IRENA QUARTERLY
Q3 2016
Special Edition

SUMMER OF SOLAR

THIS SUMMER, IRENA IS RELEASING
A SERIES OF PUBLICATIONS THAT HIGHLIGHT THE KEY ROLE OF SOLAR ENERGY IN THE ONGOING ENERGY TRANSITION

LETTING IN THE LIGHT

The age of solar energy has arrived - it came faster than anyone predicted and is ushering in a global shift in energy ownership

Solar photovoltaic (PV) power is already the most widely owned electricity source in the world in terms of number of installations, and its uptake is accelerating. In only five years, global installed capacity has grown from 40 gigawatts (GW) to 227 GW. By comparison, the entire generation capacity of Africa is 175 GW. Solar PV accounted for 20% of all new power generation capacity in 2015. IRENA estimates that solar PV capacity could reach between 1 760 GW and 2 500 GW in 2030, producing between 7% and 13% of global power generation. Solar has emerged mainstream.

We are seeing the emergence of solar power everywhere: from large-scale utilities to micro-grids.

Rooftop solar PV could cover 40% of US electricity demand

The primary driver for the solar revolution is dramatic cost reduction, as witnessed by the recent bid that was below US cents 3 per kilowatt-hour (/kWh) in Dubai. This is no longer the exception, recent renewable energy auctions in Germany, Mexico and Peru have also seen very low prices. IRENA's recent cost reduction analysis predicts that global average cost for utility scale PV are projected to fall by an additional 59% until 2025, driven by technology, market and financing model innovation.Today, solar PV provides less than 2% of global electricity.

The experience of countries pioneering solar power, such as such as Germany, Italy and island states like Samoa, shows that 10-20% solar PV can be integrated into an electricity system without problems. But integrating higher levels will require a host of new activities. These include the introduction of more interconnectors, demand-side management, electrification of the transport and building sectors, and ultimately electricity storage.

With cost-competitive utility-scale solar PV power plants starting to replace fossil-fuel plants as the technology of choice. Large-scale generation is growing in tandem with an expanding, and increasingly distributed, network of small-scale solar PV installations. For example, Germany has 1.5 million power generation units today, mostly rooftop solar PV units. The resource is there: rooftop solar PV could cover 40% of US electricity demand.

More than 44 million pico-solar products — solar lanterns and home systems smaller than 10 W —had been sold worldwide by the second half of 2015. In the developing world, 89 million people already have at least one solar lighting product in their household, and 21 million have been lifted onto the first rung of the energy access ladder. About one in three off-grid households will use off-grid solar by 2020. India, for instance, has set out to deploy more than 100 000 solar water pumps for irrigation.

Beyond the power sector, solar PV also has direct consequences for the environment, economy and society at large. For the wider economy, solar PV accounts for the bulk of renewable energy investments to the order of USD 80 million per year. Around half of this economic activity is related to production of hardware but local project development, installation, and operation and maintenance activities account for the other half.

For the environment, solar PV is already contributing to greenhouse gas mitigation in the range of 200-300 million tonnes of carbon dioxide per year. Increased solar PV deployment from 200 GW today to 1 600 GW in 2030 will result in greenhouse gas emission reductions of between one and three gigatonnes in 2030. This could grow to 10 million jobs by 2030. Solar PV is the largest renewable energy employer, accounting for 2.8 million jobs in 2015, of which about two-thirds were in China. But solar demands a paradigm shift of power system design, operation and business models. Variable renewable energy (VRE) generators make baseload power plants redundant.

At the household level, we have seen the rise of new leasing models for rooftop solar PV financing. At the moment, grid costs are mostly paid by the consumer through a kilowatt-hour consumption levy. If some users then drop their consumption, the cost rises for the rest. Net metering allows power generation by consumers to increase dramatically; but new cost allocation models or self-consumption policies may be needed if the share of self-production rises significantly. One alternative tariff model is a fixed monthly fee plus a lower charge per kilowatt-hour.

The appearance of VRE, including solar PV, has resulted in new intra-day markets, some operating at less than an hour ahead of time. New capacity and ancillary grid services have emerged. While opinions differ about critical market design elements, there is general agreement that an adjustment is needed as the proportion of variable renewable power rises significantly. Smart grid technologies combined with electricity storage at a decentralised level are allowing the creation of virtual communities of solar PV owners who effectively share electricity through the existing grid. According to this model, consumers can buy and sell electricity from each other by trading the electricity contained in their batteries.

Today, 89 million people in the developing world own a solar lighting product in their household

On an institutional level, major new international solar energy initiatives have emerged or are in preparation such as the International Solar Alliance, the TeraWatt initiative, the Global Solar Council and the Global Energy Interconnection Initiative. They are reporting a rapidly rising interest in the public and private sectors to reap the benefits of this emerging solar PV opportunity.

Solar PV is a valuable addition to the growing toolkit of renewable energy options that includes concentrating solar power, solar thermal, biomass, geothermal, hydro, oceanic and wind.

Letting in the Light: How solar photovoltaics will revolutionise the electricity system was launched at the occasion of the InterSolar conference in Munich, 22 June 2016.


Learning how to install solar panels, Senegal

Photo: IRENA/ S. Alzouma

RENEWABLE ENERGY JOBS JUST KEEP GROWING AND GROWING

The price of oil may be down, but that has not stopped the growth of solar energy, nor the growth of jobs in that sector. In 2015, 8.1 million people were employed in renewable energy — 5% more than last year. Of that figure, 2.8 million people were employed in solar energy, making it the largest employer of all renewable energy sources. But what's driving the growth of solar and for how long will it continue?

Historically, the largest barriers in deploying solar technology were price and efficiency, but that is rapidly changing. Since 2009, the price of photovoltaic (PV) modules has declined by 80% and their efficiency has improved greatly too — reflected in the pricing of energy.

These price declines, coupled with countries seeking to decarbonise their energy sectors to meet climate and development goals, has led to a 20% jump in PV installations globally in 2015 and with it, job growth.

While European solar employment has taken a dip since 2014, a shift of manufacturing to Asia has driven a surge of solar employment. The Chinese solar sector employ almost 1.7 million people in the, making them collectively the world's largest solar PV employer, and last year these companies installed a record 15 gigawatt (GW) of solar PV.


Shutterstock

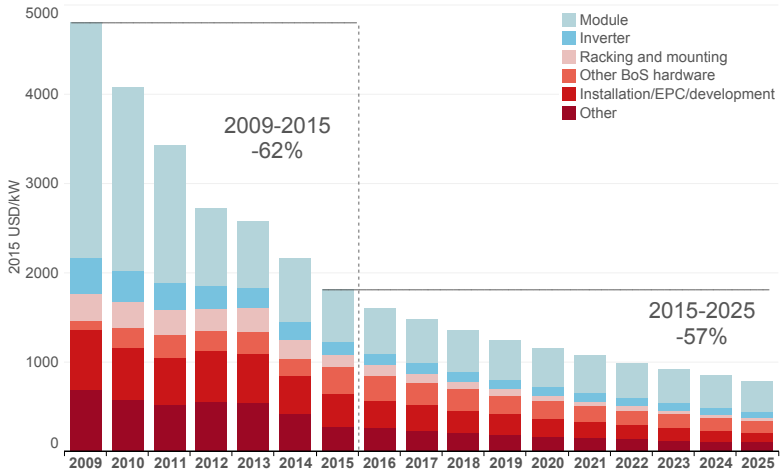
In the US, solar employment grew 22% last year — 12 times faster than job creation in the rest of the US economy. India has also emerged as a major market for both large and small-scale PV. New policy frameworks in the country drove the instalment of 1.9 GW of solar PV last year with plans for a further 23 GW. India's ultimate goal is to have 100 GW of cumulative PV installations by 2022, which would add a further 1.1 million jobs in the sector.

Off-grid PV is also expanding across South Asia, and in Bangladesh over 700 000 homes installed 'solar home systems' — stand-alone PV systems — bringing the total number of solar installations in the country to 4.5 million. Over 127 000 people now work in the PV sector in Bangladesh, a 13% rise from 2014, and of those jobs a quarter work in manufacturing and the rest in distribution, installation, and after-sales services.

In Africa the solar sector is expanding, but is still small. Egypt's budding PV sector employs 3 000 people, and in South Africa that employment is up to 20 000. Interestingly, Morocco's Ouarzazate Solar Power Station will be the world's largest solar power plant when completed. The first phase created 1 800 construction jobs and a further 250 permanent operation jobs. Its future expansions will see the creation of thousands of construction jobs and up to 500 more permanent positions.

To learn more about the solar job market see Renewable Energy and Jobs — Annual Review 2016.

Global weighted average total installed costs for utility-scale solar photovoltaic, 2009 to 2025



COST REDUCTION POTENTIAL FOR SOLAR POWER TECHNOLOGIES

The industrial revolution drove an unprecedented rise in wealth and improvements in the quality of life, yet for some time it has been known that the unmitigated consumption of fossil fuels is placing that prosperity at risk, with changes being manifested, for example, through climate change.

The development and deployment of solar energy technologies — including photovoltaics (PV), solar thermal collectors for heat and concentrating solar power (CSP) — offer one of the most concrete examples of the transformation that is possible with modern renewable technologies.

These commercially available technologies are highly modular solutions, meeting our modern energy needs. Most excitingly, solar PV in particular, has the potential to rapidly provide electricity and modern energy services to the 1.2 billion people today who still lack access to electricity, and it can do so at a cost equal to or lower than the price that these people pay today for lower quality energy services.

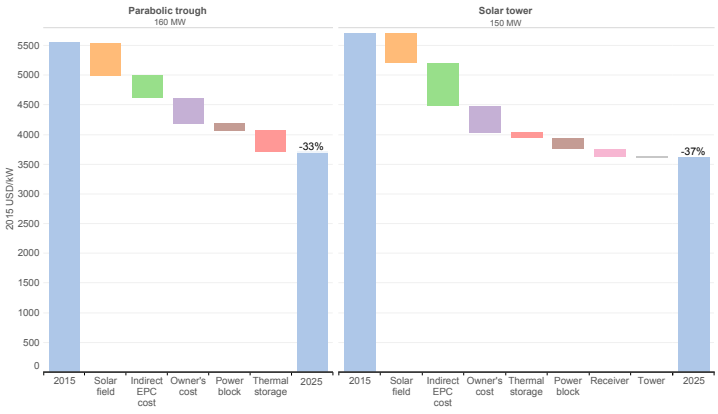
Exciting technological innovations are continuing to improve the performance and are driving down costs, helped by the increased scale of deployment and rising competitive pressures. Solar PV module prices fell by around four-fifths between the end of 2009 and 2015, while global total installed costs for utility-scale solar PV fell by an average of 62% over the same period.

The outlook for the next 10 years is for continued cost reductions. Driven by technological improvements in solar PV modules, manufacturing advances, economies of scale and reductions in balance of system (BoS) costs (costs that encompass all components of a PV system other than the PV panels), the global average installed costs of utility-scale PV systems could fall by as much as 57% between 2015 and 2025. As much as 70% of the total installed cost reduction coming from a markets shift to best practice costs (see main figure on costs for utility-scale solar PV).

By 2025, crystalline silicon module global average prices could fall to between USD 0.28-0.46 per watt (/W), compared to USD 0.52-0.72/W in 2015. The Levelised Cost of Electricity (LCOE) of utility-scale PV projects could fall by an average of 59% between 2015 and 2025, with most project costs in the range of USD 0.03-0.12 per kilowatt-hour (/kWh) by 2025.

The same trend is also predicted for total installed costs of CSP, which could fall by between 33% for parabolic trough collector plants (PTC) and 37% for solar towers (ST) by 2025, for plants with 7.5 to 9 hours storage respectively.

Total installed costs for parabolic trough collector plants and solar towers, 2015 and 2025



By 2025, the LCOE of CSP technologies could decrease by 37% (PTC) and by 43% (ST). Around 60% of this decrease will be driven by lower installed costs. By 2025, PTC plants could average USD 0.11/kWh for a reference plant, with STs achieving costs of USD 0.09/kWh.

Electricity costs could fall by 59% for solar PV

Looking forward, as equipment costs for solar and wind power continue to fall, balance of system costs, operations and maintenance (O&M) and the cost of capital will rise in importance as cost reduction drivers. The correct policy settings will be essential to unlock ongoing technological improvements and cost reductions. In some markets, changes to existing policy settings will also be essential in addressing the challenging issues surrounding persistent cost premiums.

Seizing this opportunity could see the cost of electricity from solar technologies fall by between 37-43% for CSP and 59% for solar PV by 2025. The winners in this transformation will be customers, our environment and future generations.

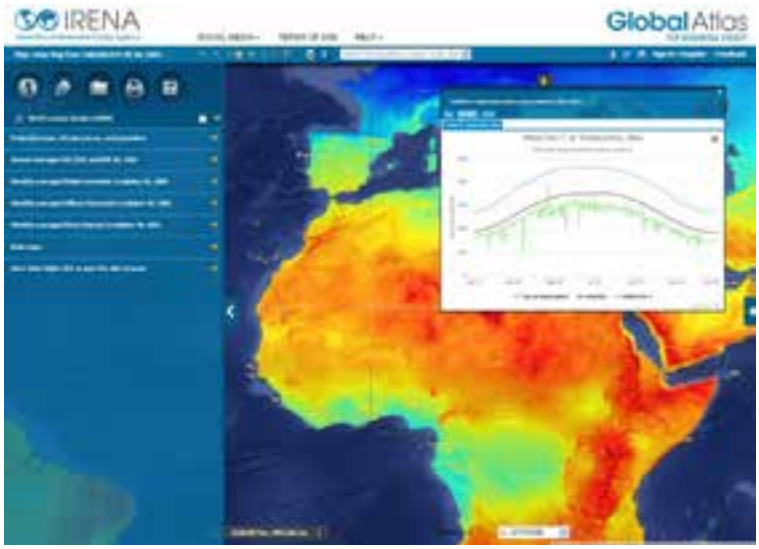
For more information please see The Power to Change: Solar and Wind Cost Reduction Potential to 2025.

SOLAR RESOURCE DATA AND TOOLS IN THE GLOBAL ATLAS FOR RENEWABLE ENERGY

The Global Atlas initiative offers a complete suite of services to support solar resource mapping and assessment, including an online GIS interface, solar maps that cover every country in the world, online analysis tools, and the ability to export data and maps in several different formats.

To view global solar irradiation data, see the Vaisala map, or visit the Map Gallery to search for country- or region-specific maps. The Global Atlas also provides tools to support early site pre-screening, like the PVWatts tool for estimating the electrical output of a proposed PV project, and the Helioclim tool that provides solar time series data. For more information on how to use this data, watch our recent webinar on solar resource assessment.

For more detailed resource data needs, IRENA can put you in touch with our partner companies and organizations to provide assistance and expertise. Just email potentials@irena.org with your request.




Farmers using solar pumps at the Oxfam's Ruti Dam Irrigation Scheme, Zimbabwe

Photo: Oxfam/J. Magrath

SOLAR-POWERED IRRIGATION SYSTEMS: AN UNTAPPED OPPORTUNITY

Worldwide, food is produced mainly on rainfed land with approximately 95% of farmed land in sub-Saharan Africa and 60% in South Asia relying on seasonal rains to meet water needs. Productivity on these farms, many of which are subsistence, can be particularly low, exacerbated by unpredictable rainfall.

Increasing productivity in the agriculture sector is widely recognised as one of the most effective ways to fight poverty. Irrigation is among the measures that can improve yields, reduce vulnerability to changing rainfall patterns and enable multiple cropping practices. Land that is irrigated tends to give greater crop yields than land which is rainfed. Looking forward, yields will need to increase to cope with rising demand for food and the land area under irrigation will expand. Transporting water from the source to the fields will require affordable, reliable and sustainable energy.

Solar powered irrigation has gained prominence lately, providing reliable, cost-effective and environmentally sustainable energy for decentralised irrigation services in many settings. When deployed, the benefits include improved livelihoods (increased productivity and incomes, and food security), increased social welfare (poverty alleviation, emissions reduction) and reduced spending on fossil fuel subsidies and centralised energy infrastructure.

Contributing to several of the United Nations' Sustainable Development Goals, these solutions are becoming increasingly widespread, as demonstrated by the initiatives of a growing number of governments, development agencies and the private sector. Bangladesh, for instance, has set a target to deploy 50 000 solar pumps by 2025; India, 100 000 by 2020; and Morocco, 100 000 by 2022.

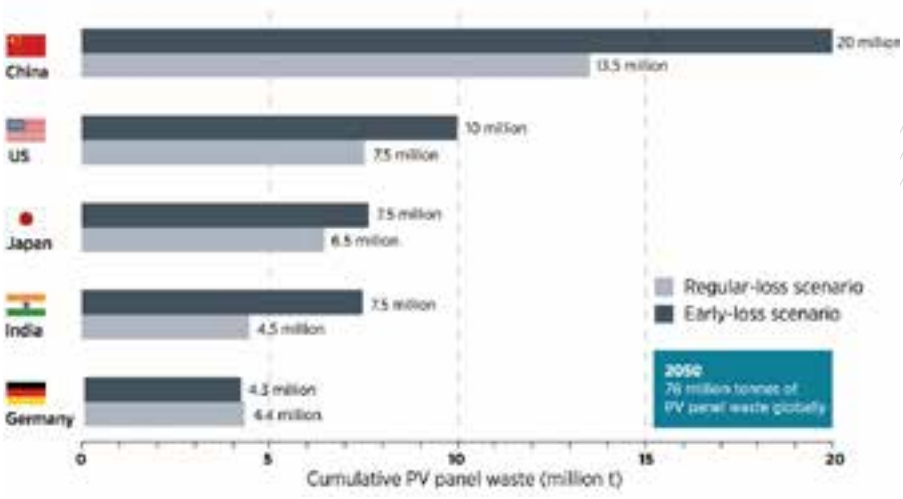
A case study in Zimbabwe demonstrates the transformational impact of solar irrigation. Oxfam's Ruti Dam Irrigation Scheme uses solar pumps to expand the coverage of the scheme from 40 hectares to 60 hectares. Two-thirds of the Ruti scheme is based on gravity-fed irrigation, and additional solar booster pumps have been deployed to pump water into a storage reservoir. Nearly 270 smallholder farmers, who were previously growing little more than subsistence crops of maize, can now feed themselves, earn an income and also their neighbours can benefit. Farm yields have increased to an average of 4-5 tonnes per hectare. Irrigation enables farmers to grow three crops a year and increase diversity into the rotations to include cash crops, such as potatoes and sugar beans.

A project evaluation by Oxfam shows that household incomes increased by 286% for the very poor, 173% for the poor and 47% for the middle income groups. Furthermore, employment creation increased as farmers no longer had to target large-scale farm employment in exchange for food, producing food and new job opportunities on their own land instead.

IRENA's new Policy Brief on *Solar pumping for irrigation: improving livelihoods and sustainability* (2016) analyses diverse case studies where solar irrigation solutions have been deployed and brought substantial benefits for farmers as well as governments.

The Policy Brief is part of a broader IRENA work stream focusing on the nexus between the water, energy and food sectors; including Renewable Energy in the Water, Energy and Food Nexus (2015), Water Use in China's Power Sector: Impact of Renewables and Cooling Technologies to 2030 (2016) and the "In-focus" chapter on desalination in Renewable Energy Market Analysis: The GCC Region (2016).

A projection of PV panel waste volumes up to 2050

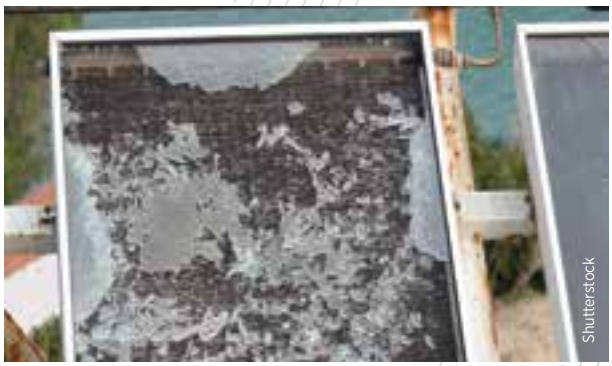


GROWING PHOTOVOLATIC WASTE PRESENTS A NEW BUSINESS OPPORTUNITY

The global solar photovoltaic (PV) boom currently underway will represent a significant untapped business opportunity as decommissioned solar panels enter the waste stream in the years to come.

The world's total annual electrical and electronic waste (e-waste) reached a record 41.8 million tonnes in 2014. Annual global PV panel waste was 1 000 times less in the same year. Yet by 2050, the PV panel waste added annually could exceed 10% of the record global e-waste added in 2014. Given that the average panel lifetime is 30 years, large amounts of waste are anticipated by the early 2030s.

Analysing a projection of PV panel waste volumes up to 2050, highlights that recycling or repurposing solar PV panels at the end of their roughly 30-year lifetime can unlock a large stock of raw materials and other valuable components. The analysis estimates that PV panel waste, comprised mostly of glass, could total 78 million tonnes globally by 2050. The top three countries for PV panel waste, as seen in the figure, will be China, followed by the US and Japan.



If fully injected back into the economy, the value of the recovered material could exceed USD 15 billion by 2050. This potential material influx could produce 2 billion new panels or be sold into global commodity markets, thus increasing the security of future PV supply and other raw material-dependent products.

Addressing growing solar PV waste, and establishing an industry to handle it, would require: the adoption of effective, PV-specific waste regulation; the expansion of existing waste management infrastructure to include end-of-life treatment of PV panels; and the promotion of ongoing innovation in panel waste management.

In most countries, PV panels currently still fall under the classification of "general waste" but the European Union (EU) was the first to adopt PV-specific waste regulations, which include PV-specific collection, recovery, and recycling targets. EU's directive requires all panel producers that supply PV panels to the EU market (wherever they may be based) to finance the costs of collecting and recycling end-of-life PV panels put on the market in Europe.

For more information on challenges and opportunities for PV end-of-life management, see *End-of-Life Management: Solar Photovoltaic Panels,* prepared by IRENA in joint collaboration with International Energy Agency's Photovoltaic Power Systems Programme (IEA-PVPS).

Recent publications

Letting in the Light: How solar photovoltaics will revolutionise the electricity system

Solar photovoltaic (PV) power generation is poised to revolutionise the electrical system in countries around the world. This report examines PV technology, economics, applications, infrastructure and policy, highlighting the global PV industry's prospects for the future.

Renewable Energy Statistics 2016

The 2016 Yearbook shows data sets on renewable power-generation capacity for 2006-2015, renewable power generation for 2006-2014 and renewable energy balances for 100 countries and areas for 2013 and 2014. It also features statistics on investments in renewable energies for the period 2009-2014.

The Power to Change: Solar and Wind Cost Reduction Potential to 2025

In energy markets around the world, rising competitive pressures drive continual innovation, while equipment costs keep declining. This cost-analysis report analyses the important drivers for overall cost reduction and looks at the factors that will continue to reduce the costs of solar and wind power worldwide.

Unlocking Renewable Energy Investment: The role of risk mitigation and structured finance

Global investment in renewables remains far below its potential, reflecting market barriers and perceptions of high risk that deters private investors and financiers. This report examines these and supplies a toolkit for policy makers, public and private investors, and public finance institutions to scale up their investments in renewable energy.

www.irena.org/publications

About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.