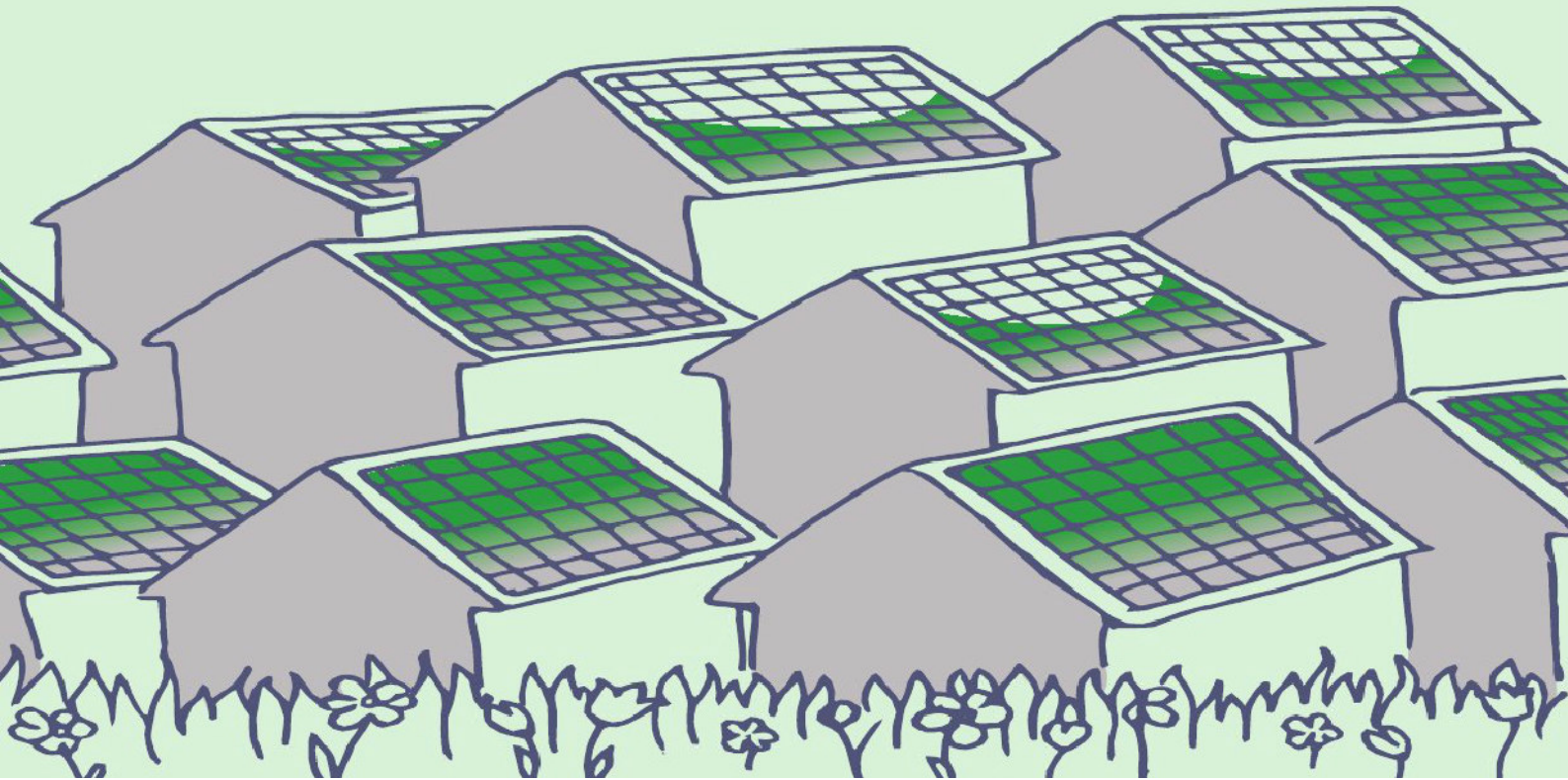
Solar Production to become Greener

A key selling point for PV and solar applications is the 'Green' benefits for societies and industrial infrastructures. With some of the materials that have been used in PV and solar production, the industry was in danger of creating problems as they fixed others. Luckily there has been a positive move towards a cleaner and greener approach to manufacturing. The **Solarpeq** team look at the growing issues.

Triple Green is the new motto in photovoltaics: for modules that generate clean energy, that are recycled and – what's more – ecologically produced. This is how the solar power industry can build its image and sustainably cut costs. However, this perfect triad is difficult to implement because "green factories" require high initial investment.

This time the innovation does not originate from China or the USA but from Osterweddingen in Saxony-Anhalt: the Malibu company that manufactures modules from thin-film silicon in this little town near Magdeburg, now cleans its process chambers with fluorine rather than the hazardous greenhouse gas nitrogen trifluoride (NF3). This does not sound too spectacular but affords major ecological benefits: "It allows us to avoid any emission risks," says Malibu Production Manager Antje Bönisch. If inadvertently released into the atmosphere NF3 is 17,200 times more dangerous for global warming than carbon dioxide. By comparison fluorine, she says, has no greenhouse gas potential. This turn towards ecological processes only becomes really attractive for the company through falling operating costs. "We are saving a six-digit sum every year," says Bönisch and adds that it is giving Malibu a competitive



edge on the extremely competitive thin-film market.

The key to more efficient manufacturing is a so-called fluorine-on-site-generator made by the Linde company and connected to the supply lines of the plant. Malibu's modules are made by vapour-depositing silicon onto glass in vacuum chambers. Since plenty of material ends up on the chamber walls in this process, these need to be purified after each coating cycle. The generator introduces the fluorine which then reacts with the silicon to form gaseous silicon tetrafluoride, which is pumped off, captured and reacted off.

The new method reduces climate risks and is fast: usually cleaning accounts for more than 10 % of the total process time in a vacuum chamber but fluorine reduces this time by half thanks to its high avidity, explains Linde-Manager Andreas Weisheit. This improves the line throughput and cuts costs.

Plenty of Chemistry and Energy

This makes Malibu one of the pioneers in the industry seeking not only rapid but also clean growth. Triple Green ideally means: factories built using organic materials and supplied with energy from regenerative sources producing silicon, wafers, cells and modules while emitting scarcely any carbon dioxide or waste materials anymore and consuming minimum energy, gas, acid and water.

The ambitious green motivation of the solar industry goes back to one reason in particular: its clean image is at stake because its rapid growth goes hand in hand with increased resource consumption and emissions. Over the past two years global module output has doubled to eight gigawatt (GW). And this growth is predicted to continue at the same rate according to forecasts. As Eric Maiser of VDMA, the German Engineering Federation, explains silicon generation requires high levels of chemical and energy resources: producers melt down sand to metallurgical silicon and then use hydrochloric acid to reduce it to liquid trichlorosilane. This then is thermally decomposed and in the process grows into solar-grade silicon in the form of ingots. The processes run at high temperatures and are "power guzzlers". In most cases this power comes from nuclear and fossil-fuel fired power plants because conventional power is simply cheaper for producers and more easily available than that from regenerative sources.

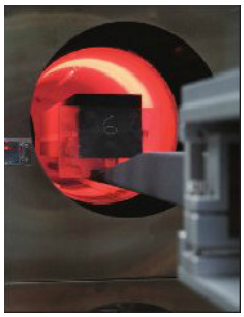
Ökowerk: The power required for module production is obtained by the Freiburg-based company Solar-Fabrik from cells on the façade and roof of its own factory. (Photo: Solar-Fabrik)

The following wafer and cell manufacturing processes are just as resource consuming: when cutting the wafers out of the ingots nearly half the silicon is lost and must be melted back down for it to be re-used. For cleaning wafers producers often use hydrochloric acid and for etching their surfaces poisonous fluoric and nitric acid as well as potash lye are deployed. The busbars applied as a rule consist of silver and aluminium. To electrically orient the crystals, companies use phosphoric acid. At the end of the day all of these chemicals end up in the waste water of the solar factories. Although this is treated, pollutants such as heavy metals and nitrates find their way into the sewage system.

Thin-film production also requires high amounts of energy and chemicals. CIS or CdTe modules are made at high temperatures and in long processes from copper, indium, toxic selenium, cadmium and sulphuric acid or cadmium telluride. For thin-film silicon manufacturers cleaned their chambers with NF3 until now. And however carefully they do this – they cannot prevent 100% of the greenhouse gas emissions. "17 % are released into the atmosphere during the product life cycle," says Linde Manager Weisheit who goes on to say that this is also the reason for the rising demand for Linde's fluorine generators in the photovoltaics industry.

Suppliers with Clean Solutions

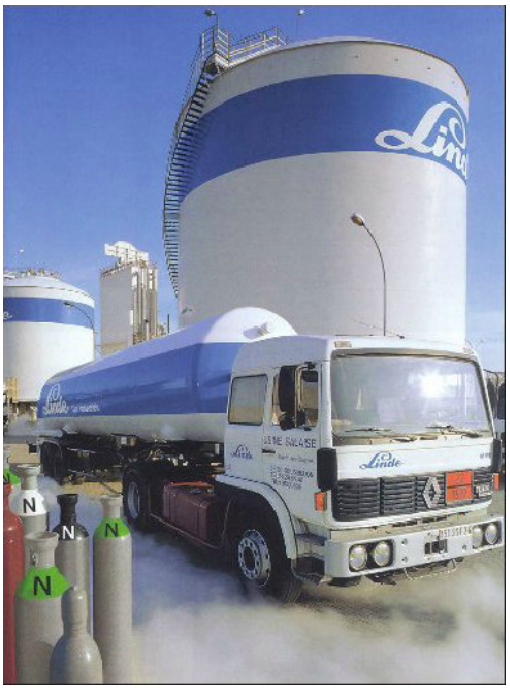
However, solar system producers can do a lot more than just change their gas suppliers. Upstream suppliers offer them a number of possibilities to make their production greener. State-of-the-art production equipment increases



Energy-intensive: For electrical wafer orientation producers introduce phosphorus into the silicon at high temperatures in diffusion furnaces. (Photo: Q-Cells)

the yield while reducing consumption levels. Suppliers of thin-film production equipment such as Applied Materials or Von Ardenne offer machines that apply the absorber material faster to larger surfaces. Machinery manufacturers specialised in crystalline systems such as Schmid supply plants that can process thinner silicon wafers. And there are also more and more recycling specialists that offer their services to PV. For instance, the Italian company Saita has recently begun offering cell producers a system that recycles 96 % of the process water for reuse in a closed loop system. This reduces the fresh water requirements for cell production by 75%, explains Marketing Manager Carlo Enrico Martini who goes on to say that thanks to this recycling no waste water ends up in the sewage system.

Berlin factory planner ib vogt goes even one step further: he has developed a so-called “Greenfab” that is built and operated ecologically. It can produce up to one GW of solar energy. The energy required, explains Project Manager Lino Garcia, is generated by solar or geothermal systems on site. Waste heat is used for heating and cooling. Less dirty water ends up in the sewage system since a large proportion is recovered. Integrated logistics and transport concepts shorten distances and also boost energy efficiency. This means solar system manufacturers can kill several birds with one stone with “Greenfab”: large amounts of PV technology are produced efficiently and cleanly. Some of their green innovations and approaches will be presented by the suppliers from 28 September to 1 October 2010 at the Trade Fair for Solar Production Equipment, solarpeq, in Düsseldorf. Held in parallel, glasstec, the leading international trade fair for the glass industry, offers the relevant solutions for solar glass.



Gas for PV: The solar system producers are now among the key customers of gas specialist Linde. (Photo: Linde)

“Silicon bakery”: Employees at the silicon and wafer manufacturer PV Crystalox charge crystal-growing furnaces with raw silicon. Here the material is molten, freed from impurities and then solidifies at a controlled rate. (Photo: PV Crystalox)

However, as big as the benefits of green fabrication are – the eco-breakthrough is a gradual rather than a sudden one. Though developed three years ago, ib vogt has not sold a single complete “Greenfab” yet according to Garcia but always just single, ecologically very critical manufacturing components such as concepts for waste-water recycling. “In contrast to the chip industry PV has not embarked upon the green manufacturing voyage yet,” says Carlos Lee of SEMI, the global semi-conductor association.

Green in Small Doses

So what is inhibiting the breakthrough of Triple Green in the solar sector? A decisive aspect is the high investment required for sustainable production. A Greenfab with one GW capacity is “definitely somewhat more expensive” than a regular 1 GW factory, explains Garcia. This

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investment does pay off through energy and raw material savings, he says, but the exact amortisation period differs from case to case. What is key though: those investing many millions of Euros must know the time for their return on investment. After ten years it would probably be too late since the factory design and fittings would be obsolete considering the high speed of innovations in PV. As a result, the green factory would be fit for demolition before it yields a profit.

Moreover, recession has put a brake on investment. Many producers have faced declining sales and profits. “At a time like this major spending is taboo,” says Kevin Reddig of the Fraunhofer Institute for Manufacturing Engineering and Automation in Stuttgart. The introduction of green manufacturing technologies and processes currently suffers the same fate as the implementation of novel cell concepts: the commercialisation of complex solutions associated with high financial spending such as the back contact cells are being postponed. Instead, manufacturers focus on the less expensive optimisation of standard cells contenting themselves with moderate efficiency gains.

Not made for manual handling: Brazing individual solar cells to form strings is a hot topic: many brazing metals contain poisonous lead. (Photo: Aleo Solar)

Since “green” is expensive, its profitability is vague and the sector is forced to save we will see a rather gentle transition to Triple Green. “Green will come carefully dosed,“ says Maiser of VDMA. Lee at SEMI refers to the developments in the semi-conductor industry, which took years to sizeably reduce its consumption. By their own accounts, it took STMicroelectronics, Europe’s largest semi-conductor producer, from 1994 to 2009 to reduce its CO2-emissions by 65 percent, its energy consumption by 54 percent , its water consumption by 70 percent and its waste by 71 percent.

Today, the solar sector stands where the chip industry used to be 15 years ago. The solar group Solarworld does not build a Greenfab but first creates transparency in its Sustainability Report for all its relevant environmental data and that of its upstream suppliers thereby paving the way for green investment. Module maker Solon pursues the same avenue: it has spent EUR 200,000 on a new environmental management system to gain an overview of where sustainable solutions make business sense at all. These companies are guaranteed to reach the next green milestone – but presumably only after the crisis.