

**SUSTAINABILITY OF PHOTOVOLTAIC SYSTEMS  
The Energy Pay Back Time**



**Sustainable Photovoltaics**

Photovoltaic (PV) is a renewable energy technology that converts solar radiation directly into electricity. Solar energy is abundantly available; the Earth receives enough solar energy every hour to meet the world’s annual energy needs.

The advantages of PV are manifold:

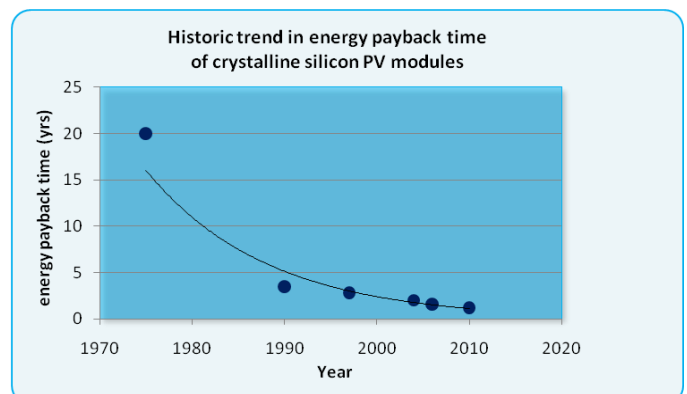
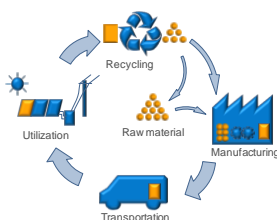
- Unlimited resource of solar energy
- Available in all parts of the world
- Modular, it varies from milliwatt in consumers products up to gigawatt in future power stations
- During operation, it produces electricity with no air emissions and no waste production
- Virtually no maintenance
- Silent during operation
- Proven technical lifetime of 30+ years.

**The Energy Pay Back Time**

The energy payback time (EPBT) of photovoltaic (PV) systems is an important criterion in understanding the sustainability of PV. The EPBT is the amount of time a PV system has to operate in order to compensate for the energy required to fabricate the system itself. A quantitative methodology known as Life Cycle Analysis (LCA) is used when calculating the EPBT (I). It takes the following actors into consideration: the impact of a product throughout the entire life cycle – from material sourcing, through manufacturing, construction, operation, dismantling and product collection and recycling.

$$EPBT = E_{input} / (E_{output}/year)$$

The major contributors to the EPBT are energy inputs that are primarily driven by the requirements during module manufacturing and the energy output, which is specific to the characteristics of the PV technology used in addition to the location of the system. For areas with high solar irradiance, such as Southern Europe, the EPBT is shorter as compared to areas with lower solar irradiance.



Note: For rooftop installations in Southern Europe (1700 kWh/m² yr). Irradiation on optimally-inclined modules (II), (III)

**Did you know...?**

- Recent EPBT calculations have been made in the major European Integrated PV R&D Projects, Crystal Clear, Performance and within the EPIA Sustainability Working Group
- Depending on the type of PV system and the location of the installation, the EPBT at present is between 0.5 (IV) and 1.4 years (III)
- The technical lifetime of PV systems is 30+ years; hence they produce net clean electricity for more than 95% of their lifetime.

**The Future...**

The EPBT of PV systems will continue to decrease through its main drivers:

- Reduction in material usage (e.g. thinner silicon wafers, thin-film modules)
- Higher system efficiencies for converting solar energy into electricity
- Improved manufacturing processes resulting in increased throughput and yield, and a reduction in energy usage
- Recycling of materials and PV systems.

The continuation of significant improvements to PV EPBT will depend on reductions in the energy requirements to produce commodity materials such as glass, semiconductor materials, and foils.

To learn more about EPIA: [www.epia.org](http://www.epia.org)

(I) Methodology Guidelines on Life Cycle Assessment of Photovoltaic Electricity, Report IEA-PVPS T12-01:2009  
 (II) [www.ipcrystalclear.info](http://www.ipcrystalclear.info)  
 (III) Recent results of an LCA carried out by several of EPIA Sustainability Working Group members, to be published  
 (IV) M. Held, R.Ilg, Update of environmental indicators and energy payback time of CdTe PV systems in Europe, Progr. Photovolt: Res. Appl., 2011