Unstoppable power

This year, pv magazine is setting a new editorial agenda. Via our program, UP, we will be diving deep into the topic of what it means to be truly sustainable, looking at what is already being done, and discussing areas for improvement. Over the coming weeks, months, and years, we will share our findings across our various digital platforms, in our print magazines, and via our roundtable events and webinars. Are you UP for it?

At this point it is undeniable. Solar PV and energy storage together are an unstoppable force. Given their myriad unique characteristics – decentralized, positive operational effects, and rapid discharge, to name but a few of the strongest – they were always predestined to take the lead in moving our energy infrastructure away from fossil fuels to renewables, and to set a new ecological example. And despite the eye-watering subsidies still being paid to fossil fuels, and the stunning heel digging some are still performing in a bid to cling onto them, the price drops and growth rates of the former are persistent.

According to the latest figures shared by Fraunhofer ISE, at the end of 2018, cumulative PV capacity reached 515 GW, while it accounted for 1.7% of the worldwide electricity share. The compound annual growth rate of PV installations was 24% between 2010 and 2017, and this growth rate looks at the very least set to continue. More likely, however, it will ramp up. This means that by 2030, it is not beyond the realms of possibility that over one terawatt of solar will be deployed annually.

Great responsibility
While the origin of the saying is disputed – Voltaire, Churchill, Spiderman? – the meaning is very clear: With great power comes great responsibility.

One of the most pressing issues for the industry in the coming years is that of end of life. According to the most recent figures from both the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA), which released a report in 2016 titled End of Life Management, Solar Photovoltaic Panels, between 60 million and 78 million metric tons of PV waste are expected to be produced by the 2050s (see chart to the bottom right), with China, the United States, Japan, India, and Germany, leading the way.

As you’ll see in the article on pp. 26-28, few countries have adopted PV-specific waste regulations. This is problematic, say experts like Dustin Mulvany, associate professor, Department of Environmental Studies, San José State University, and Michael Braungart, one of the founders of Germany’s Green Party, cofounder of Greenpeace’s chemistry division, and visionary behind the cradle to cradle concept (see box below left) – particularly if you consider the fact hazardous chemicals, like lead, are still being used in PV modules.

Their volumes may be small on an individual module level, but when you consider the capacity at which modules will be produced in the near future, the issue becomes more pertinent, and is one of the key discussion points we will be focusing on in future editions of pv magazine. Circausol (Circular Business Models for the Solar Power Industry) – a four year project funded by the Horizon 2020 program of the European Commission – further points out that the current PV modules on the market “cannot be ‘re-opened’ and the only way for recycling is through destructive processes such as shredding.”

Meanwhile, Michael Braungart says, “The materials which are used in PV were never intended to be recycled. It’s never recycling – it’s only downcycling” (see interview pp. 24-25).

Sustainability issues around the mining of conflict materials such as cobalt for batteries, and the handling of chemicals like hydrofluoric acid in production processes,
are also concerns which need to be closely examined.

It would be devastating if the energy transition was delayed on the back of doubts about its social and economic responsibility.

**Pause for reflection**

On April 2, 2019, France-based eco-fashion company Veja sent out an update to its social media followers: “A few years ago, we realized Veja was heading on the wrong path. We had a sneaker that was different, more ecological, more socially balanced than the other brands, but what about the rest? What about our team? What about our office in Paris? What about the other suppliers? We realized in 2007 that you could do the best ecological project, and still be the worst kind of company … When we changed in 2009, nobody was understanding why. Today, the answer appears clearly: We, as a company, are responsible [for] all the steps we make.”

Veja may not have anything directly to do with the solar or storage industries, however the point it makes couldn’t be more relevant. Indeed, while it is cause for celebration that solar and storage are the superheroes in our story, as we sit at the tipping point of the green energy transition, there is time for reflection.

Is everything being done to create a truly renewable industry? Are products and manufacturing practices clean enough? Are human rights and equality issues being appropriately addressed?

Employing renewable energy has the potential to not only address the issues created by fossil fuels – including the two most critical: geopolitics and pollution – but they could also help focus on others like energy poverty, a lack of education, and gender and racial inequality.

**Setting a new course**

We believe the industry should be doing more than just generating renewable electricity. It should also be helping to build a renewable society.

In light of this, **pv magazine** is setting a new editorial agenda. Via our program, UP, we will be diving deep into the topic of sustainability in the solar and storage industries.

This will focus on approaches like the circular economy, cradle to cradle, and others (see pp. 26-28), across our various digital platforms, in our print magazines, and via our roundtable events and webinars.

Together with you – the actors driving the solar and storage industries – we want to define what it means to be truly sustainable; to look at what is already being done in this area; to discuss areas for improvement; and to set sustainability goals, time lines, and evaluation criteria. To open the discussion and take the industry forward in a renewable way.

On the following pages, you can discover Braungart’s vision for the future of solar, find out what is already happening in the area of sustainability on a global level, and read about Volkswagen’s efforts to up its green game.

Join UP! Step UP! Help us shape the sustainability agenda!  

**Be a thought leader, join UP!**

As part of the new UP initiative, **pv magazine** is rolling out a new series of events to support the next level of our quality campaign. Step UP: Share your ideas and projects via our various digital and print platforms. Partner UP with us. Contact up@pv-magazine.com to discover the many opportunities to promote your Unique Passion!
Reinventing solar

As one of the founders of Germany’s Green Party, as well as the cofounder of Greenpeace’s chemistry division, and the visionary behind the cradle to cradle (C2C) concept, Michael Braungart is a true pioneer. In a conversation with pv magazine, he lays out his vision for the future of solar – an industry he says is one of the keys to our future. It includes innovative module designs and new business models.

You mention the vital role solar needs to play in our energy transition in your book, The Upcycle, coauthored with U.S. architect William McDonough. However, you don’t mention its design. What are your thoughts on the industry?

No other industry has so much potential for the future of the planet. But the business needs to be organized differently. Under existing conditions, chemical compositions of solar panels are a nightmare for the environment and for human health.

We solve the energy problem by causing a much bigger material problem. There is a whole series of rare problematic materials, like UV stabilizing antioxidants, plasticizers, as well as rare and toxic metals like lead, chromium, selenium, mercury, indium, gallium, germanium, and nickel.

What needs to be done?

I am talking about reinventing the whole photovoltaics business by a different design. That means no longer selling the materials or equipment, but selling the service of using it. Nobody needs a solar panel. All you need is photons. Once you buy a solar panel, you basically become an owner of toxic waste. Also, when you sell solar panels, you have to take the cheapest materials, not the best ones. They should be a service. If you are just selling 25 years of harvesting photons, then you can use the best materials. You could make solar panels that could be disassembled much more easily, which is not the case at all right now, and reuse your very good materials.

How should a manufacturer finance this?

Basically, the PV system, the solar panels and equipment, could become material banks, when you are no longer selling decommissioned systems to high tech waste management as hazardous waste. We think that manufacturers in Europe could be competitive, if they considered the service approach and did not try to compete on selling the cheapest module. Then you can transfer the costs of the materials into another financing system. Talk to the insurance companies – they would love to insure the materials. You know exactly where they are and exactly when you can harvest them. This is totally different to the business model where you sell the solar panels and you never know what happens to the materials.

And when you see that there are panels on the market that contain really environmentally toxic materials like cadmium telluride (CdTe), the manufacturers definitely need to change to a services-like business model.

Silicon panels comprise a much larger portion of the PV industry. What chemicals could be changed there?

The question is more, how to design PV in a different way from the beginning. The materials used in PV were never intended to be recycled. What will happen to these panels when they are decommissioned? It will never be recycling, only downcycling. For example, you use vinyl acetate to separate different layers in the solar module. The industry could come up with a technology that would allow it to separate these layers more easily and the vinyl acetate could be reused, for example, in new flooring systems. Also, there are far too many different materials being used. Solar panels consist of more than 280 different chemical components and there’s no need for this. You could do the same solar panel and equipment with less than 10 if you chose the best materials.

Which materials are in there which are not needed?

We would not need, if you handled it properly, aluminum or steel frames. We could use a polymer, a plastic, like the polycell foams for example, polysulfonic compounds, which can be used 500 times for the same purpose and which keep their size and strength at different temperatures. But this polymer needs to be a service. We are at the end of the possible optimization of the existing system, so we need to rethink it from a different perspective and from a different business model.

“...there are far too many different materials being used..."
Can you expand on this?
To give you an example, I have been working with Ford Motor Company to take a vehicle apart. We wanted to know why it takes twice as much time to assemble a Ford Mustang compared to a Toyota Corolla. It turned out that Ford used 516 different bolts just to make this car. The logistics are amazing. Toyota used less than 20 bolts. Each bolt was much more expensive, but the overall system is so much cheaper.

How does this translate to solar?
Solar panels use the cheapest materials instead of defining a different business model. When your solar panels become a material bank you could sell ownership to third parties. To give you an idea for a windmill. A 7.5 MW windmill needs at least 12 [metric] tons of copper. When you don’t sell the copper and you give it to a third-party investor, a bank that can then sell one [metric] ton of copper to each of us, then you could store the copper in the windmill for 20 years. It would make the windmill €60,000 cheaper, because they don’t need to buy the copper anymore and they can pay an interest rate on the copper in the windmill.

Many manufacturers can’t think beyond cost. How do you broach a subject like this, where you say you need to redesign everything?
The technology is key for fighting against climate change. We better invest in this rather than in dealing with more energy efficiency of old module technology. Because with future innovation comes potential. If you can use the best materials, the module becomes a material bank. Because you know that for 25 years, the material is stored in a certain place, you could use the PV system as a storage place. But it needs different technologies. The industry has been optimizing the wrong things. It makes the wrong things perfect and now they’re perfectly wrong. Every solar panel needs to be seen as a technical nutrient not as a liability problem.

Interview by Becky Beetz
The sustainable pioneers

In the coming weeks, months, and years, pv magazine will be digging deeper and expanding our sustainability horizons, defining – with your help – the most effective courses of action. What follows is an overview of current sustainability initiatives in the solar and, to a lesser extent, storage industries.

Change is not always easy. Many believe there is a contradiction between being cost-effective and being sustainable. Some fear that by looking at negative sides of the industry, we will add more fuel to the anti-solar fire. Others, however, are presenting business models and case studies showing the economic benefits to be reaped and positive PR to be had.

Setting the stage

In 2010, non-profit PV Cycle was founded to establish collection and recycling of used PV modules. By the end of 2018, PV Cycle said it had collected over 27,000 metric tons, or around 340 MW of modules. "Related to general expectations of the recycling industry, these are low amounts but provide a base of knowledge and experience to build proper recycling technologies in the future," it says.

Two years after the formation of PV Cycle, the EU rolled out its WEEE (waste electrical and electronic equipment) Directive for solar, obliging producers to take back for free and recycle, PV modules. This was – and to date still is – the first time a law had been passed dealing with the topic of PV waste. EU countries had until 2014 to transfer the directive into their respective national laws.

While not a specific solar or storage law, REACH, or the Registration, Evaluation, Authorisation, and Restriction of Chemicals, is an EU regulation that came into effect in 2006. It aims to address potential impact of chemicals on humans and the environment. All companies manufacturing or importing one metric ton or more of chemical substances into the EU annually must register with the European Chemicals Agency (ECHA). Criticism has been aimed at the fact it uses animal testing, and that progress is slow, however.

Eco-labeling

This year, the European Union is looking at applying the EU Ecolabel – a design standard promoting the principles of the circular economy – to PV systems. Karl-Anders Weiß, Head of Service Life Analysis at Fraunhofer Institute for Solar Energy Systems, has been involved in the process from the beginning. He and his colleagues have pushed for the label, believing that if people become aware that PV is the only electronics industry still using materials like lead and fluoropolymers, this could be “severe for the image of the industry.” The Ecolabel will be addressed in-depth in upcoming editions of pv magazine.

Dustin Mulvaney, associate professor, Department of Environmental Studies, San José State University explains that in the United States, the Federal Government doesn’t have comprehensive e-waste laws, so states are responsible for creating their own regulations. He says California is looking to introduce the concept of extended producer responsibility. While he believes there will be some pushback from industry, which will complain that regulation will financially ruin it, these are issues that have an effect. “We want to put natural gas out of business, we don’t want to put solar out of business,” says Mulvaney. “That said, they might put themselves out of business. Some of [these] things I talk about in my book [Solar Power, Innovation, Sustainability, Environmental Justice, released this April] – e.g. the Washington Post expose in 2008 on polysilicon dumping. Liquidity from the industry vaporized as stock prices fell… The same thing happened with a hydrofluoric acid spill a few years later: one company lost $100 million in value overnight… So if end-of-life photovoltaics in landfills start to make headlines… it could affect a company’s bottom line.”

Going circular

While some legislative progress is being made on the topic of sustainability, there are programs and initiatives in place that go further. All the initiatives mentioned here exist, in some form or another, under the term ‘circular economy’.

“We want to put natural gas out of business. We don’t want to put solar out of business”
In March, the European Commission wrote, “The circular economy is now an irreversible global trend.” Yet, much is still needed to scale up action at EU level and globally, to fully close the loop and secure the competitive advantage it brings to EU businesses. Increased effort will be needed to implement the revised waste legislation and develop markets for secondary raw materials. Also, the work started at EU level on some issues (like chemicals, non-toxic environment, eco-labeling and eco-innovation, critical raw materials, and fertilizers) needs to be accelerated if Europe wants to reap the full benefit of transition to a circular economy.

In a nutshell, the concept of a circular economy is an alternative to a linear economy built on the principles of make, use, dispose, and argues for keeping resources in use for as long as possible, extracting the maximum value from them whilst in use, and then recovering and regenerating them at the end of each service life. The concept of waste does not exist.

Many modern proponents of the circular economy, like the Ellen MacArthur Foundation, base their visions of the circular economy on the principles of cradle to cradle (C2C).

Cradle to cradle
A host of companies, governments, and organizations have already embraced C2C certification (see pp. 24-25). To date, just two are from the solar industry: Sunpower Inc., which obtained Silver certification in 2014, and JinkoSolar Power Holding Co. Ltd, which claims to be the first Chinese company ever to receive the certification (also Silver), in November 2017 for its Eagle module series.

Products are certified based on analysis in five categories: material health, material reutilization, renewable energy and carbon management, water stewardship, and social fairness. “A product receives an achievement level in each category — Basic, Bronze, Silver, Gold, or Platinum — with the lowest level representing the product’s overall mark,” explains the C2C Products Innovation Institute.

Responding to why the company applied for certification, Radu Roman, Product & Business Development Manager – Europe at JinkoSolar, says it was a reaction to customer feedback. “What we saw in the last couple of years is that there is more interest in what companies are doing in terms of being environmentally friendly. So we decided to formalize our efforts,” he says, adding, “everybody is talking about solar modules along with other renewable technologies offsetting CO₂ emissions. But that’s the product … We wanted to show that it is possible to do something with carbon emissions when it came to manufacturing. So the carbon offsetting is reflected in the value chain.”

Roman believes that C2C is currently the most comprehensive certification out there, as it looks at more than just carbon footprint. And to prove its commitment, Jinko is in the process of rolling out C2C certification to another two products.

Going further?
Mulvaney believes C2C is “a great step in the right direction.” However, he says the standard he has been working on together with various groups including NGOs, environmental organizations, manufacturers, and landfill operators, goes further.

Mulvaney explains that the American National Standard, NSF/ANSI 457 Sustainability Leadership Standard for Photovoltaic Modules was a stakeholder-led process, where criteria were decided upon collectively. “You can find out a lot more about a company’s manufacturing, where a company falls short, and where they are successful, there’s just a lot more detail.” To date, he continues, no company has met the standard, but some are working on it, and he expects that several will.

According to the official document, “The purpose of this standard for photovoltaic modules is to establish sustainability performance criteria and corporate
performance metrics that exemplify sustainability leadership in the market. These performance criteria are intended to form the basis of conformity assessment programs, such as third-party certification or registration.” It has most recently been expanded to include inverter manufacturers, and storage is now in discussion.

**Broadening horizons**

PV Cycle is expanding its horizons, and has, since last June, been investing 1% of its income into R&D for Circusol (Circular Business Models for the Solar Power Industry) – a four year project funded by the EU’s Horizon 2020 program. According to the website, “It brings together 15 partners from seven European countries to develop and demonstrate business solutions for circular economy in the solar power sector.” Keywords here are ‘second life’ and ‘PSS’ or a product-service system which, similar to Braungart’s ideas (see interview on pp. 22-23), propose business models based on pay-per-use, for example. PV manufacturer Solitek will reportedly work together with recycler Loser Chemie, PV Cycle, and research institute imec “to identify how product design can lead to life cycle cost reduction, and how business models can help to align incentives and create business wins for circular product designs.”

Sheila Davis, Executive Director at the Silicon Valley Toxics Coalition (STVC), tells pv magazine she is currently working on updating the coalition’s annual solar scorecard. Coming up for 10 years in 2020, she believes it is now time to update the criteria to encompass the circular economy. Not only that, but together with the Collaboratory for a Regenerative Economy (CoRE) – a partnership led by Niagara Shares in collaboration with the University of Buffalo’s Department of Materials Design and Innovation and Clean Production Action – she is looking to apply the circular principles to the whole of the solar economy in Buffalo, New York, where Tesla and Panasonic have their U.S. manufacturing base.

This June, they will hold a summit looking at the entire life cycle of solar. The goal is to try and map out the environmental and social impacts, looking at three areas: First, when you make a life cycle design or chemical change, how does it change the whole system? Where can we have the most impact in terms of advocating for those changes? Where is the most leverage? What are the priorities? Second, look at the life cycle of the supply chain. What are the types of social and natural capital investments that should be made? And third, what type of technology is needed to accelerate sustainability?

**General awareness**

Circular economy is also a topic being addressed by glass coatings and backsheet supplier DSM. “What we noticed is that there are company stakeholders that are really concerned – it’s an important topic,” explains Imco Goudswaard, Sustainability Manager for DSM Advanced Solar. To this end, DSM has been investing over the past years in finding ways to produce products that fit these principles. Particularly when it comes to the backsheet, however, this is no easy task.

While backsheets currently cannot be recycled as a finished product in the PV module, the edge-trim waste produced in creating the backsheets can be reused by packaging suppliers to make boxes, or other companies making chairs, for instance, he says. Responding to the fact that there are already C2C certified polymers available, he says, “As a customer of polymers, I think we should look carefully and see if this is applicable for the solar industry.”

Goudswaard adds that while people are concerned about these issues, general awareness of the topic is limited, and few companies really put research and resources into it. “If you ask them if they are going to spend some money, few are willing.” Watch out for the full interviews with the above mentioned industry players on www.pv-magazine.com in the coming days and weeks. - Becky Beetz
Sustainability and an ‘electrification offensive’

Volkswagen’s spokesperson for environment and sustainability Günther Scherelis, and life cycle assessment specialist, Marko Gernuks talk to pv magazine about the car manufacturer’s electric vehicle plans and new sustainability agenda. In the past, the company tried to achieve such sustainability by advocating diesel. This ended, as we all know, in Germany’s emissions scandal, dieselgate, in 2015. Now VW needs a new direction.

Earlier this year, VW announced a supply chain performance rating, to take environmental impacts and social responsibility into account. What is this about?

Marko Gernuks: We are going to be CO₂ neutral in 2050. We have set a milestone in 2025 where we want a carbon dioxide reduction of 30% of our fleet. The question is: How can we get this in the most cost efficient way?

One step is our new electric vehicle, ID, which is going to be delivered CO₂ neutral. We are going to be CO₂ neutral at our manufacturing plant in Zwickau, Germany. We also got a commitment from our battery supplier that they will use green electricity for their production. This is a hot spot in the life cycle assessment, so it is a great step forward.

How will you ensure they are really using green electricity?

Günther Scherelis: An audit system will be introduced, to be online by the start of July. We have agencies visiting mines and companies – VW has 40,000 suppliers worldwide. Another issue is human rights: No slave or child labor, for instance, is tolerated.

Are you looking at materials such as cobalt in terms of sustainability?

Cobalt is a conflict material and we are fully aware of this. We try to achieve transparency, although in an environment where there is no security, it is hard to trust any certification. So, nobody has 100% transparency. But we are working on this. We are also working on reducing the amount of cobalt we use.

How are you doing this?

MG: At the moment the batteries are one part nickel, one part cobalt, and one part manganese, so 1:1:1. In the next generation, we will have 6:2:2, so 60% nickel, 20% cobalt, 20% manganese. Then we will have 8:1:1, so 80% nickel and just 10% cobalt and 10% manganese. We are also thinking about reducing cobalt to 5% or even lower. 6:2:2 we will finalize in the next year, and the 8:1:1 will come some years later.

“Nobody has 100% transparency. But we are working on this”
You recently joined up with Swedish battery manufacturer Northvolt to create the European battery union. What do you hope to achieve with this?

The new consortium is to be led by the Volkswagen Group and Northvolt. Joint research will cover the entire battery value stream – from raw materials through cell technology to recycling.

What plans do you have in place for battery recycling?

GS: At the moment, we are setting up test recycling at our Salzgitter plant in Germany. We have to see how the batteries are performing in real life. It's not that after one car life they go to a recycling plant – we will test them for a second life. We expect larger quantities at the end of the 2020s.

MG: We started to research the recycling issue in 2009 and there are two different routes of recycling. One, you melt the batteries and you get the valuable materials. The other, which we are favoring, is where you shred the module, put it through a drying process, to end up with a pile of black powder. In there, you find the lithium, cobalt, and nickel. You then treat it hydrometallurgically, where you recover the raw material from sustainable chemical processes. Then the raw materials can be used in new battery cells. It's working quite well. It's just a question of capacity.

What percentage of materials can you retrieve from the recycling process?

Recyclers state they can recover 90% of the cobalt and nickel from a battery. In pyrometallurgical processes, the lithium, as far as I know, is going to slag and it is quite difficult to get it out of there – maybe around 50%. The way we are doing it, we get the lithium in a solution. Like this, it is easier to get it back. Our idea is to get more than 70%.

Ninety percent sounds like a great number when you look at it, but you end up in 100 years at just 30%. Is it really sustainable from this perspective?

GS: I doubt we will have batteries the same size in 20 years. We are working on solid state batteries and they are completely different – they have higher energy densities. Considering all these conflict minerals, all manufacturers are working on alternatives. These calculations won’t work in reality.

Are you looking at other energy storage technologies?

We are also working on hydrogen power to x, and hydrogen for fuel cells. The question is, if you have one kilowatt hour of green electricity, do you put it in a battery electric vehicle, or do you go down the hydrogen pathway? Where we have to do electrolysis, and then you have to bring the hydrogen to the filling station, then people must trade it up to be compressed, then the hydrogen has to be re-transferred into electric energy, and there’s another 50% loss. So we end up with quite a poor overall energy [transfer] compared to electric vehicles. However, for long distance travels or specific use cases the fuel cell electric vehicle might be the better choice.

GS: We are focusing primarily on the battery electric vehicle, because what we are doing now is not just replacing the combustion engine with an electric engine – we are changing the whole system.

A car with a combustion engine contains 3,000 to 4,000 parts. The electric vehicle has about 1,200. A lot of value added will be produced in the manufacturing stage, where you also have a much bigger CO₂ footprint. Also, today you have gas stations, but in the pure electric future, we won’t need these anymore. What will the people do, what will the stations do, what will the companies which sell the parts do? You don’t need as many people for assembling the cars. This completely changes the system and that is underestimated at the moment. Also, we are going to have tens of thousands of EVs on the market in the next years, but there is a lack of charging infrastructure. This is a problem.

What is VW doing in this area?

At the moment we have our own charger business, Ioniity, which is a joint initiative with Daimler, BMW, and Ford. We are working on all the major motorways throughout Europe to install charging spaces every 120 km. We already have about 40 or 50 of these stations. We are also offering wall boxes for consumers to charge EVs at home, but this is not enough. Interview by Becky Beetz