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White paper

Solarge Manifesto

The Age of Fully Circular Ultra Low Carbon Solar Modules has begun

The transition to a solar powered economy is necessary and urgent. Fortunately solar development has recently accelerated. However, present generation solar modules still have a number of drawbacks. A paradigm shift is needed to fully and unconditionally be able to reap the full solar potential.

Now Solarge has succeeded in realising this giant leap forward. It can now proudly proclaim the Age of Fully Circular Ultra Low Carbon Solar Modules has begun:

The unique properties of these future-proof solar modules

- Ultra Low Carbon Solar footprint: 80% better than conventional modules (in new factory)
- Fully recyclable and circular, due to the ease of disassembly at end of life
- Can be made of biobased polymers or recycled polymers. The module making process will have a negative carbon footprint*
- 50% lower weight when compared to other modules
- Contain no toxic materials such as PFAS

Due to these unique properties following results can be achieved

- Can be applied at nearly any roof: 100 km^2 extra rooftop available for solar in the Netherlands alone. This solar surface can generate as much power as from current gas production from the province of Groningen
- The residual end-of life value of the modules exceeds the cost of recycling. This allows working with deposits to stimulate recycling
- Avoids 12 Gton CO_2 release during the next 20 years (80% savings on a potential of 15 Gton CO_2 release from conventional modules)

By licensing this technology it can be scaled fast.

* Note this does apply for the module production, not for the processing steps that lead to the solar cell

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White paper

The game changer in solar power has arrived: Ultra Low Carbon Solar Modules

Four revolutionary steps forward

A main driver of the transition to renewable energy is reducing the amount of carbon emitted into the atmosphere. So what's more logical than that the transition itself uses the lowest-carbon means possible to achieve this goal?

However, present scenarios foresee a staggering 14-18 Gigatons of Carbon emissions over the next 20 years just from making solar panels. Obvious therefore is the need for a quick solar supply chain decarbonization.

A second urgent need is that solar modules should fit to any roof, no matter how little its bearing capacity. However 30-40% of all roofs are not adequate for carrying conventional solar modules based on (heavy) glass, Dutch research shows. Estimates confirm these numbers for many other countries. Obvious therefore is the urgent need for light weight solar modules.
It is also clear that future-proof solar modules should not contain toxic materials like PFAS (actually present in 70% of all solar modules).

Obvious moreover is the necessity to only produce circular solar modules, that can be 100% recycled over and over again.

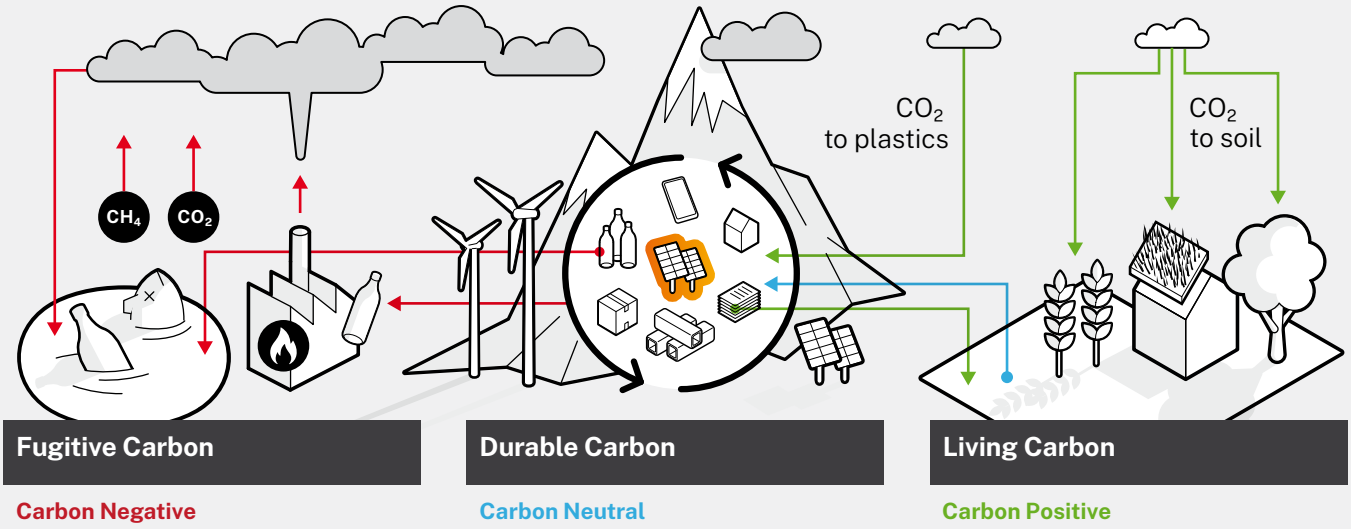
These four essential requirements are all met by Solarge. In close cooperation with SABIC*, it has developed solar modules that are low in carbon, lightweighted, non-toxic and circular by design.

Solutions for the solar energy market: new materials and circular design

As stated: future-proof solar module must be circular and recyclable against low cost. And that is possible already now: *Solarge modules* have overcome the complexities in recycling (faced by all present producers) by changing the design of the solar module.

* SABIC is one of the largest polymer manufacturers in the world. Developed in close collaboration with Solarge, essential raw materials and components for the Solarge modules. Sustainability and circularity are of paramount importance.

The New Language of Carbon



Classic design of solar modules is based on silicon cells with a glass cover and an aluminum frame. Solarge replaces the glass and aluminum by lightweight polymers that are fully recyclable in the SABIC TRUCIRCLE programme.

The reason behind this drastic design change is best understood by referring to the "New Language of Carbon" by William McDonough, published in 2016. See graphic above.

This new language of carbon teaches us that we should clearly distinguish between 'bad carbon' (fugitive), 'good carbon' (living organisms) and 'durable carbon'. Durable carbon is created from recycled polymers and/or by using biobased (non fossil) carbon. The energy that is propelling the cradle-to-cradle use of polymer products is generated by clean solar and/or wind energy.

Solarge will take this approach even one step further: the energy generator (shown in the picture) itself is made out of durable carbon, meaning it is circular and of the lowest carbon footprint. Instead of 'greenwashing' the production of solar modules, they are circular and low in carbon footprint by design. The Ultra Low Carbon Solar Alliance is creating awareness for this through organisations such as Renewable Energy Buyers Association.

As McDonough points out, many great products today are made from organic substances. In fact, human produced materials have evolved from the 'stone' age, through 'bronze' and 'iron' age into the 'polymer' age. Polymers are the logical next step, as those materials are cheap and their application potential is enormous due to smart molecule engineering. Modern cars already exist for more than 40% out of polymers.

The paradigm shift that stems from the "New Language for Carbon" is that the solar industry should produce circular polymer products that, at the end of life, should not be burned (incineration) or disposed of (e.g. Ocean Bound Plastics, landfill). The SABIC TRUCIRCLE pyrolysis plant 'enables' polymers to become circular.

Future-proof solar modules

The circular design of future-proof solar modules is based on advanced polymer technologies, developed

Solarge lightweight solar modules on agri roof

from know-how that evolved from innovations in polymers for automotive and food packaging industries. Research by TNO and SABIC has demonstrated that the lifetime results fulfill the standards of the solar industry.

Below the five big advantages of the new Solarge design solar modules are explained in more detail.

Carbon footprint

Already now *Solarge modules* have a 25% lower carbon footprint than conventional solar modules. That footprint will be even 80% lower, once the TRUCIRCLE plant is fully operational (2023-2024). These impressive improvements are the result of changes in design and in processing.

Conventional modules use glass frontsheets of 3 mm thickness, and aluminum frames. These materials are produced with energy intensive, high temperature processes. Gas fired production of solar glass is done at 1600° Celsius melting temperatures; 1000° Celsius is required for aluminum melters. These processes cause high carbon footprints. The resulting payback time for carbon is 4 years in North West European climate conditions.

The silicon used for the solar cell also requires a lot of energy due to the processing of quartz sand into silicon, and high temperature melting to shape the silicon into ingots, that are sawn into thin wafers. Furthermore, 70% of all solar modules use silicon that is being produced with energy from poor performing coal-powered electricity plants, with high carbon emissions.

Recycling and circularity

Solarge modules are fully recyclable. By a simple reheating step the different parts can be taken apart from each other without contaminations. The SABIC TRUCIRCLE concept is then used for polymer recycling. Also the fresh polymer materials can be based on SABIC TRUCIRCLE – eliminating fossil-based polymer use from the start. The recycling of the solar cells at end-of-life can be done by Rosi Solar, that uses technologies that allow separating the metals (aluminum, silver, copper, tin and silicon) within the solar cell recycling process, thereby eliminating circa ⅔ of total emissions at the silicon manufacturing step.

Conventional modules are generally hard to recycle. With the exception of the aluminum frame, all materials tend to mix with each other, because of the way they have been laminated ('glued') to each other. During disassembly they then contaminate each other. This self-contamination causes huge problems and costs in recycling. As a result, most of the other materials end up in incineration plants. Alternatively, at best, some is being used in downcycling (e.g. in asphalt, insulation glasswool).

Non-toxic materials

Solarge modules do not contain PFAS (Fluoropolymers) and can produce leadfree modules with a partner solar module manufacturer.

Conventional modules contain PFAS in 70% of all volume sold to the market. This PFAS is contained in their backsheets. Some companies offer lightweight solar modules, but all of them use PFAS in their frontsheets. PFAS will soon be banned by European legislation. In addition to that, solar modules soldering materials contain small portions of lead in most cases.

Weight

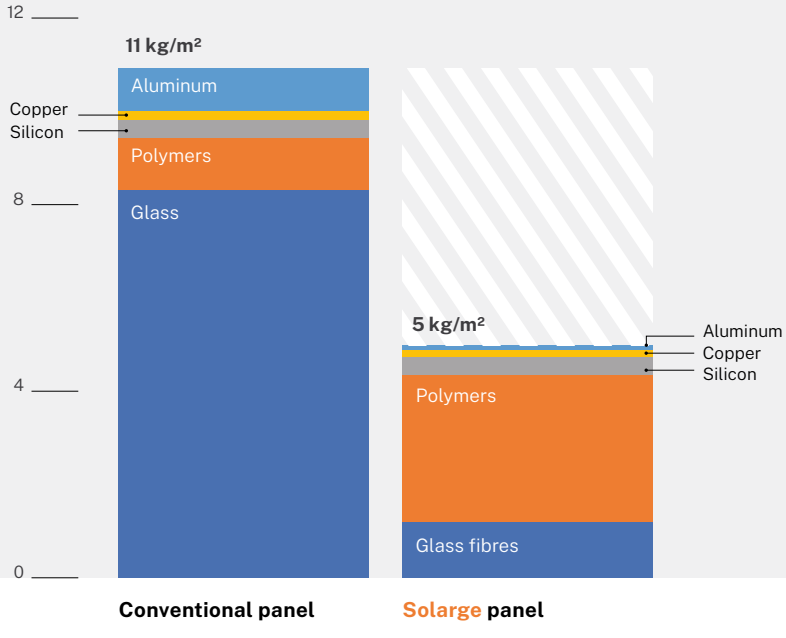
Conventional modules typically weigh 11 kgs/m^2. This is because aluminum and glass are relatively heavy materials, 2700 and 2500 kgs/m^3 when compared to polymers with 1000 kgs/m^3.

Solarge modules are lightweight: just 5 kgs/m^2 thanks to the replacement of the frontglass and the aluminum frame from the module by polymers. The glass weight (present in a limited amount of glass fibers) is strongly reduced (from 8.3 kgs/m^2 to 1.2 kgs/m^2). As aluminium and glass are high in carbon emissions, Solarge drastically reduces the carbon footprint of solar modules. In the Netherlands alone, that makes an extra 100 km^2 available for rooftop solar. This is a huge gain: it equals (and could replace!) the annual energy generation potential of the 2021 electricity production from gas from the province of Groningen.

Supply chain

Solarge modules are produced in EU and thus contribute to a more reliable supply chain, creation of jobs, low transportation costs and lower emissions. This fits with the plans and support of EU to support a more diverse and resilient solar supply chain. Solarge aims for a high expansion of the use of it's polymer technology by a licensing model, made available through some 'add-on' equipment to existing or new production lines for solar modules. The solution is agnostic to cell technology and can be licensed to almost all existing solar module manufacturers, provided some additional equipment investments are made to the plant.

Weight difference between Solarge and conventional solar modules



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Conventional modules are usually made in Asia, dominated by China. The covid-19 pandemia has shown that vulnerability of the supply chain can be an important issue, besides emissions due to long-distance transportation of relatively heavy goods.

Even under the high worldwide growth rates for solar, there are no expected shortages in raw materials used for solar modules: silicon, silver, copper, tin, aluminum, various polymers.

However, it must be emphasized that the worldwide market for silicon is dominated by just a few companies. Cost of electricity is a leading element in choice of the region for silicon production. The production of silicon usually goes along with a high carbon footprint, since mostly coal is being used as the energy source needed for production.

Paradigm shift for solar energy

Solarge future-proof module design, and its use of recycling loops with biobased materials for polymer products, will cause a paradigm shift:

Growing plants generally use less than 1% of the solar irradation, whereas the solar modules created from them generate about 23% (current commodity cell technologies) on annual basis from the same radiation, on existing building roofs.

This makes the process circular, enabling the solar module to produce 50x more energy than is required for producing it. Moreover, this can be repeated eternally. The CO_2 that was generated by producing it, will be earned back in just 4 months even in NW-European climate conditions.

Solarge modules have received IEC certification from KIWA.

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