REC

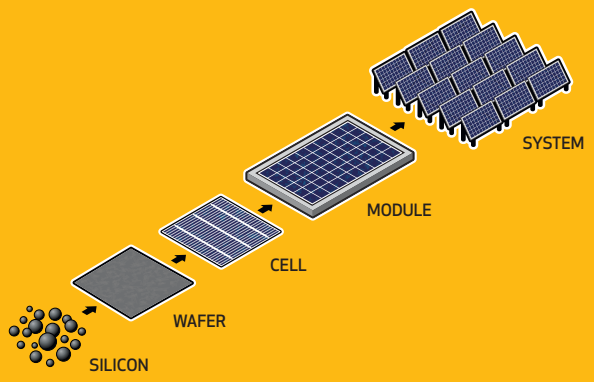
DELIVERING SUSTAINABLE SOLAR SOLUTIONS

SMART ENERGY FOR A CLEANER FUTURE

Reducing energy consumption and increasing energy efficiency with cost-effective renewable energy sources are now more important than ever. Solar energy is an increasingly competitive solution able to meet this global challenge. With control of the complete value chain, and an uncompromising focus on quality, efficiency and operational excellence, alongside strict adherence to environmental standards, REC is leading the way towards this goal. Through continuous innovation REC maintains a leading position in the industry, working to ensure solar solutions deliver sustainable value.

THE SOLAR VALUE CHAIN:

The solar value chain encompasses the complete journey of silicon from the purification of sand, to the production of a solar wafer and a solar cell, through to the assembly of the solar module and developing a solar energy system. REC owns each stage of this process, which makes us the world's most vertically integrated solar company, able to ensure a high level of quality while regulating the amount of energy used throughout the production process. Extraction of raw materials, transport and recycling are also part of this.



Reducing Energy Payback Time

To understand the environmental impact of our REC module, REC commissioned the independent Dutch research institute ECN (www.ecn.nl) to analyze the complete lifecycle of an REC module according to the standard ISO 14040 for the first quarter of 2011. This followed from a similar study we conducted in 2007.The 2011 results for the energy consumed throughout the lifetime of a module are in the lowest in the industry, even with the inclusion of recycling. In 2007, the Energy Payback Time (EPBT) of an REC module was 1.4 years. Today, we have reduced it to one year thanks to continuous technological innovation throughout the value chain. With the ownership of the complete solar value chain, REC was able to provide comprehensive data from the whole lifecycle, giving the customer a complete overview of the environmental impact of solar module production.

LIFECYCLE ANALYSIS

A lifecycle analysis (LCA) is an assessment into the 'cradle to the grave' environmental impact of a product from the beginnings of its manufacture to its eventual 'retirement' or recycling.

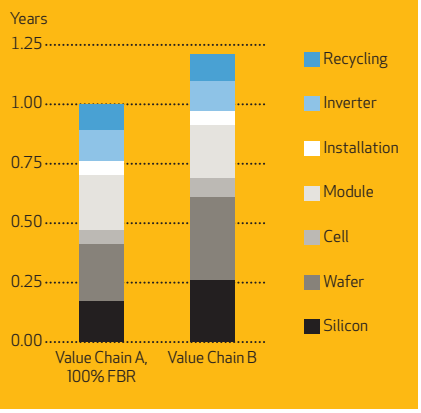
For the study, ECN analyzed REC's production data and calculated the primary energy consumption involved during each step of production, including raw material extraction and all transportation up to when the module is assembled, to recycling. Generic data for installation and recycling was used to calculate the EPBT of a complete system. The data is based on a yearly solar insolation value of 1700 kWh/m², which is a typical value for a Southern European Mediterranean location such as Barcelona or a mid-US location such as New Jersey.

The energy used in different production sites impacts the EPBT of a module. The EPBT of REC products manufactured in different locations using different technologies are compared to transparently show the environmental impact of REC production.

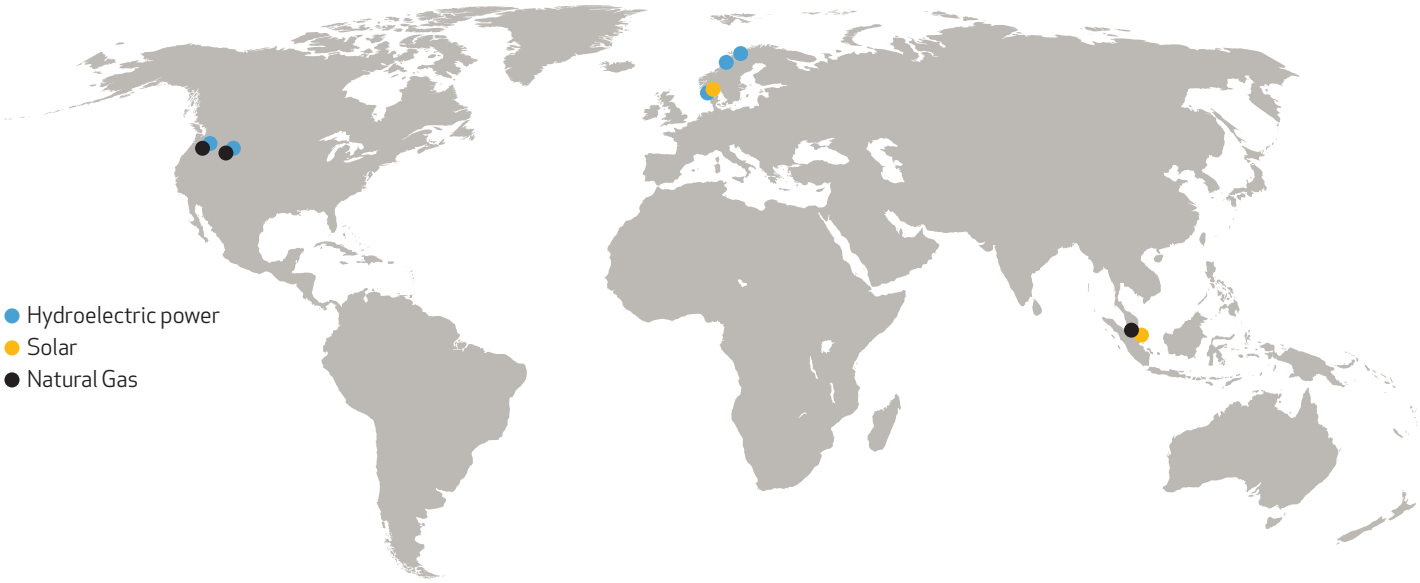
- Modules containing 100% silicon produced using the proprietary Fluidized Bed Reactor (FBR) process in the USA, wafers and cells produced in Norway and modules assembled in Singapore have an EPBT of 1.0 years. See value chain A illustration.
- Modules containing silicon produced using a mix of the proprietary FBR and Siemens reactor processes in the USA and wafers and cells produced in Singapore have an EPBT of 1.2 years. See value chain B illustration.

ENERGY PAYBACK TIME OF ONE YEAR

A module's Energy Payback Time is the time it takes for a PV module to generate the same amount of energy required for its manufacture. The lower this figure, the faster the module can make a contribution to a cleaner energy future.



REC'S MANUFACTURING FACILITIES WORLDWIDE



Our Carbon Footprint

To ensure REC has a minimal impact on the environment, efforts are continually made to reduce carbon emissions.

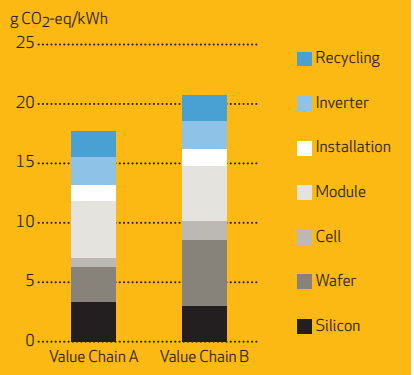
The carbon footprint of REC products was calculated based on ISO14040 to be amongst the lowest in the industry:

- 18 g CO_2-eq/kWh for wafers and cells produced in Norway and modules manufactured in Singapore (see value Chain A).
- 21 g CO_2-eq/kWh for wafers and cells and modules produced in Singapore (see value Chain B).

As shown in the map above, REC uses the most environmentally friendly energy sources wherever possible. This means hydroelectric power in Norway, natural gas and solar in Singapore and in the United States natural gas as well as hydroelectricity. This means the carbon footprint is kept as low as possible compared to competing companies producing solar solutions at sites supplied by coal-fired power plants. The carbon footprint of such modules is approximately 30 g CO_2-eq/kWh.

CARBON FOOTPRINT OF REC SOLAR SOLUTIONS

The term Carbon Footprint represents the amount of greenhouse gases produced by a given activity. It is measured in units of carbon dioxide and typically given in tons of CO_2-equivalent (CO_2-eq) per year or per product unit. For solar energy it is measured per kWh of electricity produced by the system accumulated over its lifetime.



REDUCING ENERGY CONSUMED IN SILICON PRODUCTION

FLUIDIZED BED REACTOR (FBR) – A patented technology applied by REC to the deposition of silicon from the gas phase using a reactor where solid silicon particles float and grow in an upward gas flow (typically using silane) inside a chamber. This uses at least 90% less energy than a Siemens reactor.

SIEMENS REACTOR – The conventional reactor for deposition of silane or trichlorosilane on long silicon rods. This is used by most manufacturers of polysilicon.

Reducing waste in product design

Reducing waste thanks to product design
Throughout the product design process REC works to reduce material, packaging, without compromising on quality and removing toxic substances whenever possible.

Using sustainable materials
The silicon-based photovoltaic solutions REC provides are based on silicon made from sand which is an abundant and readily available resource.

Reducing energy in silicon production
Most of the energy consumed in producing solar is used in the silicon production process. The proprietary FBR process taken to scale by REC in silicon production reduces energy consumption by 90% compared to more commonly used Siemens technologies by maintaining a much more balanced temperature.

Improving ingot crystallization efficiency
Improving the overall quality of the ingot is also a vital part of improving cell efficiency. REC uses furnaces that crystallize more than 1000 kg of ingots per cycle as compared to the conventional 400–500 kg possible. REC is working towards crystallizing 2000 kg of ingots per cycle.

Decreasing wafer thickness
REC has made substantial advances in the use of thinner wire for the production of thinner wafers reducing wafer thickness to 180 µm. Thinner wires and wafers means a more efficient production overall and that more wafers, cells and modules can be made from silicon stock. This also reduces energy consumption.

Increasing cell efficiency
REC produces solar cells with higher conversion efficiency and less costly processing. Through this, REC continues to increase its efforts in cell and module development to make solar energy more energy-efficient and cost-effective. Increased efficiency means more energy is created from the same surface area, helping to lower the EPBT even further. REC cells have already reached 16.7% efficiency and are expected to reach 18% in 2012.

Increasing module energy yield
REC is constantly working to increase the energy yield of our modules to help the customer benefit from a return on their investment. In the Photon Field Performance Test REC modules produced 6% more energy than competing modules, continually ranking in a leading position during the last 18 months.

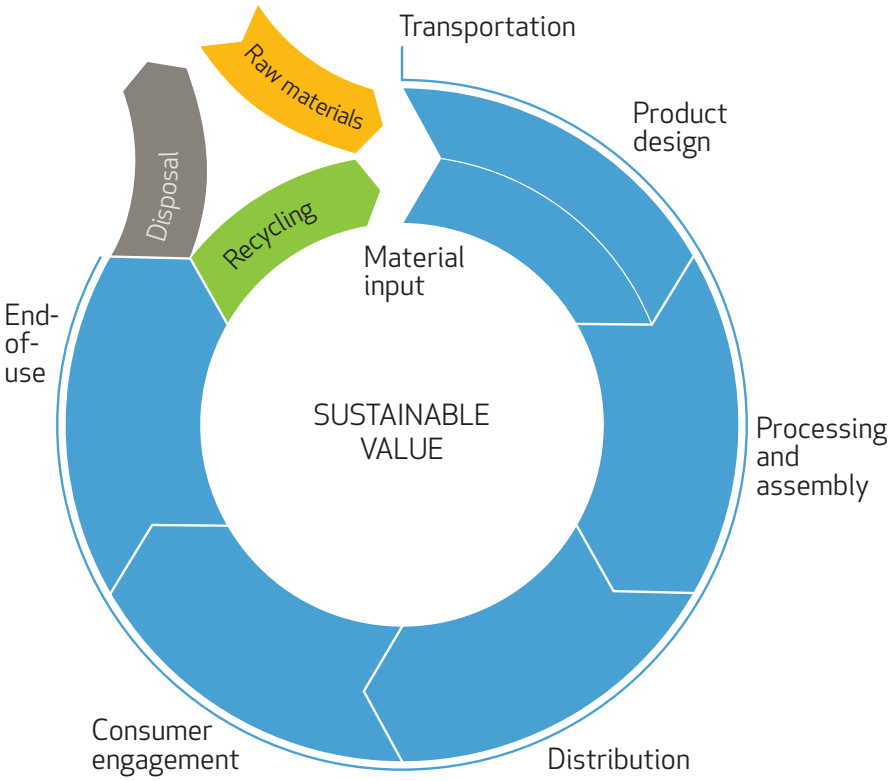
Reducing Waste by Recycling

Being environmentally friendly is not just about producing modules with as little environmental impact as possible. It also means ensuring that waste created in the manufacturing process is disposed of properly and that modules can be recycled at the end of their lives.

REC aims to efficiently recycle material used throughout the value chain, minimizing waste in every aspect of the manufacturing of our products. For example, the slurry used during the wafer production process is recycled and reused, which greatly reduces chemical consumption as well as waste.

REC is a founding and board member of PV Cycle, a voluntary take-back and recycling programme for end-of-life modules. REC works with customers to identify the recycling center closest to them. All materials in REC modules can be safely recycled.

OVERVIEW OF A LIFE CYCLE ANALYSIS



Conclusion

Delivering one of the first crystalline modules to reach an EPBT of one year, REC has shown how sustainable and increasingly competitive PV is. Thanks to our ownership of the complete solar value chain, the REC 2011 LCA is one of the most comprehensive evaluations of the energy used in the solar manufacturing process. Educating consumers to understand that the energy used to produce a solar module is as important as the energy a module produces will help to make the industry more sustainable overall. As energy prices increase, focusing on reducing the amount of energy used to produce a module will become even more important. Innovations like the proprietary REC FBR technology are helping to reduce the environmental impact of solar delivering smart energy for a cleaner future.

THIS IS REC

REC is the world's most integrated solar energy company, owning every part of the solar value chain. The company is one of the world's largest producers of silicon and wafers for solar applications, and one of the fastest growing producers of solar cells and panels. REC is also engaging in project development activities in selected segments of the market. Throughout REC there is a continuous focus on technological innovation, lean production and universal reduction of unit costs.

Production facilities

Moses Lake, WA and **Butte, MT** in the USA
— Polysilicon and silane gas production

Herøya and **Glomfjord** in Norway
— Wafer production

Narvik in Norway
— Cell production

Singapore
— The world's largest integrated manufacturing complex for wafer, cell and solar panel production

Facts

- Established in 1996
- Headquarters in Oslo, Norway
- Listed on the Oslo Stock Exchange (ticker: REC)
- 4000 employees worldwide
- More than 200 patents granted or pending

www.recgroup.com

CREUNA Photo: REC

REC

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