Workshop on Sustainability Aspects for TeraWatt-Scale Photovoltaics

Thursday 8 September 2011, CCH - Congress Center Hamburg, Hamburg, Germany

Minutes

Introduction, Wim Sinke, Chairman of the European Photovoltaic Technology Platform

Wim Sinke opened the workshop and welcomed the participants by emphasizing the great attendance to the workshop. He mentioned that in order to achieve an impact on a global scale and to strongly reduce the CO2 emissions, PV need to play an active role into the terawatt scale. In the last decade the PV sector focused on the cost reduction. Now it is time to look at the requirements of terawatt scale and its sustainability. Accelerated scenario and paradigm shift scenario of the Solar Generation VI report from EPIA and Greenpeace show that PV should reach the terawatt scale around 2030. This means PV has to grow by a factor of 100 to reach this aim. Sustainability is a must to reach this goal.

Sustainability is a multi-dimensional concept, which has to take into account:

- Supply chain security
- "Cradle to cradle" approach
- Low zero or positive impact in manufacturing, installation, operation, and decommissioning
- Public acceptance

There are still misleading statements on the PV technology, which is still seen as a technology not fully sustainable. The aim of this workshop "is to start an objective discussion in scientific terms on the sustainability of the PV technology in order to provide clear input to correct the misleading statements on the PV sustainability.

Wim Sinke provided the audience with an overview of the programme of the workshop:

- Eco-factories and PV manufacturing, Klaus Eberhardt, technology manager photovoltaic, M+W Group
- Solar parks and their influence on biodiversity, Andreas Wade, sustainability manager, First Solar

- Materials challenges for terawatt-scale photovoltaics, Peter Rigby, EU Government affairs, Umicore
- The Sustainability of PV: is it quantifiable in external costs? Carol Olson, research scientist, ECN Solar Energy
- Panel discussion 'Major challenges for sustainable terawatt-scale photovoltaics'

Afterwards he introduced the first speaker, Klaus Eberhardt who gave a presentation on ecofactories and PV manufacturing.

Eco-factories and PV Manufacturing, Klaus Eberhardt, Technology Manager for Photovoltaic, M+W Group

Klaus Eberhardt focused on the requirements necessary to guarantee PV cost reduction while ensuring at the same time its sustainability. A further cost reduction in the PV sector is needed to reach the PV grid parity and to enable PV power parks to compete with conventional power plants.

The key elements to further reduce the costs for PV manufacturing are related to:

- technology improvements
- diluted overhead costs
- optimization of facilities
- recycling and reuse of chemicals
- vertical integration

Other key factors to be taken into account in the future PV manufacturing are:

- legislature
- availability and cost of energy due to limited resource of fossil fuels
- voluntary commitment by the industry to reduce energy consumption and CO2 emissions

A tool to guarantee the reduction of energy consumption and CO2 emissions could be the green certification systems, such as LEED (Leadership in Energy and Environmental Design), which was initially developed in the United States for public and commercial buildings, but now is increasingly applied also to electronics and PV manufacturing. According to the LEED approach, a reduction in energy consumption and CO2 emissions can be achieved through improved efficiency during design and operation.

Klaus Eberhardt emphasized that a possible introduction of compulsory CO2 trading will not only trigger a reduction in energy consumption but also in what type of energy source will be used.

CO2 discharge and CO2 footprint are key elements to be taken into account to ensure the PV sustainability. CO2 emissions differ significantly between fossil and renewable energy sources. Crystalline Silicon based modules exhibit a slightly higher emission rate due to high energy flux. Thin-film based PV modules exhibit fairly low CO2 footprint. There is a strong dependency on the operational phase of most facilities and what could be reduced during this process. Analysis on overall energy consumption is therefore needed.

In addition, Klaus Eberhardt explained the life cycle CO2 footprint of a PV module which is constituted by 8% for construction of the module (including CO2 emission through transportation, use of steel and concrete etc.), 4% for decommissioning and 88% for operation which contains the life cycle stages: production, supply and disposal. Given that sustainability plays an ever more important role, the question arose of how this 88% of CO2 footprint for the operational stage of a PV module construction can be decreased. Mr Eberhardt mentioned the importance of recovering the waste products of PV module construction such as waste water, waste heat, scrap and packaging. Consequently, potential enhancements in facility system design can contribute to the reduction of these waste products. Potential enhancements should include:

1) Dual temperature chill
2) Free cooling
3) High temperature process cooling water system
4) Heat recovery
5) Reclaim and recycle
6) Use of alternative energy supply concepts (Tri-generation Plant)

Klaus Eberhardt concluded his presentation by stressing the ever-increasing role sustainability will play in legislative compliance, manufacturing competitiveness and in improving the corporate image of PV production facilities. One of the key methodologies to optimize possible scenarios is an energy and mass flow modeling to determine and evaluate new approaches.

Solar Parks and their Influence on Biodiversity, Andreas Wade, Sustainability Manager, First Solar

Andreas Wade started his talk about the impact of solar parks on biodiversity by emphasizing the public acceptance issues Solar and PV are facing at the moment. The PV sector should look at the softer part of the PV footprint and its impact, making it a necessity to have responsible project developments. Andreas Wade discussed two best practice samples to proof the positive influence of solar parks on biodiversity: Topaz Solar Farm in the USA, and Lieberose/Oberspreewald Solar Park in Germany.

Biodiversity refers to the uncounted variety of living things on the planet. These living organisms, interacting among themselves and with the non-living environment, comprise the ecosystems of the world. They supply food, medicines, timber and fuel, and play a fundamental role in providing breathable air, conserving soils and stabilizing climates. The importance of biodiversity to human society is hard to overstate as it is the precondition for sustainable development. Hence, solar parks need to avoid and minimize the impact on biodiversity through responsible project management and by providing an opportunity to improve biodiversity by changing the use of land. Solar parks are part of the sustainable energy mix and will gain more importance with further cost reduction as they form part of the clean energy production with no emission or water use and a minimal land use footprint.

Studies show the potentially positive biodiversity impacts of solar parks contributing not only to future energy supplies but also being able to provide a refuge for plants and animals. Although construction projects always involved disturbances of existing flora and fauna, after the construction phase solar parks can on the long-term improve the quality of habitats for various plants and animal species and even create new habitats as proven by the two case studies in Germany and the USA.

Concluding, Andreas Walde emphasized that solar parks are key to ensure the growth of PV in coming years and to improve the public acceptance of solar parks. However, the land use for solar power plants needs to be done in a responsible and publicly accepted way. Local communities need to identify opportunities for biodiversity and the PV sector needs to address these in order to avoid missing them due to an automatic exclusion of local communities and local ownership of this process. Furthermore, the PV industry community, nature protection organizations and political decision-makers should enter into a dialogue about ecologically responsible solar power plants and maybe even go as far as developing guidelines on the sustainability of future solar parks and their influence on biodiversity.

Materials Challenges for Terawatt-scale Photovoltaics, Peter Rigby, EU Government affairs, Umicore

Peter defined the challenge and future trends in PV industry. PV is only one of panoply of 21st century growth industries. Taking this for granted requires a careful consideration and forward thinking with respect to availability of material and resources and future competition due to resource scarcity.

The material challenges for Terawatt-scale Photovoltaics are multi-facetted and relates to material availability, supply chain, costs and material performance. In order to identify these challenges further, different facets of PV need to be quantified, categorized and a mitigating strategy needs to be developed. Mr. Rigby highlighted the challenge a PV-Paradigm shift scenario for 2020 will leave for the material and application sector.

PV has the advantage of having several interchangeable technologies each using different material systems (CPV, CIGSe, CdTe, a-Si, c-Si) and a combination of the following materials Copper, Aluminum, Zink and Lead. This signifies that a changing evolution of which material will be prevalent will be determined by market prices and the availability of the material. An increased demand in materials can only be met by an increased primary production of major metals which will place an absolute cap on total material availability. Extraction and refining are complex processes and require planning and investment and an increased demand will lead to temporary price peaks during the lead time necessary to install new capacity. Another point taken into consideration is the influence this might have on other industries and sectors e.g. the incident of "China's rare earth policy hurts optics makers".

Although there exist the possibility of increasing the extraction rate of raw materials, improvements have to be made in optimizing material yields in device production and waste recycling circuits. Mr. Rigby defined the following strategies for the PV industry to meet these future material challenges for terawatt scale PV:

- Defining the challenge: PV competitiveness to reach Grid Parity and to reduce costs for PV which means that in order to reduce the costs we need to increase the number of PV modules
- Reducing specific material needs
- Improvements have to be made in material usage: Cell and Module Efficiencies have to be improved
- Efficiency evolution of c-Si is fast compared to other Thin-film PV technologies
- Other alternatives: organic PV where there should not be any shortages in material

- Substitution of Indium? Technically very challenging but many research groups are working on the subject

The EU has been concerned about material availability and has been involved in a number of new industrial policy developments, resource efficiency plans and innovation unions such as the Raw Materials Initiative, Resource Efficiency Roadmap, and the Innovation Partnership. Further, pilot plans on financing and recycling as well as Innovation Action Partnerships have been developed to form joint research projects.

The SET Plan and the Material Research Roadmap also focus on developing materials and their availability for PV, wind, nuclear and fossil fuels.

The anticipated strong growth in PV will be accompanied by stress in the supply chain for specialty scarce metals. Peter Rigby summarized his points with a positive outlook to the future of terawatt scale photovoltaic as this stress is manageable. To manage this stress, the extraction rates of primary refining metals need to be improved as well as the knowledge of material reserves worldwide. In order to use less material, the in-process waste management and recycling must be optimized and an effective end of life recycling scheme deployed. Furthermore, Photovoltaic should continue maintaining parallel PV technologies using different materials systems and developing new substitute materials systems.

The Sustainability of PV: is it Quantifiable in External Costs? Carol Olson, Research Scientist, ECN Solar Energy

Carol Olson from ECN Solar Energy Research Institute in the Netherlands began her talk with the question of whether the sustainability of PV is quantifiable in external costs. In order to answer the above raised question, Carol Olson compared the levelized cost of electricity of PV with coal and nuclear electricity production to draw a comparison between the three sectors and to take a wide view on the topic of sustainability, health and climate.

The levelized cost of energy is found from the present value of the total cost of building and operating a generating plant over its expected economic life. Costs are levelized in real dollars, i.e., adjusted to remove the impact of inflation. External costs in contrast are defined as costs that are not included in the market price of a good because it is not included in the supply price. They arise when the economic activities of a power station, for example, have an impact on a group of persons and when that impact is not fully accounted or compensated by the power station operators. In this example, the environmental costs are

external because, although they are real costs to these members of society who are suffering of the impact of the power station, the owner of the same station is not taking them into account when making decision or when asked increase the price of electricity in order to pay for these damages.

For PV there could be two possibilities for external costs to accrue: 1) through unsustainable manufacturing practices and 2) through unsustainable end of life disposal and the recycling of solar modules. However, when compared to the external costs of both coal and nuclear, PV's external costs are comparatively low. The levelized costs of both coal and nuclear technologies, however, have been showing a tendency to increase when technology improvements to meet air quality standards or to mitigate other environmental issues are taken into account. For PV, assuming sustainable manufacturing and end-of-life solutions for PV modules, there is no risk transferred to the public, according to Carol Olson.

What is needed instead is a "real" levelized cost of electricity taking into account the external costs of each technology. Low-end estimates of external costs would put the cost of nuclear and coal at least 2-3 times higher than those stated. Furthermore, these costs are rapidly increasing for both nuclear and coal. As consequence, PV will become more sustainable and more truly economical than the coal and nuclear options.

The presentation of Carol Olson is part of the work done in the framework of the European project "PV Parity" (http://www.pvparity.eu/).

Panel discussion 'Major Challenges for Sustainable Terawatt-scale Photovoltaic'

Wim Sinke invited the candidates on stage to start a discussion on the topics presented by asking their opinion on what really is the biggest challenge of all for PV to grow to a terawatt scale in the next decades. All participants agreed that the biggest challenge for PV is to reduce the costs of production while promoting the use of renewable energies. Andrea Wade further stressed the point that another challenge is to make sure that all energy sectors are evaluated according to the same standards. Mr. Rigby went a step further, elaborating on the challenge of establishing the right levelized price for PV and the other sectors including external costs in order to motivate the right people to fight for PV. Carol Olson added that the PV community should look at the commitment of the PV industry and then to communicate this commitment to sustainability to the policy-makers.

Following these statements, Wim Sinke opened the floor for the workshop participants to raise questions or contribute new points to the discussion. One of the participants raised recycling as the biggest challenge PV is facing, as poisonous chemicals are also used for the construction and operation of PV modules even if less than the traditional industries. However, PV should look at what is happening and stick to their commitment of sustainability.

Following Andreas Wade's presentation, biodiversity was also discussed as the most important and biggest challenge particularly when talking about miscommunication and misinformation prevalent amongst politicians and the larger public. PV needs to learn from the lessons learned from the wind industry in regards to misinformation and the role the media plays in influencing public opinion. The PV community must stand together in getting the message across to the public and in order to convince politicians of PV's commitment to sustainability.

On the question of what kind of incentive could be offered to the industry in order to decrease their use of material and metals in the future as shown in Peter Rigby's presentation, Wim Sinke demonstrated his ideas of eco-labeling of products in the PV sector to create a drive to decrease energy content and having a renewable generation power plants in the manufacturing process of PV modules. One of the most important points to remember in this regards is to think about the benefits that must be offered to the industries and that the whole PV sector needs to work to the same rule. Wim Sinke summarized the most important points of the workshop stressing that the mentioned challenges we are facing as a sector can be managed. The PV community needs to communicate much better in the future than what was done in the past, particularly in dialogue with the European Commission in order to bring messages and commitments from the PV community to the right table at the right time and in the right form.

Afterwards, Wim Sinke thanked the participants and the presenters and closed the workshop.