

### 3<sup>RD</sup> PHASE ACTIVITIES OF IEA-PVPS TASK8 (2006-2008): VERY LARGE SCALE PHOTOVOLTAIC POWER GENERATION (VLS-PV) SYSTEMS ON THE DESERT

K. Komoto<sup>1</sup>, K. Kurokawa<sup>2</sup>, M. Ito<sup>3</sup>, J. S. MacDonald<sup>4</sup>, C. Beneking<sup>5</sup>, M. Ermer<sup>6</sup>, D. Faiman<sup>7</sup>, F. Paletta<sup>8</sup>, A. Sarno<sup>9</sup>, J. Song<sup>10</sup>, P. van der Vleuten<sup>11</sup>, T. Hansen<sup>12</sup>, H. Hayden<sup>13</sup>, N. Enebish<sup>14</sup>

<sup>1</sup>Mizuho Information & Research Institute (MHIR), 3-1 Kanda-Nishiki-cho, Chiyoda-ku, Tokyo 101-0054, Japan, tel: +81-3-5281-5286, fax: +81-3-5281-5466email: keiichi.komoto@gene.mizuho-ir.co.jp

<sup>2</sup>Tokyo University of Agriculture and Technology (TUAT), 2-24-16 Naka-cho, Koganei, Tokyo 184-8588, Japan, tel/fax: +81-3-42-388-7132, email: kurochan@cc.tuat.ac.jp

<sup>3</sup>Tokyo Institute of Technology (TIT), 2-12-1 Ookayama, Meguro-ku, Tokyo 152-8550, Japan, tel: +81-3-5734-3429, fax: +81-3-5734-3433, email: ito@iri.titech.ac.jp

<sup>4</sup>Day4 Energy Inc., #101-5898 Trapp Avenue Burnaby, B.C. V3N 5G4, Canada, email: jmacdonald@day4energy.com

<sup>5</sup>ErSol Solar Energy AG, Wilhelm-Wolff-Str. 25, 99099 Erfurt, Germany, email: claus.beneking@ersol.de

<sup>6</sup>SolarWorld Industries Deutschland GmbH, Domagkstr. 34, 80807 München, Germany, email: m.ermer@solarworld-industries-deutschland.de

<sup>7</sup>Ben-Gurion University of the Negev, Sede Boqer Campus, 84990 Israel, email: faiman@bgumail.bgu.ac.il

<sup>8</sup>CESI Ricerca, Via Rubattino, 54, Milano 20134, Italy, email: paletta@cesiricerca.it

<sup>9</sup>ENEA, Italy, email: sarno@portici.enea.it

<sup>10</sup>Korean Institute of Energy Research, 71-2 Jang-dong Yusong-ku, Taejon 305-343, Korea, email: jsong@kier.re.kr

<sup>11</sup>Free Energy International, Ambachtsweg 21, 5627 BZ Eindhoven, The Netherlands, email: p.vleuten@free-energy.net

<sup>12</sup>Tucson Electric Power, Mail Stop OH 203, P.O.Box 711, Tucson, AZ 85702, U.S.A., email: thansen@tucsonelectric.com

<sup>13</sup>Arizona Public Service, 400 N. 5<sup>th</sup> street, Phoenix, AZ 85004, U.S.A., email: herbert.hayden@aps.com

<sup>14</sup>National Renewable Energy Center, P.O.Box 479, Ulaanbaatar 210136, Mongolia, email: enebish@magicnet.mn

**ABSTRACT:** The objective of IEA PVPS Task8 is to examine and evaluate the potential of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems on desert areas, which have a capacity ranging from multi-Megawatt to Gigawatt, and to develop practical proposals for demonstrative research toward realization of the VLS-PV Systems in the future. The Task8 started in 1999 (as 1<sup>st</sup>-Phase) and the 2<sup>nd</sup>-Phase was succeeded in 2005. To develop these results toward an implementation of VLS-PV system, we've started 3<sup>rd</sup>-phase activity. In 3<sup>rd</sup>-Phase (2006-2008), specific case studies from viewpoints of local, regional and global aspect are carried out, and financial and institutional scenarios and a general instruction for practical project proposals are developed. Also, considerable future technical options implementing VLS-PV system are analysed. Through the activities, Task 8 will give recommendations to stakeholders and for world brightness future.

**Keywords:** Large Grid-connected PV systems, sustainable, desert, VLS-PV

## 1 INTRODUCTION

Task 8: 'Study on Very Large Scale Photovoltaic Power Generation (VLS-PV) System' was set up for feasibility studies in 1999. To initiate our study, a lot of imagination was required. It was felt that dreams and imagination were really welcome and that it was worth while to consider things for the future generations, our children or grand-children. People have to imagine their lives after 30 years or 50 years, even 100 years since it requires a longer lead time to realise energy technology. In this sense, studies in terms of VLS-PV include plant design by extending present technologies as well as discussing basic requirements for PV energy in the future energy-supplying structure, the social impact on regions, and the local and global environmental impact.

It may be known that very large deserts in the world have a large amount of energy supplying potential. Around those deserts, the population is generally quite limited. Then, too much power generation by PV systems becomes worthless. However, world energy needs will grow larger and larger toward the middle of the 21<sup>st</sup> century. In addition, when global environmental issues are considered, it is felt that future options are limited. These circumstances became the back-bone and motive force for VLS-PV work.

The objective of the Task 8 is to examine and evaluate the potential of VLS-PV systems on desert areas, which have a capacity ranging from multi-Megawatt to Gigawatt, and to develop practical proposals for

implementing the VLS-PV Systems in the future.

For this purpose, in 1<sup>st</sup>-Phase (1999-2002), key factors that enable VLS-PV systems feasibility were identified and the benefits of this system's applications for neighbouring regions were clarified as well as the potential contribution of system application to global environment protection and renewable energy utilization in the long term was clarified. Mid- and long term scenario options for making VLS-PV systems feasible in some given areas were also proposed.

In 2<sup>nd</sup>-Phase (2003-2005), case studies on VLS-PV systems were carried out in depth and practical proposals for selected regions, which would enable sustainable growth into VLS-PV Systems in the future, and general instruction to propose practical projects for large-scale PV system were discussed.

To develop these results toward a implementation of VLS-PV systems, we've started 3<sup>rd</sup>-phase activity. In 3<sup>rd</sup>-Phase (2006-2008), specific case studies from viewpoints of local, regional and global aspect are carried out, and financial and institutional scenarios and a general instruction for practical project proposals are developed. Also, considerable future technical options implementing VLS-PV system are analysed.

## 2 RESULTS ACHIEVED UP TO NOW

### 2.1 'Energy from the Desert': 1<sup>st</sup> publication in 2003

In 1<sup>st</sup>-Phase, the feasibility and potential for Very

Large Scale Photovoltaic power generation (VLS-PV) systems in desert areas were examined. The key factors for the feasibility of such systems were identified and the (macro) economic benefits and the potential contribution to the global environment were clarified.

From the perspective of the global energy situation, global warming, and other environmental issues as well as from the case studies and scenarios, it is apparent that VLS-PV systems can:

- contribute substantially to global energy needs.
- become economically and technologically feasible.
- contribute considerably to the environment.
- contribute considerably to socio-economic development.

These results were published in 2003, as a book: Energy from the Desert [1].

## 2.2 'Energy from the Desert: Practical Proposals for Very Large Scale Photovoltaic Systems' [2][3]

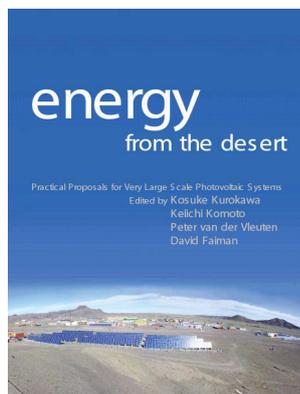
In 2<sup>nd</sup>-phase, we discussed proposals of practical projects for selected regions, which enable sustainable growth of VLS-PV in the near future, and developed proposals of practical projects for selected regions, e.g. the Mediterranean region, the Middle East region, Asian region (China and Mongolia) and Oceania region.

It is strongly indicated that VLS-PV could directly compete with fossil fuel as the principal source of electricity and with existing technology for any country that has desert areas. This could be accomplished by finding an investment scheme and by getting institutional and organizational support for its implementation.

From a viewpoint valuing the technological aspect, starting with the R&D stage or the pilot stage might be important considering overall desert development. Aiming at commercial operation, an initial project to be proposed should not be the R&D stage, but the pilot or demonstration stage. The technology innovations on PV and global energy systems will make VLS-PV economically and technologically attractive and feasible.

The proposals developed in this study may motivate expected stakeholders to realize VLS-PV projects in the near future. Moreover, developing practical project proposals from different viewpoints and directions will enable providing essential knowledge to develop detailed practical instructions to enable sustainable implementation of VLS-PV systems in the future.

These results are published as a new book, entitled 'Energy from the Desert: Practical Proposals for Very Large Scale Photovoltaic Systems', in 2006 [2].



**Figure 1:** 'Energy from the Desert: Practical Proposals for Very Large Scale Photovoltaic Systems'

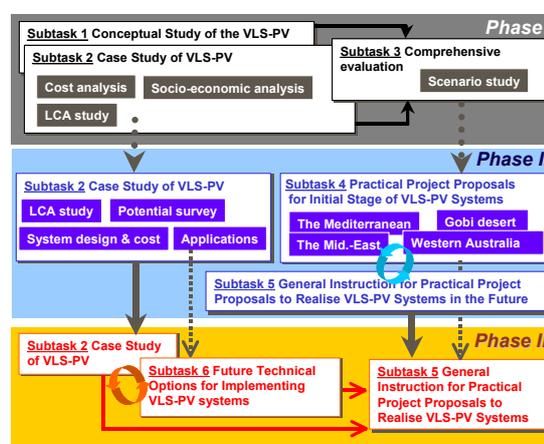
## 3 WORKPLAN OF 3<sup>RD</sup> PHASE ACTIVITY

### 3.1 Objectives of 3<sup>rd</sup> phase activity

In 3<sup>rd</sup>-Phase (2006-2008), toward a realisation of VLS-PV systems, specific case studies from viewpoints of local, regional and global aspect are carried out, and financial and institutional scenarios and a general instruction for practical project proposals are developed. Also, considerable future technical options implementing VLS-PV system are analysed.

The works in pursuit of the foregoing objectives will be performed by electrical engineers, structural engineers, environmental assessment experts, photovoltaic industry specialists and related experts from several other fields in the Participants' countries.

In 3<sup>rd</sup>-phase, Participants will carry out extended Subtask 2 and 5, and new Subtask 6.



**Figure 2:** Overall framework of Task8 activity

### 3.2 Subtask 2: Case studies for selected regions for installation of VLS-PV systems

Employing the concepts of VLS-PV and the criteria and other results produced under Subtask 1, Participants have been undertaking case studies on VLS-PV systems for the selected regions and evaluating the resulting effects, benefits and environmental impact. Feasibility and potential of VLS-PV on deserts will be evaluated from viewpoints of local, regional and global aspect. Some activities will carry out the following work for the regions selected in parallel.

The capacity of VLS-PV system and configuration of each component have been being assessed, considering future phase-in of modular sub-units. The assessment has been taken into account the site condition, regional electricity demand, system performance, transmission technology or other alternative options and concurrent use with other energy resources. The possibility of multipurpose use of electricity generated by the VLS-PV systems to improve the nature and socio-economic condition in the region may be investigated. Furthermore, the socio-economic and environmental impacts of installation of VLS-PV systems have been being evaluated from a life-cycle point of view.

From viewpoints of desert developments regional environmental impacts will be evaluated, and life-cycle analysis of VLS-PV systems will be further performed including issues on recycling PV system and Si materials, as specific case studies. Also, grid-connected issues in selected regions will be discussed concretely.

3.3 Subtask 5: General instruction for practical project proposals to realise VLS-PV systems in the future

Detailed practical instructions and training kit for the development of other practical project proposals, to enable others to sustainably implement VLS-PV systems in the future, will be discussed. Employing the results developed under Subtask 4, financial and institutional scenarios will be further discussed, and the guidelines for practical project proposals will be developed.

Taking into account practical experiences and governmental, financial and economic requirements for large energy and development projects, guidelines for the development of practical project proposals will be discussed. By extracting essential knowledge from the results developed by 2<sup>nd</sup>-Phase, a detailed practical instructions and a training kit for the development of other practical project proposals will be discussed.

Based on experts' experiences in the field of PV and large-scale renewable technology including industry, project developer, investor, policy-maker, etc., successful and un-successful factors for VLS-PV project, on both technical and non-technical aspects, will be clarified. Existing financial schemes will be overviewed and available financial and institutional scenarios and case

studies will be also discussed.

The instructions will comprise non-technical issues as well as technical issues, to enable others to sustainably implement VLS-PV systems in the future.

3.4 Subtask 6: Future technical options for implementing VLS-PV systems

We will propose and analyze various technical options for implementing VLS-PV systems, including scenarios for storage and for reliable integration of VLS-PV systems into the existing electrical grid networks. From the viewpoint of future electrical grid stability, a global renewable energy system utilizing globally dispersed VLS-PV systems as the primary electrical energy source will be also analyzed.

Considerable technical options to be discussed are, for example, electricity grid network scenario, energy storages, concentrator technologies and solar hydrogen scenario for future.

A variety of practical VLS-PV technologies will be enumerated, together with a clear picture as to the technologies and grid operation concepts needed to reliably integrate VLS-PV into existing and future grid networks.

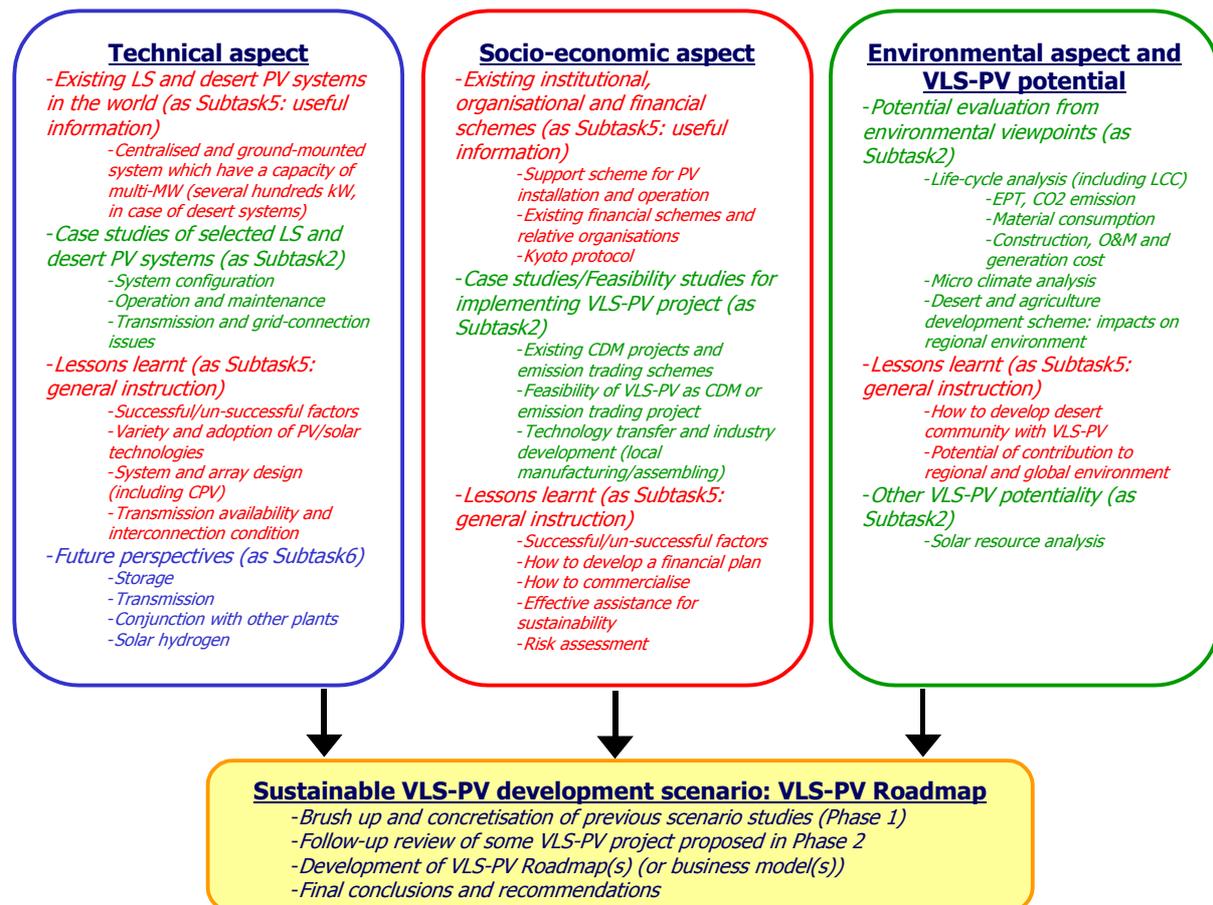


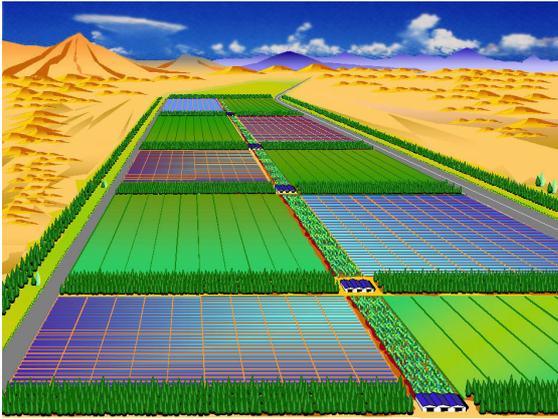
Figure 3: Proposed working items for 3<sup>rd</sup>-phase

#### 4 FUTURE PERSPECTIVE

Toward implementation of VLS-PV system, stakeholders targeted to will be policy makers, investors and project developers including PV industries, which enable to make a plan and concrete vision to realize VLS-

PV from a viewpoint of global energy and environmental issues, as well as researchers and engineers in the field of solar cells and PV system technology.

Through the activities, Task 8 will give recommendations to stakeholders and for world brightness future.



**Figure 4:** Image of a VLS-PV system in a desert area

#### REFERENCES

- [1] Kosuke Kurokawa, *Energy from the Desert*, James & James (Science Publishers) Ltd., London, 2003
- [2] Keiichi Komoto, Peter van der Vleuten, David Faiman and Kosuke Kurokawa, *Energy from the Desert: Practical Proposals for Very Large Scale Photovoltaic Systems*, James & James (Science Publishers) Ltd., London (to be published in 2006)
- [3] Kosuke Kurokawa, Keiichi Komoto, Peter van der Vleuten and David Faiman, *A New Knowledge How to Make the Very Large Scale PVs Happen on the Desert!*, 21st European Photovoltaic Solar energy Conference and Exhibition, Dresden, Germany, 4-8 September 2006