes reserve) could be added to the system to smooth PV power fluctuations and to provide reserve energy for reducing the rotating reserve to a minimum.

• The annual solar energy contribution to total energy delivered is not very high. However, the solar power share can be momentarily high. In order to stabilize the system without battery storage, control strategies for the rotating reserve management could be based on power predictions for the load and solar resource.



Kings Canyon, Australia

- 225 kW flat plate PV
- No storage

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- 3 diesel gensets (continuous operation)
- Interconnected by 11 kV distribution network
- Owned and operated by electric utility





Multi-master inverter dominated architecture • This minigrid confid



• This minigrid configuration is characterized by the coupling on the AC-bus of most power sources via inverters. The power sources can be distributed in the minigrid (e.g. PV generators can be integrated in the roofs of different houses). Several grid forming units (like battery storage or rotating machines) can operate in parallel in a multi-master mode.

• Reactive power/voltage and active power/frequency droops, similar to those used in utility grids may be used to control inverter power sharing. Supervisory control just provides parameter settings for each component.

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Kythnos, Greece





Early results

- First draft of study report on multimaster inverter dominated architecture has been completed.
- Study reports in progress on single changing master architecture and multimaster genset dominated architecture.

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Sustainability Issues

Subtask 40 is using a case study approach with the following work plan

- Write and deliver a "light" case study template to all Task 11 participating countries to collect information on candidate PV hybrid mini-grid systems.
- 2. Produce a methodological tool to manage data collection and analysis with a focus on the social, financial, and environmental aspects of the systems,
- 3. Analyze the light case studies received from Task 11 participants and select a short list of representative case studies for deeper analysis (considering the sustainability context and the availability of data),
- 4. Gather case study information using the tool developed in step 2,



Early case study results

- Over 35 system descriptions for PV hybrid mini-grids have been obtained from Task 11 countries using the "light case study template"
- Next step is to select 10 12 representative systems for more detailed study.





To conclude ...

- Mini-grid technology is being pursued in several OECD countries. Task 11 enables consolidation of the experiences of the national programs and identification of best practices.
 - Should speed commercial adoption of the technology
- Task 11 is also the champion for a significant PV fraction in the mini-grid energy mix.

Thank you for your attention!