5 things you need to know about solar power

As the world seeks to adopt green energy alternatives, hundreds of thousands of solar panels are manufactured annually. Ultimately, this will result in a deluge of defunct solar panels posing a significant challenge for the solar industry, our environment and society more broadly. But, for those future-focused enough to read the signals, there are opportunities to be explored. ***Adam Parsons*** *looks at the signals shaping the future of solar energy.*

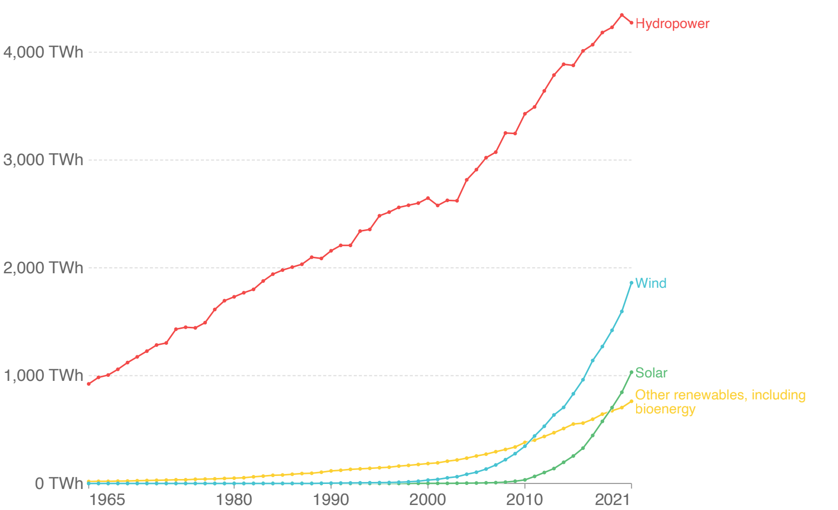
The growth of the world's capacity to generate electricity from solar panels, wind turbines, and other renewable technologies is on course to accelerate over the coming years, according to the latest edition of the IEA's annual Renewables Market Report.

Solar PV (photovoltaic) remains the powerhouse of growth in renewable electricity, with its capacity additions increasing by 17% in 2021 to a new record of around 160 GW. The exponential growth in solar power is due in part to the increasing efficiency and declining cost of solar panels, as technical improvements and economies of scale mimic Moore's Law.

But what are the longer-term consequences of unbridled growth in solar power? It's easy enough to stick some panels on the roof of your house or factory, and join the solar revolution; but what happens when they reach the end of their useful lives, or you upgrade to more powerful, cheaper panels? Let's dive right in.

Solar power, as a renewable energy source, has really been enjoying its time in the sun – so to speak – demonstrating exponential growth in installed capacity over the last decade. According to Hannah Ritchie, author of ***Renewable Energy***, annual solar generation reached more than 1,000 TWh in 2021, increasing at an average compound annual growth rate of 33%. As a result, solar power has become the third largest renewable energy source, after hydro- and wind-power, surpassing bioenergy in 2019.

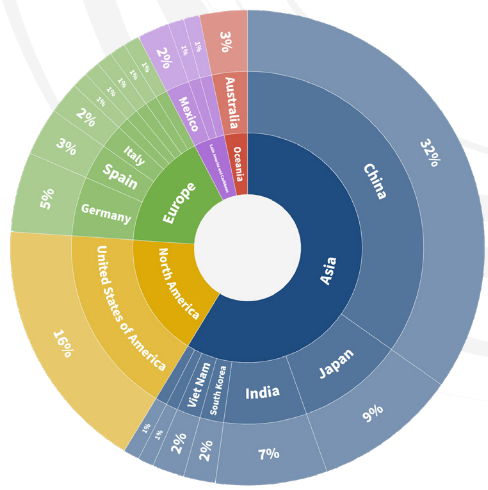
Modern renewable energy generation by source, World



Source: Our World in Data based on BP Statistical Review of World Energy & Ember

OurWorldInData.org/renewable-energy • CC BY

Global solar generation split by country



Source: Ember's Global Electricity Review 2022

Here are some quick stats:

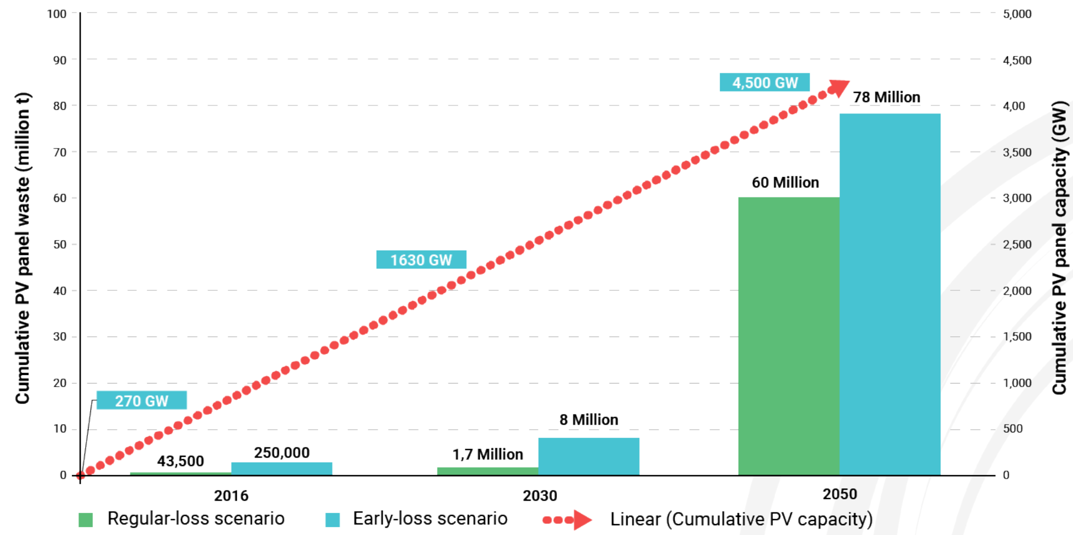
- Solar power accounted for 3.7% of the world's electricity in 2021, up from 1.1% in 2015.
- To reach 2050's Net Zero goal, generation must increase seven-fold by 2030 and account for 19% of the world's electricity, requiring a minimum year-on-year growth rate of 24%.

1. By 2030, waste from defunct solar panels could fill 2.7M shipping containers

When talking solar, the conversation is generally dominated by the undoubtedly impressive panel deployment forecasts, with the elephant in the room being the delayed, but equally impressive future growth in solar panel e-waste. With a typical lifespan of 30 years, and the majority of panels only installed in the last 10 years, we have barely begun to see the waste generated by this industry.

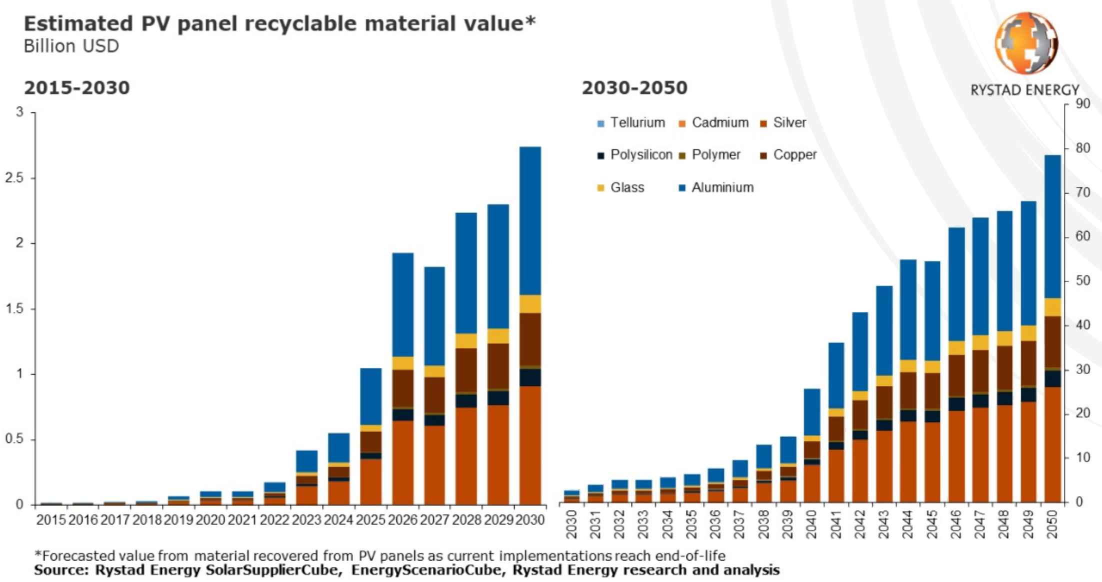
Fast Fact: Looking at regular-loss and early-loss scenarios, taking into account 'infant', 'mid-life', and 'wear-out' failures before the 30-year lifespan, the International Renewable Energy Agency estimated the solar industry would yield 60-78 million tonnes of waste panels by 2050.

Overview of global PV panel waste projections, 2016-2050



Source: International Renewable Energy Agency. (2016). End-of-life Management: Solar Photovoltaic Panels.

Evaluating the cumulative PV panel waste volume generated by the solar power industry, Rystad Energy estimates the value of contained recyclable material in the waste could amount to more than $US 2.7 bn by 2030, and nearly US$ 80 bn by 2050.



2. Not all solar panels are created equal

With solar power – and by association, solar panels – being the poster child for the sustainable green revolution, it's worth understanding what goes into, and perhaps more importantly, what, if anything, can be done with the expected e-waste.

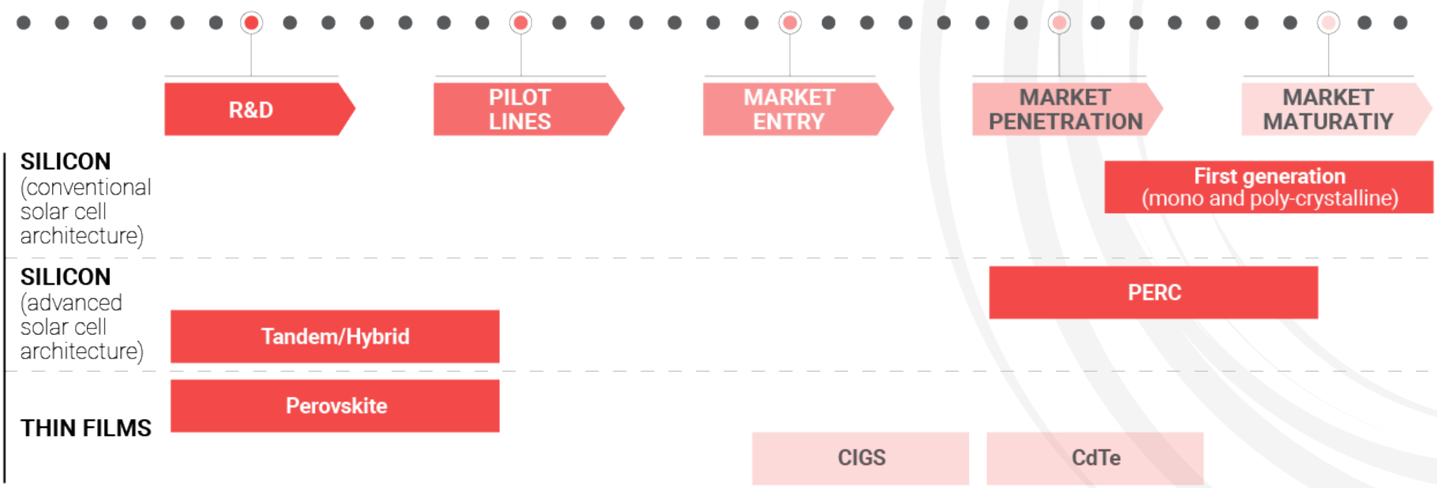
There are four main types of solar panels in the market today: monocrystalline, polycrystalline, PERC, and thin film panels, each with unique advantages and disadvantages. Let's take a deeper look:

	Silicon-based			Thin film-based
	PERC	Monocrystalline	Polycrystalline	Thin film
Typical uses	Relatively new technology, improvement on the traditional monocrystalline cell	Most popular residential rooftop solar	Budget residential rooftop solar	Large-scale utility and industrial installations
Efficiency (%)	> 25	> 20	15 – 17	9 - 15
Cost (US$/Watt)	0.32 – 0.65	1.00 – 1.50	0.70 – 1.00	0.50 – 0.70
Advantages	• Most efficient • Highest power capacity	• Less expensive alternate to PERC	• Middle option, by cost, performance, and power capacity	• Lowest cost • Easier to install
Disadvantages	• Most expensive initially • Earlier panels suffered from light and elevated temperature induced degradation	• High initial cost • Low yield in manufacturing process	• Low heat tolerance	• Shorter lifespan than crystalline panels • Requires more space • Least efficient

Source: https://aurorasolar.com/blog/solar-panel-types-guide/

Solar panel research and development is ongoing, with existing and emerging technologies seeking to further reduce costs while improving performance.

Solar PV Technology Status



Notes: CIGS = copper-indium-gallium-diselenide; CdTe = cadmium telluride. PERC = passivated emitter and rear cell/contact

Source: International Renewable Energy Agency. (2016). End-of-life Management: Solar Photovoltaic Panels.

Solar panels are broadly categorised into silicon-based and thin film-based, with silicon-based panels accounting for roughly 90% of commercial panels. There are numerous differences in the manufacture, materials, and compositions of these panels, which unsurprisingly contribute towards the various operational differences. But, they also have implications for the recycling process.

3. Not quite as green as you think

Solar power might be green, but solar panels are not. Similar to other electronic industries, solar panel fabrication relies on a variety of toxic chemicals, including arsenic, cadmium telluride, gallium arsenide, hexafluoroethane, hydrofluoric acid, lead, and polyvinyl fluoride. Solar panel production also relies on a molecule, nitrogen trifluoride (NF^3). NF^3 is a highly toxic inorganic chemical, with a greenhouse gas potential >17,000x worse than CO^2. New measurement techniques have shown NF^3 emissions are increasing rapidly, increasing 40x between 1992 and 2007 alone.

At the other end of the value chain, current recycling processes for solar panels make use of harsh chemicals to liberate and separate out the toxic components of solar panels. The recycling process typically involves the (1) removal of the frame and junction box, (2) separation of the glass and silicon wafer through thermal, mechanical, or chemical processes; and/or (3) separation and purification of silicon cells and speciality metals (silver, tin, lead, copper) through chemical and electrical techniques.

Ferroelectric solar panels offer a potential solution to the toxic chemicals and processes required for fabrication and recycling of silicon-based panels. Ferroelectric panels make use of widely available low-toxicity materials, typically achieving efficiencies of ~ 0.015% (in contrast to silicon based 15% – 25%), however, scientists have recently developed a new type of ferroelectric panel, producing 1,000x more power than conventional ferroelectric panels. While promising, the technology is still in the very early stages of development.

4. Recycling solar panels costs more than it's worth

While solar panels – both silicon-based and thin film-based panels – are comprised of widely recyclable components, the intricacy of the recycling processes gives most manufacturers pause. Despite the fact that large percentages of the materials (>80%) are salvageable in both cases, it is still significantly cheaper to simply dump panels into a landfill.

With recycling costs running between $20 and $30 per panel, versus the cost of sending to landfill ($1-$2 per panel), unless we've found ourselves in some alternate universe where companies are prepared to run at a loss, it seems obvious what will ultimately happen. Especially since, currently, the value of reclaimed materials does not cover the recycling cost.

So, yet again, we find ourselves prioritising profit over our environment, externalising costs associated with the solar value chain. Arguably, we are following the same path that resulted in the degradation of our environment to such an extent that it now threatens us. If the cost of recycling was included in the upfront cost of panels, the levelized cost of energy (LCOE) – the measurement of the overall cost of energy production over asset life – would be more than four times current projections, which could sound a death knell for the industry.

5. The future of solar isn't all doom and gloom

While the anticipated future deluge of defunct solar panels poses a significant challenge for the solar power industry – and society more broadly – it also presents opportunities. Two early market movers in the solar panel recycling space are First Solar and Solarcycle.

First Solar is a US-based company that designs and manufactures solar panels, modules, and systems for use in utility-scale development projects. They also operate solar panel recycling facilities in the United States, Germany, and Malaysia, recycling their own solar panels, recovering and reusing up to 90% of materials. As of July 2022, the company is valued at US$ 7.3 billion.

Solarcycle, a private US-based start-up, developed a proprietary technology for solar panel recycling. What makes it unique is that it recovers more aluminium and glass, but also the more valuable copper, silver, and silicon than previous recycling techniques. They boast a >95% recovery rate of all valuable materials, which can then be fed back into the solar supply chain, supporting the circular economy. Founded in early 2022, by June 2022 Solarcycle had raised US$ 6.6 million in funding from investors, including SolarCity founders Lyndon and Peter Rive.

Very often the most disruptive solutions come from those who are able to take an unconventional approach when addressing signals from the future. One such company, BRAIN Biotech, develops novel biological ingredients, such as enzymes, biocatalysts, and bioactive natural compounds. An innovation of particular interest for solar and e-waste recycling industries is the BRAIN BioXtractor, an environmentally friendly biological solution for the extraction of valuable metals from e-waste. Uniquely identified and optimised microorganisms act on e-waste materials and extract metals with yields up to 100%, depending on the source material and type of metals.

But what does it all mean?

Perhaps solar power isn't the answer to all our future energy needs. Indeed, if some of the fundamental issues with solar power, such as manufacturing processes and recyclability are not sufficiently addressed, the solar industry will almost certainly result in far greater damage to our environment than we anticipate.

As progress continues in the fields of fusion energy, artificial photosynthesis and green hydrogen, future technology may present us with alternative renewable energy sources with the potential to disrupt the solar power value chain. Like solar power, all new and exciting alternatives come with challenges and opportunities for those brave enough to capitalise on the signals. When you consider the market capitalisation of solar power pioneers like First Solar, the value of innovation in this space is undeniable.

Futureworld has decades of experience working with our clients to understand the forces shaping the future and the opportunities those forces present. If you'd like to explore the forces shaping the future of your business, reach out to us.

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About the Author

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Adam is a qualified engineer with over 10 years of industry and consulting experience, primarily in the energy and resources sectors.

Prior to joining Futureworld, Adam advised prominent clients in the Mining and Metals sector for a leading global consulting firm and delivered technical services in the Oil & Gas industry across EMEA and North America regions.

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