

## TASK 12 - PV ENVIRONMENTAL HEALTH & SAFETY ACTIVITIES

### INTRODUCTION

The growth of the PV market is based on the promise of environmentally friendly energy generation, and is sustained by the support of the environmentally conscious public via market incentives, direct subsidies and R&D support. Without such support the industry can not grow to levels that would enable the reduction of direct (production and installation) costs to the levels of conventional energy generation. Furthermore, continuing diligence on EH&S issues is necessary to safeguard the environment, which is the promise of photovoltaics.

### OVERALL OBJECTIVES

The goal of Task 12 is to facilitate a common understanding of EH&S issues among the various country members, and disseminate the Task group's knowledge and understanding to stakeholders and to energy and environmental policy decision makers.

Task 12 aims at fostering international collaboration in the areas of safety and sustainability which are crucial for allowing PV to grow and make major contributions to the energy needs of the member countries and the world. There are both technical and perception issues that need to be addressed.

The overall objectives of the Task are to:

- a) Quantify the environmental profile of PV in comparison to other energy technologies.
- b) Define and address EH&S and sustainability technical and perception issues that are important for market growth.
- c) Disseminate the results of the EH&S analyses to stakeholders, policy makers and the general public.

The first objective can be served with life cycle analysis (LCA) that describes energy, material and emission flows in all the stages of the life of PV. The second objective will be addressed by assisting the collective action of PV companies on defining material availability and product recycling issues and on communicating "lessons learned" from incidents, or preventing incidents in PV production facilities. The third objective (i.e. dissemination) will be accomplished by presentations to broad audiences, producing simple fact sheets documented by comprehensive reports, and engaging industry associations and the media in the dissemination of the information.

### APPROACH

The approach to meet Task 12 objectives is to subdivide the Task into four relevant subtasks and a number of detailed work activities on key aspects of PV Environmental Health and Safety activities.

### SUBTASKS AND ACTIVITIES

The current subtasks and activities are as follows:

#### SUBTASK 1: Recycling of Manufacturing Waste and Spent Modules

This subtask addresses the following objectives:

- Assist the development of collection infrastructure by examining and evaluating the collection infrastructure of other recyclables (e.g., electronics, liquid crystal displays).
- Enhance the interaction among industry players so that they share information and resources for collection and recycling.
- Show the technical and cost feasibility of collection and recycling (to environmental policy makers, e.g., WEEE, RoHS).
- Identify common tasks where financial resources can be shared (e.g., separation of EVA from the module).

The proposed activities to achieve the announced objectives are the following:

- 11) Define collection infrastructure paradigms that can be useful in PV module take programs in various countries.
- 12) Define the technical and economic feasibility of recycling manufacturing waste and spent PV modules
- 13) Investigate technologies for the recovery of valuable elements from PV modules

Workshops will be held in conjunction with PVCYCLE activities sponsored by EPIA and other PV associations and possibly the LCA workshops described below.

#### SUBTASK 2: Life Cycle Assessment

This subtask aims at establishing and demonstrating that PV systems are safe and environmentally friendly and that future very large-scale implementation will provide clear environmental benefits.

This will be accomplished through the following activities:

- 21) Compare the EH&S profiles of PV technologies with those of other energy technologies.
- 22) Show the improvement trends of the PV environmental profile by certain indicators (e.g., EPBT, GHG emissions, waste reduction, materials' recycling/recovery).
- 23) Continue showing such progress in annual updates over the course of Task 12 (5 years).
- 24) Valuate the environmental benefits of PV by showing avoided impacts or avoided "external" costs.
- 25) Credible communication and dissemination of results.

These activities will start with developing guidelines for a consistent methodological approach and LCI (Life Cycle Inventory) databases, enabling well-balanced and transparent comparisons among PV and other energy technologies.

The results of this subtask may continue to benefit the PV industry by developing tools to monitor and report progress on process EH&S and product sustainability, and potentially benchmark the performance of individual companies.

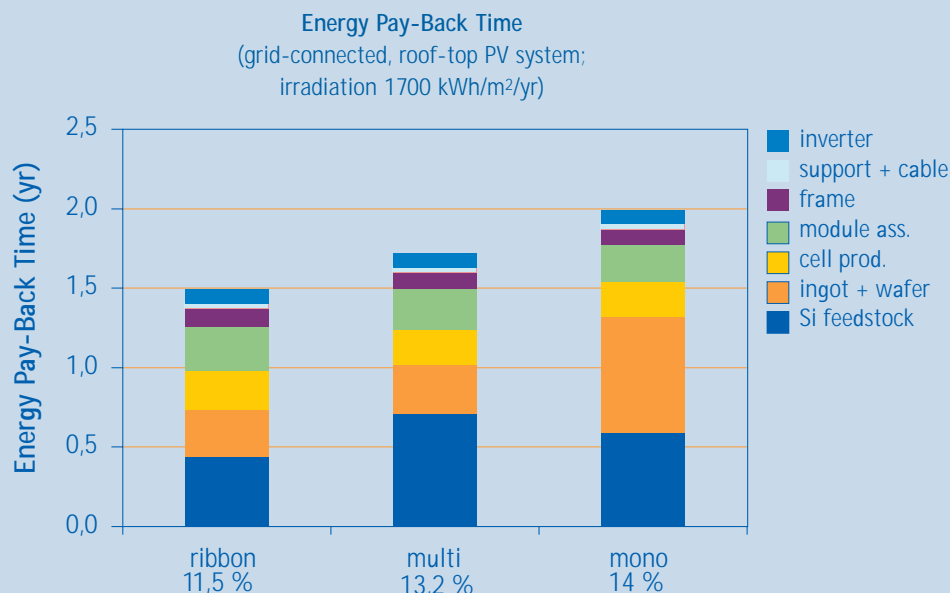


Fig. 1 - Energy Pay-Back Time of crystalline silicon PV systems in 2006 (rooftop system in S.-Europe, irradiation 1700 kWh/m<sup>2</sup>/yr, PR=0.75) (from: Alsema and De Wild-Scholten, Reduction of the Environmental Impacts in Crystalline Silicon Module Manufacturing, 22<sup>nd</sup> European Photovoltaic Solar Energy Conference, Milano, 2007).

### SUBTASK 3: EH&S in Manufacturing Facilities

The main objectives within this subtask are:

- 31) Develop risk factors and compare with other energy technologies.
- 32) Identify accident prevention and control options for specific technologies.
- 33) Identify pollution control technologies for major types of PV manufacturing facilities.
- 34) Identify prevention and control strategies for green-house gases (GHG) in PV manufacturing facilities.

The activities proposed to achieve them are:

- Host EH&S Tutorials during major PV conferences.
- Report to the Intergovernmental Panel for Climate Change (IPCC) the findings on the GHG emission assessment.

### SUBTASK 4: EH&S Information Dissemination

The methods and results obtained from sub-tasks 10-30 above will be communicated and disseminated by various target-oriented communication tools, such as:

- 41) Short and simple "fact sheets", documented by peer-review publications
- 42) Reports summarizing the activities undertaken for accomplishing the objectives of the task and the task results.
- 43) Presentations and peer-review publications

### PROGRESS IN 2007

This new Task got underway with a kick-off meeting in Brussels, in March 2007, which was attended by 11 experts in the field of EH&S, from seven different countries. This meeting's accomplishments were primarily in the areas of Task organization and the technical work program planning.

A second Task 12 Experts Meeting was held in Milan, in September 2007, in order to evaluate the work progress of the different participants within the Task.

A third one, The 1<sup>st</sup> IEA LCA Experts Meeting, was held in New York, in November 2007, where worldwide experts in the field of LCA have met in order to develop the "Guidelines for a Common Approach in Photovoltaics Life Cycle Inventory and Life Cycle Assessment." A draft document is presently being circulated among the Task member and will be published later in 2008.

### SUBTASK 1: Recycling of Manufacturing Waste and Spent Modules

A significant breakthrough has been achieved with the creation of the PV CYCLE association in Brussels, July 2007. This association was founded by EPIA and BSW and is supported by the German Federal Ministry for the Environment. PV CYCLE now counts with the participation of 17 worldwide Industries. Its goals are the introduction of a voluntary take-back and recovery system for PV modules within Europe. Technical and cost feasibility of collection and recycling are being analyzed for both crystalline and thin films technologies.

### SUBTASK 2: Life Cycle Assessment

- A database called EcoInvent has been updated on behalf of the European Photovoltaics Industry Association and the Swiss Federal Authority for Energy. Data have been collected in this project directly from manufacturers and were provided by other research projects. LCA studies from different authors are considered for the assessment. The information is used to elaborate a life cycle inventory from cradle to grave for the PV electricity production in grid-connected 3 kWp plants in Switzerland, in the year 2005.

The inventories cover mono- and multicrystalline silicon cells, ribbon silicon cells, as well as amorphous silicon, CdTe and CIS thin film cells. Environmental impacts due to cell and module production for all production steps including feedstock and wafer production, metal winning and refining, and production of special

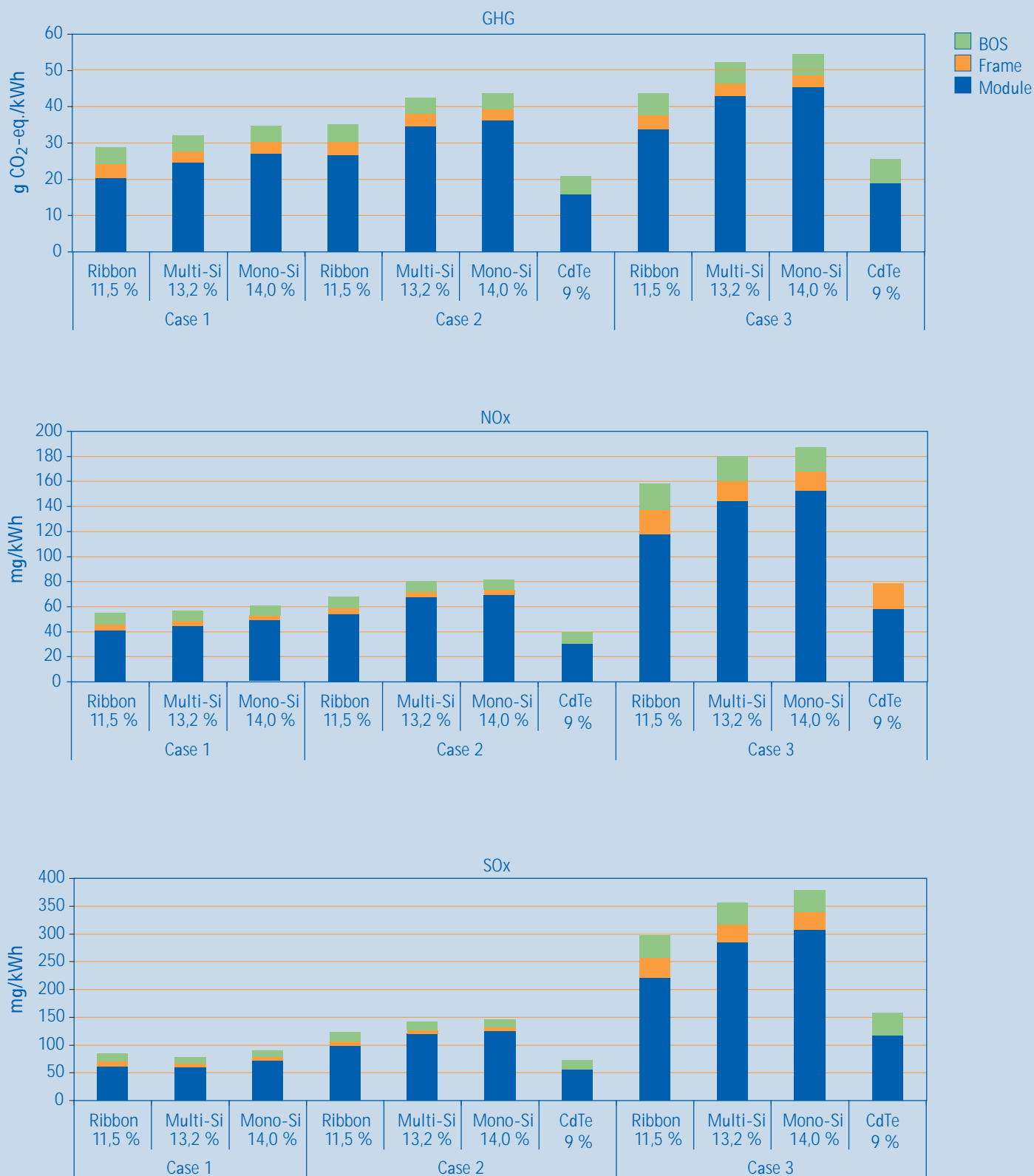


Fig. 2 - Life-cycle emissions from silicon and CdTe PV modules. BOS is the Balance of System (i.e., module supports, cabling and power conditioning). Ground-mounted systems, Southern European insolation, 1,700 kWh/m<sup>2</sup>/yr, performance ratio of 0.8, and lifetime of 30 years. Case 1- current electricity mixture in Si production-CrystalClear project and Ecoinvent database. Case 2- UCTE grid mixture and Ecoinvent database. Case 3- US grid mixture and Franklin database (Source: Fthenakis, Kim and Alsema, Emissions from Photovoltaic Life Cycles, Environmental Science and Technology, in press).

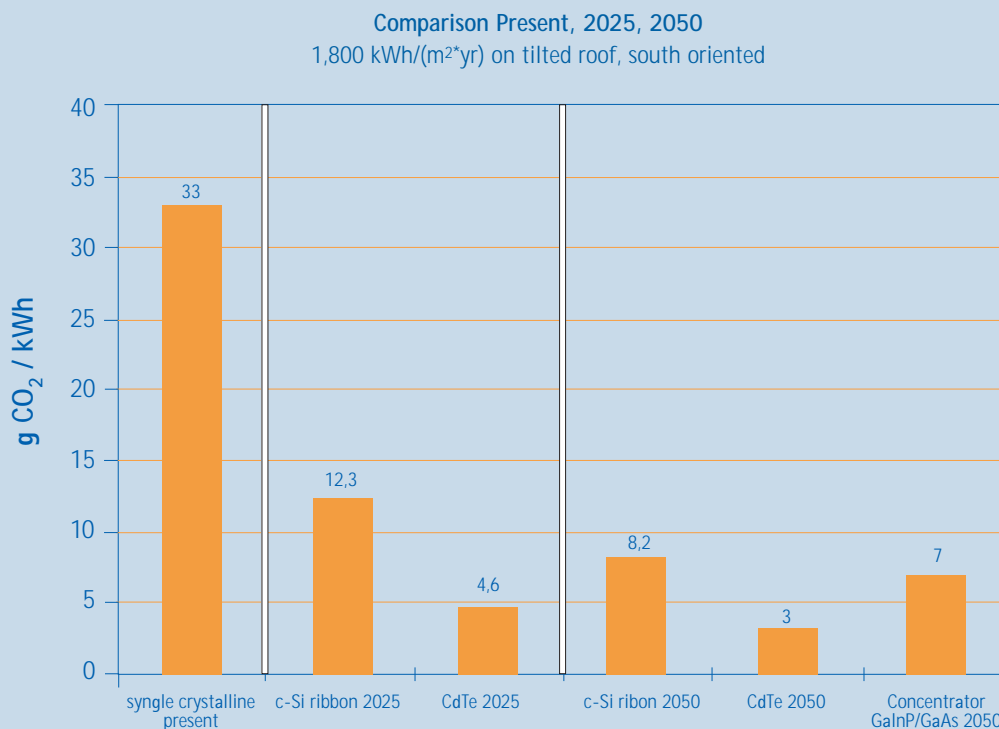


Fig. 3 - Preliminary GWP results for the Optimistic/Realistic scenario analysis of future PV systems performed within the NEEDS project (with fixed background data).

chemicals are considered. For standard materials the EcoInvent data v2.0 may be used as a background database. The content of the PV LCI datasets for crystalline silicon modules and BOS components is publicly available via the website of ECN ([http://www.ecn.nl/docs/library/report/2007/e07026-LCIdata-cSiPV-pubv2\\_0.xls](http://www.ecn.nl/docs/library/report/2007/e07026-LCIdata-cSiPV-pubv2_0.xls)), while the complete LCI dataset for all technologies is accessible for EcoInvent members at [www.ecoinvent.org](http://www.ecoinvent.org). The latter dataset will also be offered as part of a database extension by major LCA software distributors. Issues related to the representation of thin-film PV and BOS in ECOINVENT were identified (The model used in ECOINVENT for CdTe modules lacks representativeness, since it is largely based on production data for a company modules which only makes up a very small percentage of the total CdTe PV market in Europe). Remedies are currently discussed among IEA Task 12 participants.

- A first draft of an LCA model has been completed by Elkem Solar with support from ECN. The LCA model's work aims at disseminating results on environmental impact and energy use for the Elkem Solar process to produce solar grade silicon (or Elkem Solar Silicon - ESS™). This includes entities like Energy Pay Back Time and CO<sub>2</sub> Pay Back Times. In addition, models for competing processes will be set up and compared to the ESS - process.
- An experts meeting was held in New York, November 2007, with the aim to establish guidelines that promote transparency and balance in conducting and communicating comparative life cycle assessments across different PV technologies and in comparing the environmental impacts of PV systems with those from other energy technologies.
- A number of papers related to life cycle assessments and other environmental aspects have been published during 2007 and can be found at:
  - <http://www.ecn.nl/publicaties/default.aspx?au=44649>
  - <http://www.clca.columbia.edu/publications.html>
  - [http://www.chem.uu.nl/nws/www/research/e&e/e&e\\_rena.htm](http://www.chem.uu.nl/nws/www/research/e&e/e&e_rena.htm)

#### SUBTASK 4: EH&S Information Dissemination

A set of Fact sheets have been developed under the EU PV technology platform and supported by EPIA. Some of the fact sheets deal with issues as the Energy Pay back Time for PV systems (Erik Alsema) or the external costs of electricity generation (Vasilis Fthenakis). Currently they are only in English but they will be translated to several European languages during 2008.

#### PLANS FOR 2008

A workshop on silane safety will be in conjunction with the next IEEE PVSC in San Diego, USA, May 2008

The "Guidelines for a Common Approach in Photovoltaics Life Cycle Inventory and Life Cycle Assessment" are currently under review among task members and they are expected to be published during 2008.

In the framework of PV CYCLE, a one year length study on the "development of a take back and recovery system for PV products in Europe" has been concluded and the results will be published within the following months. Therefore, the best option coming from the study will be discussed and implemented.

#### PUBLICATIONS AND DELIVERABLES

The following papers will be presented at different international events:

- "Environmental Life cycle Assessment of the Elkem Solar Metallurgical Process Route to Solar Grade Silicon with Focus on Energy Consumption and Greenhouse Gas Emissions" (Silicon for Chemical and Solar Industry IX", Oslo, Norway, June 2008.
- "Comparison of the Energy Consumption in Different Production Processes for Solar Grade Silicon" (The 23<sup>rd</sup> EU PVSEC, Valencia, Spain, September 2008.
- A most comprehensive LCA study "Emissions from Photovoltaic Life Cycles" will be published in Environmental Science & Technology in Feb. 2008.