The Influence of Market Shifts and Technology Developments on the Environmental Impacts of Photovoltaic Electricity in Central Europe

ESU-services
fair consulting in sustainability

Matthias Stucki, Rolf Frischknecht, Karin Flury,
ESU-services Ltd.,
Kanzleistrasse 4, CH–8610 Uster
stucki@esu-services.ch, www.esu-services.ch

Introduction and goal of the study

In the last years, China has emerged as the world's largest producer of photovoltaic wafers, solar cells, and modules, as well as the world's second largest producer of poly-silicon.

Life Cycle Assessment studies of photovoltaic electricity generation focus on a European photovoltaic production chain.

Do Chinese PV modules increase the carbon footprint of European solar electricity by overcompensating technology improvements of the last few years?

Photovoltaic Inventories

In Life Cycle Assessment, the environmental impacts during all stages of the life cycle of a product are systematically inventoried and analysed.

The life cycle of photovoltaic electricity includes:

- extraction of energy and raw materials for the fabrication of the solar wafers, cells, and modules
- manufacturing of the mounting system, and the inverter,
- the erection of the plant,
- the operation of the plant,
- and the dismantling and disposal of the photovoltaic power plant.

Detailed manufacturing data including latest technology developments in module efficiency, wafer thickness, and sawing gap are used for different photovoltaic technologies that include accordant electricity mixes for manufacturing in China and Europe, respectively.

Fig. 1 shows the model of Central European PV market underlying the life cycle assessment results shown.

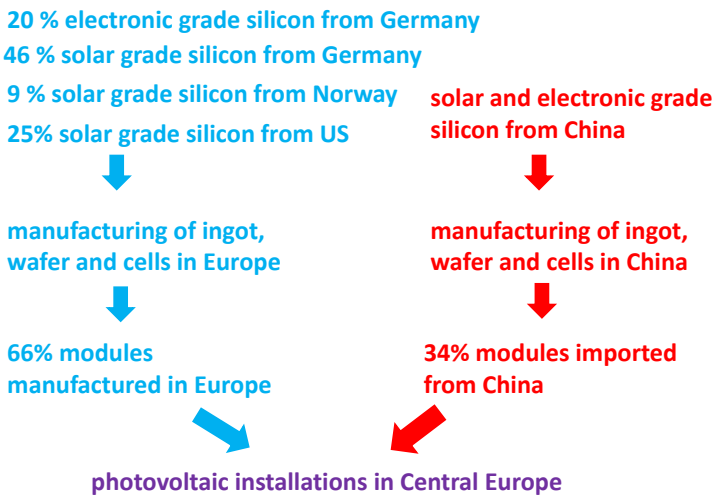

Fig. 1: Overview of the silicon based photovoltaic production chain for mono-Si and multi-Si modules installed in Central Europe (simplified model).

Technology comparison

Lower carbon footprints of photovoltaic electricity from (see Fig. 2):

- Integrated compared to mounted systems
- Thin film compared to crystalline technologies

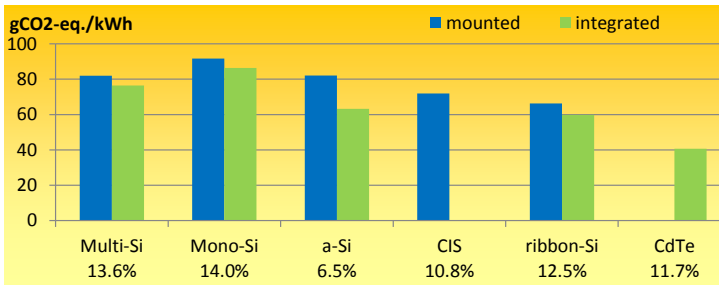

Fig. 2: Carbon footprints of photovoltaic electricity from 3kWp-rooftop photovoltaic installations (average specific module efficiency) in Central Europe; Annual electricity yield: 809 kWh/kWp. Provenience of the crystalline modules: see Fig. 1. Plant lifetime: 30 years.

Chinese manufacturing and technology improvements

Technology developments in the last years lead to 9 % decrease of the carbon footprint (see Fig. 3). This is due to:

- higher material efficiency in wafer manufacturing
- higher module efficiency of 13.6 % compared to 13.2 %.

The shift of photovoltaic manufacturing from Europe to China results in approximately 70 % higher greenhouse gas emissions due to the high share of coal power in Chinese electricity.

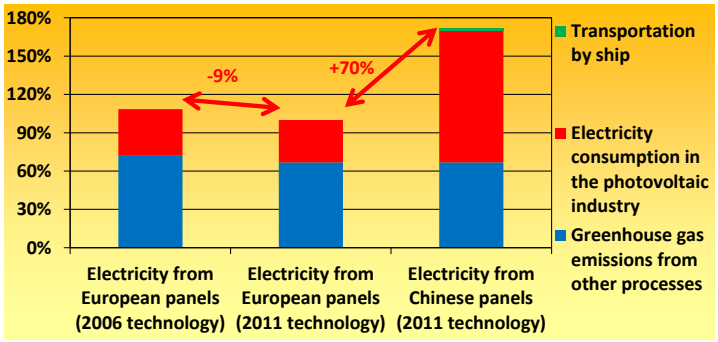

Fig. 3: carbon footprint of electricity generated with a rooftop photovoltaic 3kWp-installation in Central Europe with European (2006 versus 2011 technology) and Chinese multi-Si panels respectively. Module efficiencies: 2006: 13.2 %; 2011: 13.6 %. Annual electricity yield: 809 kWh/kWp. Plant life time: 30 years.

Photovoltaic modules manufactured in Europe are more favourable from an environmental viewpoint than modules manufactured with the Chinese electricity mix, given the same technical performance.

Chinese photovoltaic manufacturers are asked to use (more) renewable energy sources and reduce the overall energy consumption in their production chain.

Conclusions

- Environmental impacts of photovoltaic electricity differ significantly between different PV technologies.
- Environmental impacts of photovoltaic electricity differ between production chains in **China versus Europe.**
- The source and the amount of **electricity consumed** in the photovoltaic production chain is an environmental **key factor.**
- Sustainable PV manufacturers have to implement a strategy of **reducing** their **energy consumption** and. **using electricity from renewables.**

Acknowledgement: The authors thank the Swiss Federal Office of Energy (SFOE) for financing this study.