Estimating life cycle greenhouse gas (GHG) emissions based on (technical) characteristics of PV panels

Level:	**Master**
Start:	**Anytime**
Project duration:	**6 month**
Project form:	**Literature research, data analysis, life-cycle impact assessment**
Supervision:	**Tine Dammeier/Mark Huijbregts**

The environmental impacts (that is, the life-cycle GHG emission divided by the life-time energy production) of energy technologies vary with space and time. Reasons are, obviously, that the sun does not always shine, but also that e.g. panel production efficiency improves and the background electricity mix changes. Until now, no framework exists that makes it possible to easily compare different conventional and renewable energy technologies on their environmental impacts.

The goal of this internship is to come closer to establishing such a framework by deriving a relationship between (technical) characteristics of PV panels and their life-time GHG emissions. You will perform a literature review to gather data from life-cycle assessments of PV plants. Those will then have to be harmonized, after which an equation relating PV panel characteristics to GHG emissions can be derived.

By making use of long-term global climate data, the facilities' electricity production can be calculated from

$$P = A * \mu * R_{avg} * PR$$

with P the energy in kWh, *A* the solar panel area in m^2, μ the panel's efficiency (%), *R* the average solar radiation on tilted panels not including shading and *PR* the performance ratio, a coefficient of losses, normally ranging between 0.5 and 0.9 with a default value of 0.75.

By dividing a facility's life-time GHG emissions by its electricity production, a facility-specific footprint can be calculated for all known facilities worldwide. Depending on your interests and the time available it is possible to extend this internship in different directions:

- You can decide to stick to the environmental impact part and collect data and develop relationships for several other indicators (water use, land use, scarce material use, …)
- Accounting for the background electricity mix change might be an interesting though challenging topic, which you could investigate further.
- It might be interesting to look into differences in GHG emissions from different types of solar panels (mono- and multi-crystalline Si ones as well as different thin-film technologies such as CiGs, CdTe and α-Si) to see if the relationship between PV panel characteristics and life-time GHG emissions are better described using one or multiple equations.

Key references:

Hertwich EG et al. (2015) Integrated life-cycle assessment of electricity-supply scenarios confirms global environmental benefit of low-carbon technologies. *PNAS*. 112(20):6277-6282.

Kim HC, Fthenakis V, Chou J-K, Turney DE (2012) Life Cycle Greenhouse Gas Emissions of Thin-film Photovoltaic Electricity Generation – Systematic Review and Harmonization. *Journal of Industrial Ecology*. 16(S1):S110-S121.

Hsu DD et al. (2012) Life Cycle Greenhouse Gas Emissions of Crystalline Silicon Photovoltaic Electricity Generation – Systematic Review and Harmonization. *Journal of Industrial Ecology*. 16(S1):S122-S135.