Grant Agreement number: 825669

ETIP PV – SEC II

Support to all stakeholders from the Photovoltaic sector and related sectors to contribute to the SET-Plan

Deliverable 1.3 Proceedings of the Annual Conference 2019

Lead beneficiary: EUREC

Deliverable author: EUREC

Due date	31 July 2019
Submission date	2 July 2019
Resubmission date	9 July 2019

Dissemination level

PU	Public	x
RE	Restricted to a group specified by the Consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

PhotoVoltaic
EUROPEAN TECHNOLOGY & INNOVATION PLATFORM

Disclaimer

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825669. The sole responsibility for the content of this report lies with the authors. It does not necessarily reflect the opinion of the European Union. The European Commission is not responsible for any use that may be made of the information contained therein.

Partners

WIP RENEWABLE ENERGIES

EUREC The Association of European Renewable Energy Research Centres

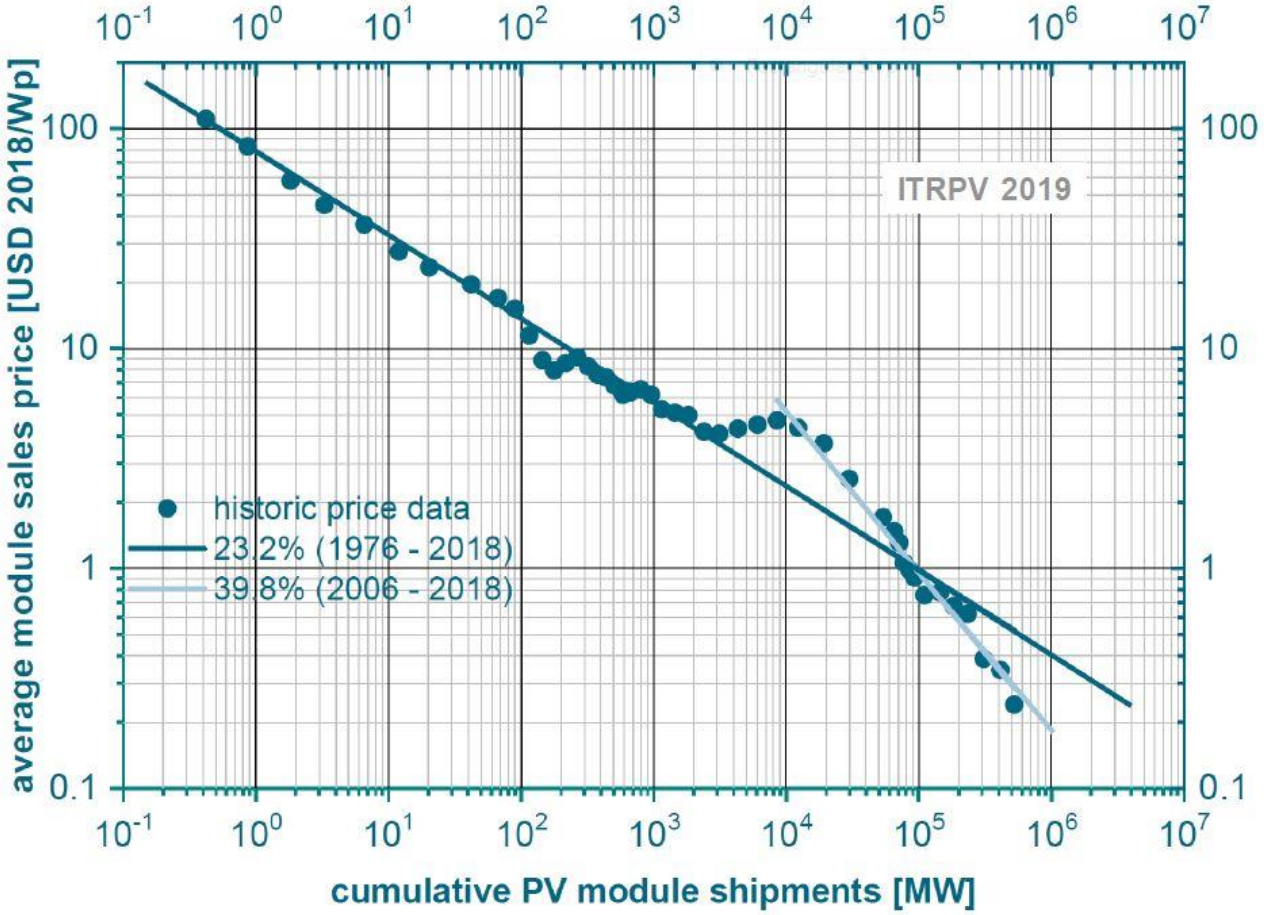
SOLARUNITED

Proceedings of the ETIP PV Annual Conference 2019
Readying for the TW era
28 May 2019

Falling costs of PV

Speakers agreed that the cost of solar has fallen rapidly. Cost reductions were shown in the slides of three speakers, both in terms of the rated power output of the module and as the yield from an installation.

Module cost decline



PhotoVoltaic
EUROPEAN TECHNOLOGY & INNOVATION PLATFORM

Solar PV cost trends

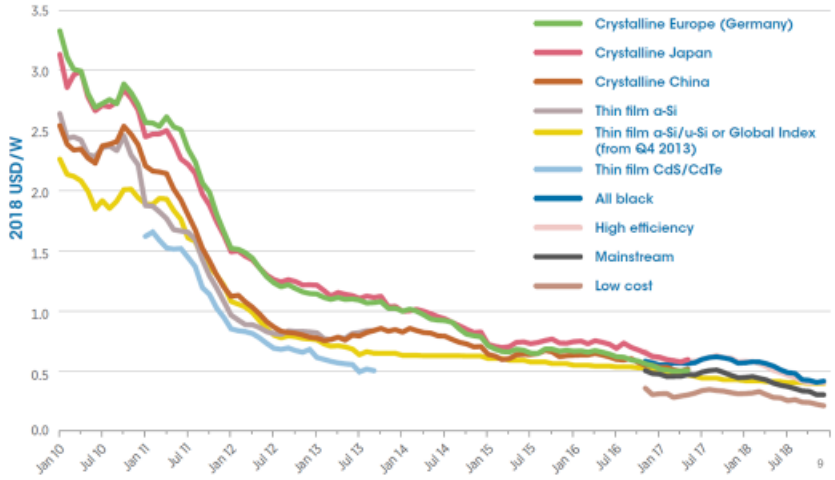
IRENA
International Renewable Energy Agency

Module costs continue its decline, though at a slower pace than in previous years

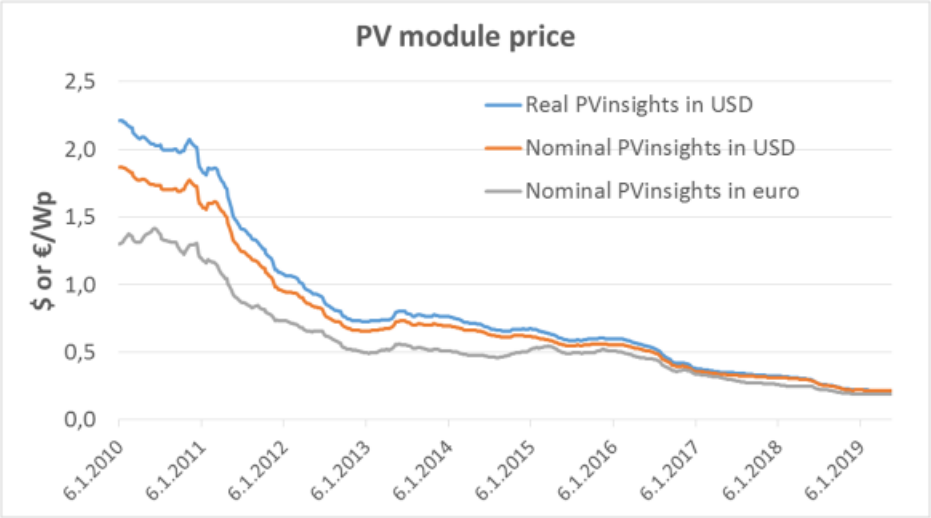
- Crystalline PV module costs decreased 90% since end of 2009 declined by a third during the year ending in 2018

Total installed costs
- Module
- Inverter
- Balance of system

- Module cost categories adjusting to reflect new characteristics paradigm (shift towards higher performing modules)



PV module real prices have decreased to 1/10 from 2010 to 2019



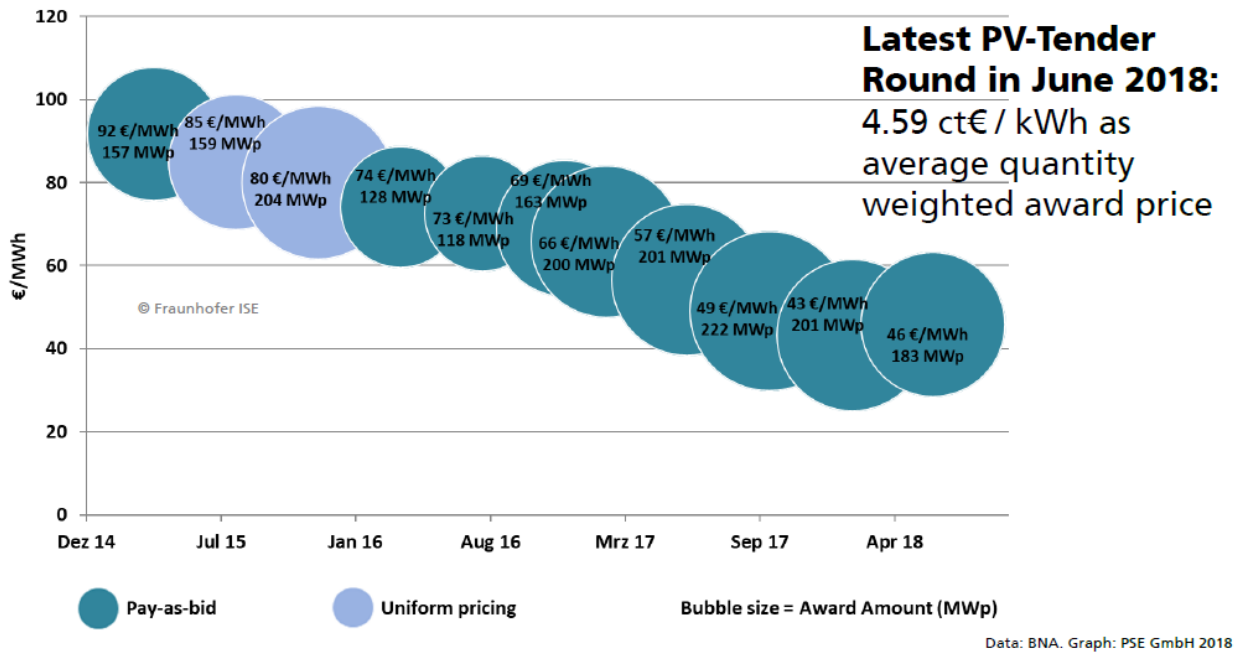
Source: PVinsights, weekly spot market price for multicrystalline modules

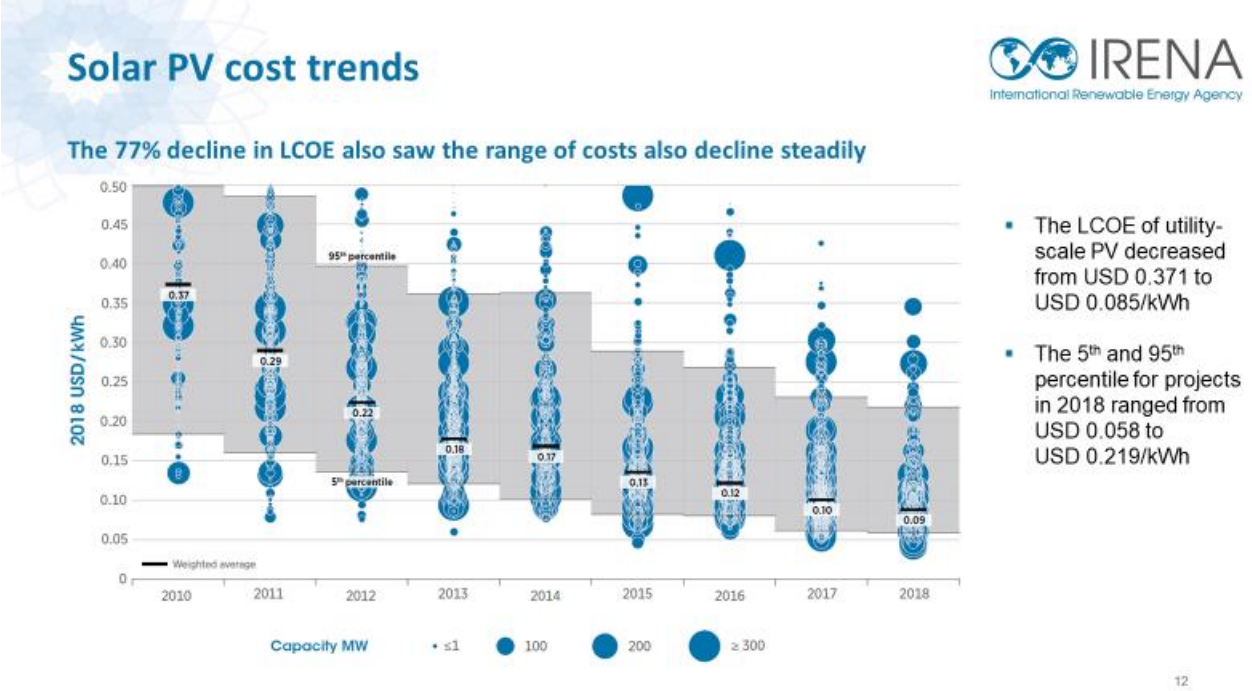
3

fortum

per MWh cost decline

PV-Tender in Germany
Average, quantity weighted Award Value





Module costs continue its decline, though at a slower pace than in previous years, said IRENA, which released a new report on renewable energy power costs a few days after the conference. The PV learning curve, however, appears to have accelerated since the mid-2000s. “Every time the global cumulative PV capacity has doubled, module price has reduced by 20-25% - but for the last 10 years by 40%,” noted Eero Vartiainen. This is borne out by the steeper pale trendline on the first of the plots above.

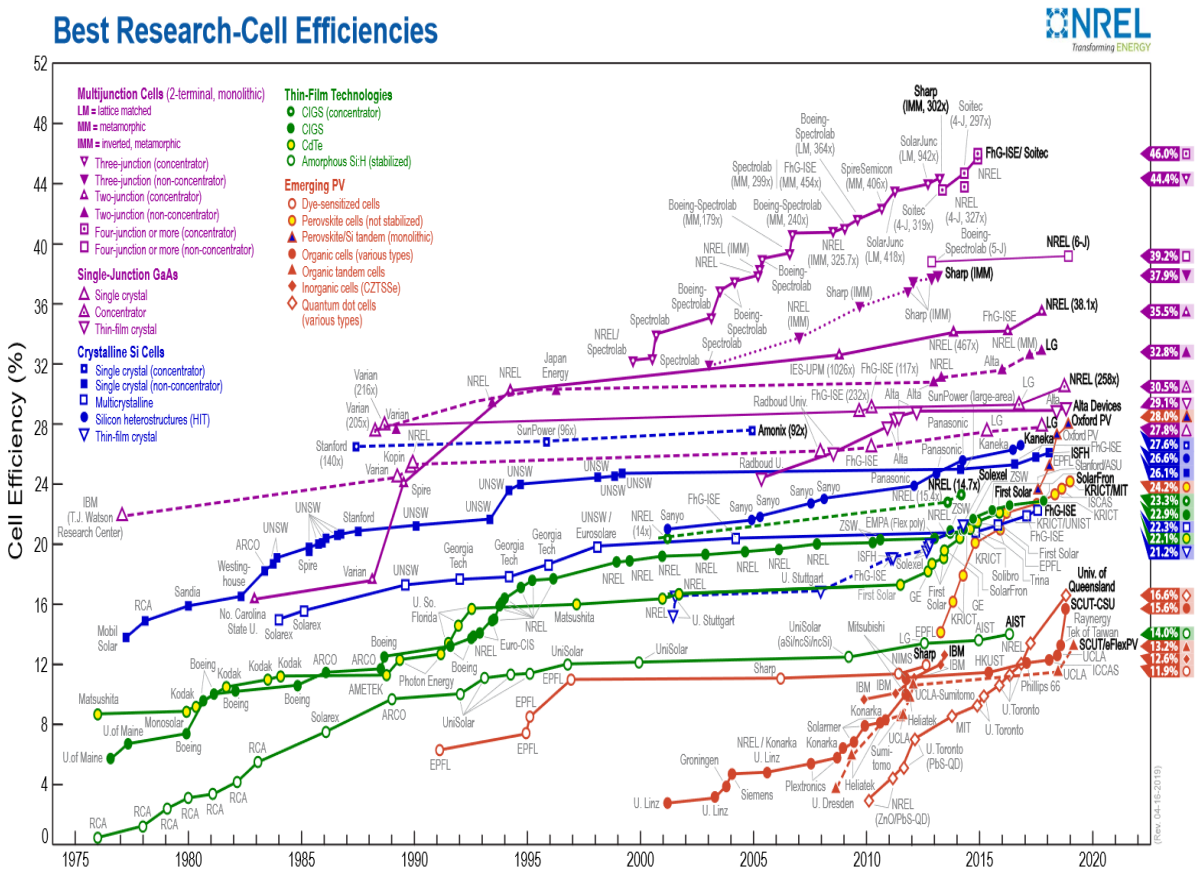
Vartiainen is cautious about the future learning rate, however, thinking it will slow to 30%. His 2017 report for ETIP PV, The true competitiveness of solar PV. A European case study, conservatively assumes a 25% learning rate.

Worldwide average improvements in cost / MWh are in part a function of where PV is installed. The more it is installed in sunnier parts, the better the yield. This is IRENA’s explanation for a slight improvement in the capacity factor of PV systems, on average across the world.

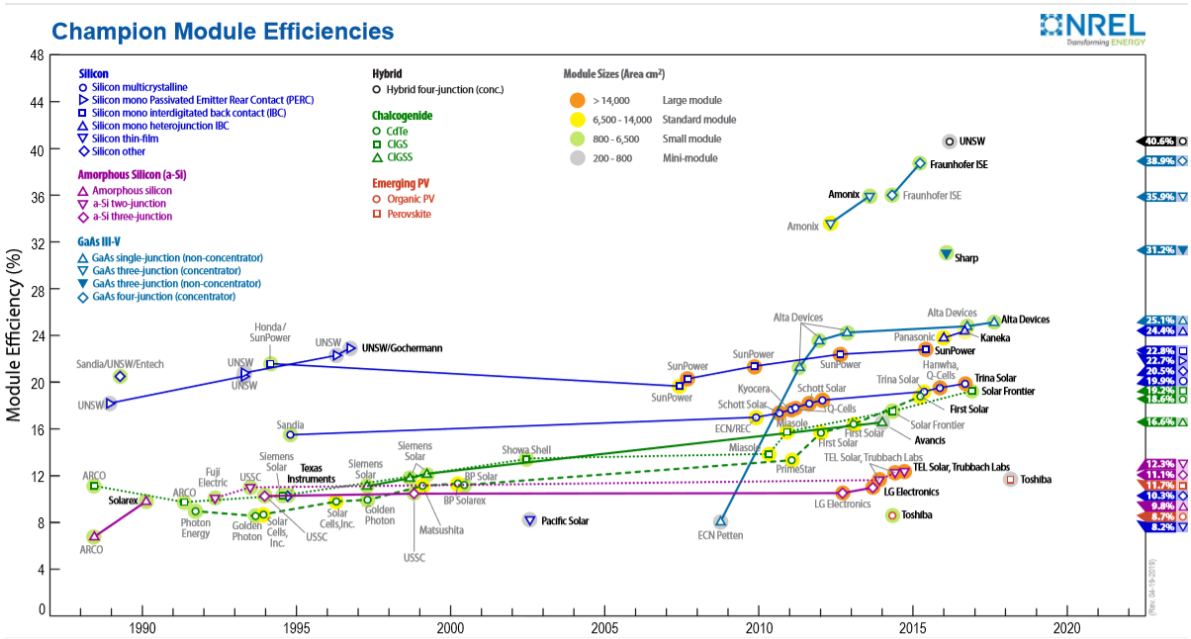
Efficiencies

NREL's data on record efficiencies was quoted by two speakers.

On research cells:



And on modules:



Future visions

Speakers presented a variety of ideas about how the world will operate if renewable energy technology is cheap and widely exploited.

The electrification of transport will allow passenger-kilometers and (for freight) tonne-kilometers to increase three times by 2050 without an increase in energy demand, since inefficient internal combustion engines will be replaced by more efficient electric ones.

Hydrogen will be necessary to decarbonize transport, said one speaker. Hydrogen from renewable energy sources is getting cheaper thanks to cheaper electricity and significant progress in the costs of electrolysers. When electricity reaches 30 €/MWh, electrolysis of water to hydrogen will be cheaper than reforming natural gas. They will need to run for large amounts of time to justify their investment. Dipping in and out of hydrogen production (i.e. significantly underutilizing an electrolyser) is not viable.

Hydrogen's low round-trip efficiency was a cause for concern. Rather than running off hydrogen, which is sometimes thought of as the only fuel suitable for heavy vehicles, trucks could be run off power lines suspended above the outermost lanes of motorways. Eventually, however, when costs are low enough, round-trip efficiency will be less relevant.

The realisation is dawning that the only way to reduce process emissions in some industries, such as steel-making, is with hydrogen. It will be transformed soon after it is produced, predicts the IEA, including into a more stable and easier-to-handle compound, ammonia.

Fuels synthesized with renewable electricity will ultimately be traded internationally, thought two speakers. An early example might be fuels containing hydrogen derived from renewable energy sources exported from Chile, which has the best solar resource on the planet.

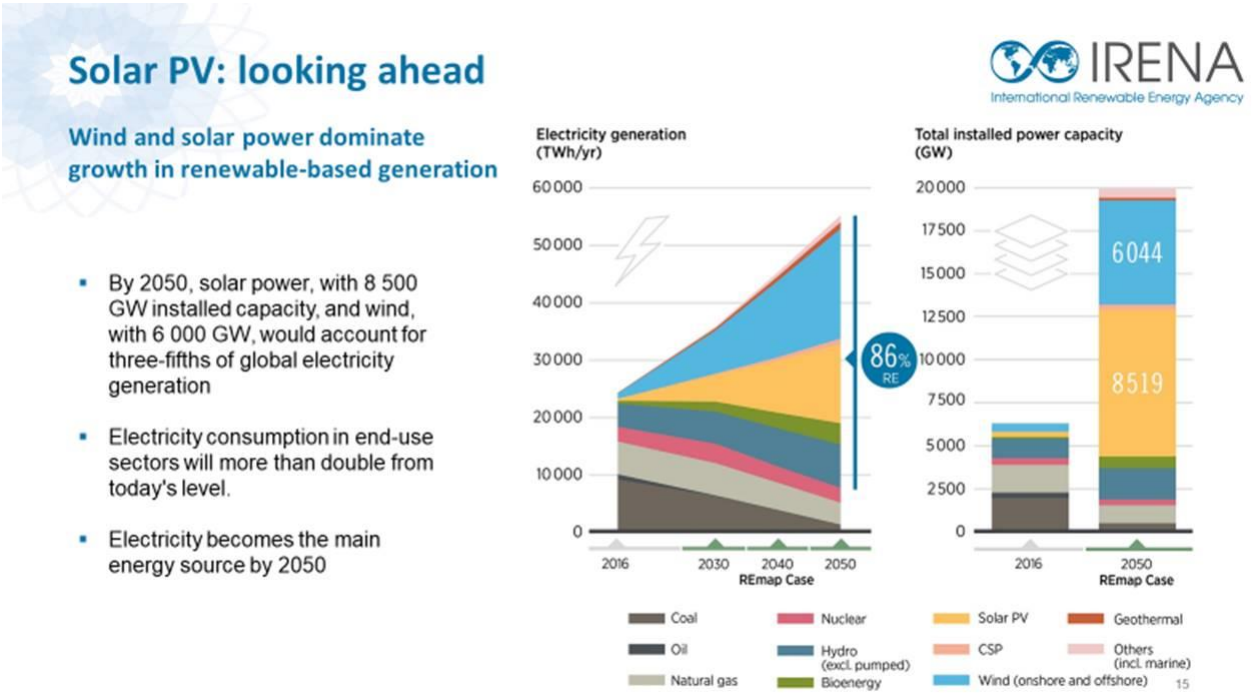
Electricity-driven "Carbon Direct Removal" technologies that draw carbon dioxide out of the atmosphere will be used in the second half of this century, said one.

What's the brake?

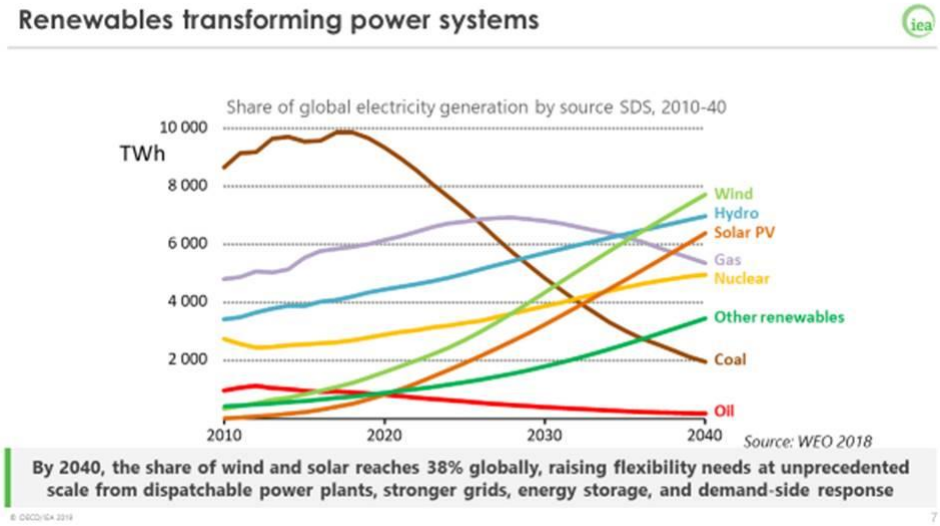
Political will is all that's missing to push forward faster with energy system transformation. The Commission presented the EU's political leaders with scenarios for achieving a net-zero-carbon economy by 2050 in its Communication of November 2018, but none relied 100% on renewable sources of energy. "I think there's plenty of space on roofs to supply all energy needs," said one speaker.

Will we reach multi TW scale in 2050?

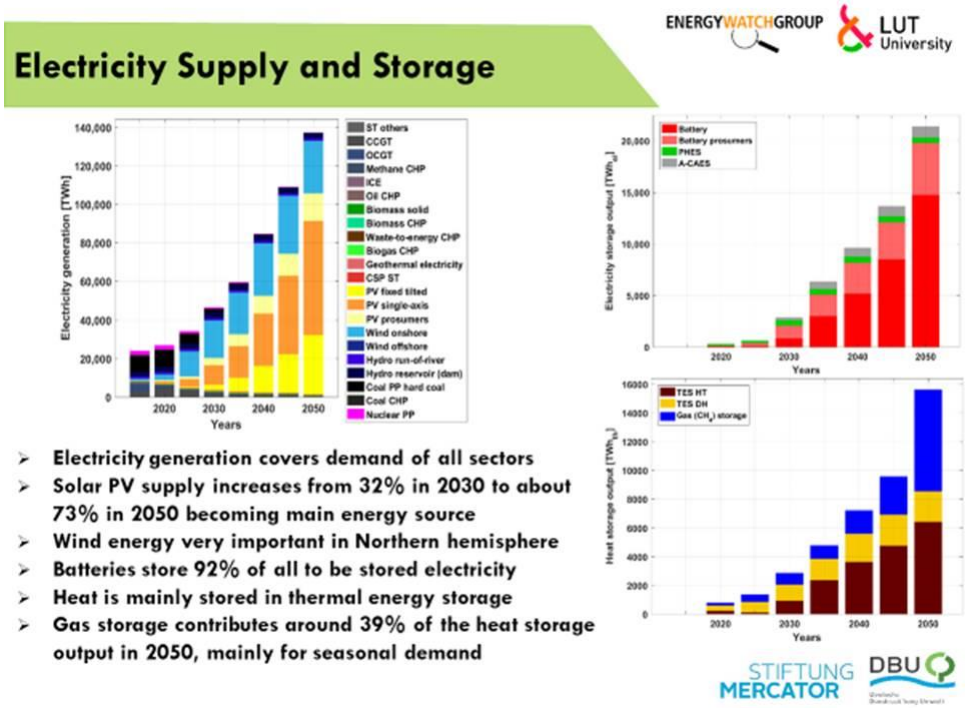
Yes, but opinions differed on how many TW exactly would be installed then. Two speakers were the same ball-park: IRENA, which presented this slide:



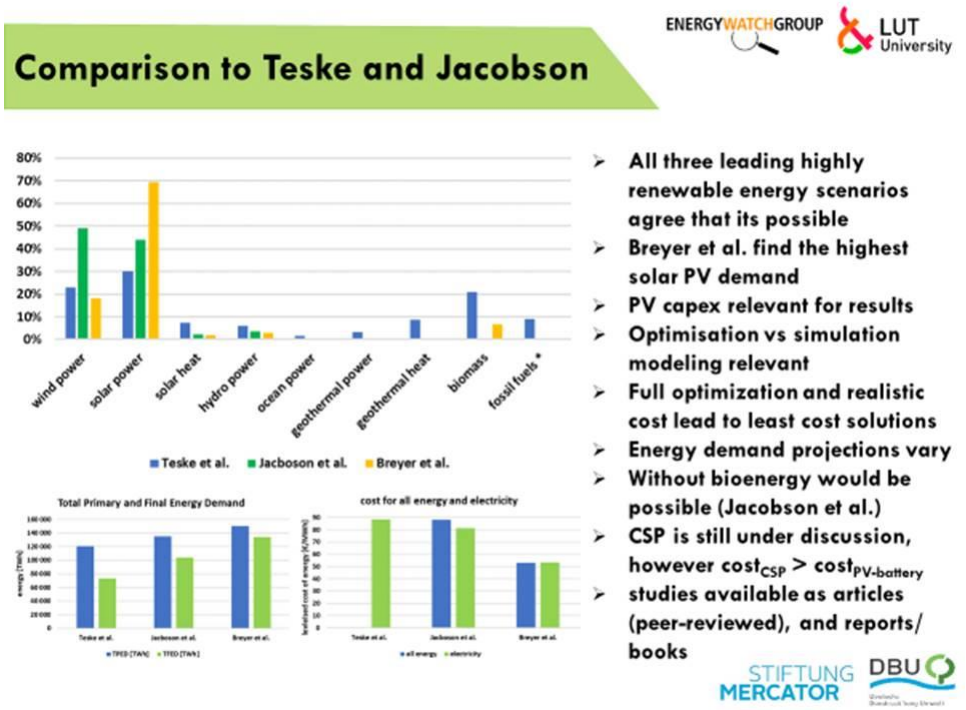
…and the IEA, which presented this slide. (1 GW PV is estimated to yield a little less than 1 TWh.)



LUT University's Christian Breyer thinks ten times more PV will be installed…



… and he pointed to two other scenarios that found estimates of the same order of magnitude:



Asked when the first TW of PV would be installed, replies from the panel ranged from 3-5 years.

Annex 1 – Summaries of presentations

Mark van Stiphout – Deputy Head of Unit, DG ENERGY

Echoing DG RTD Deputy Director General Patrick Child, who last year said "PV has harnessed a small fraction of its vast potential. According to any plausible scenario, photovoltaics is expected to provide a substantial share of global electricity generation and total energy demand," Mark said, "All the analysis points to an ever-larger role of photovoltaics in the future global energy system, with an accelerating demand." He displayed charts showing Europe's share of global PV module production and installations were falling but suggested that by betting on sustainability in module production processes, Europe could rebuild its position in manufacturing.

[Presentation not available]

Prof Christophe Ballif – EPFL & CSEM, Neuchâtel, Switzerland

Christophe made a prediction of the increase in PV capacity. By 2030, he thought production capacity worldwide would reach 1 TW (a tenfold increase compared to today), leading to 25 TW installed by 2050 and the supply of 50% more electricity from PV in that year than the amount of electricity in total consumed by the world in 2017.

Production capacity will increase as the costs of manufacturing PV decline. Mainstream modules are on a path that will lead to 20-22% efficiency around the time that the 1 TW installation milestone is reached. By 2024-2025, he expects, manufacturing costs will reach 20 c€/W_p. That could be the time that tandem cells begin to claim a noticeable market share. They can be made with relative few production steps and they would allow efficiencies above the Shockley-Queisser limit of 29.4% for single-junction cells. Ballif backs perovskites as the layer to add to a silicon subcell.

There is no such thing as a low enough cost of PV, he said. The lower the cost of PV, the more applications people will find for it. He gave many examples, including of PV integrated into watercraft and or multi-coloured PV building elements, like tiles.

He had faith in the power of IT systems to manage the flows of energy generated by myriad distributed PV systems and distributed loads each with their own flexibility, reasoning that IT systems are already today powerful enough to render sophisticated virtual worlds to gamers in real time.

The European industry, though much reduced, still has footholds in all parts of the PV value chain. R&D centres are still strong, providing the surviving companies with new ideas.

[Presentation not available]

Izumi Kaizuka – Deputy Operating Agent, IEA PVPS Task 1/Director, RTS Corporation, Japan

Izumi thought a big increase in worldwide PV production capacity was likely in 2019, bigger in absolute terms than in any previous year. 80% of PV production capacity is in China.

The industry is embracing more efficient technology. Estimated figures for 2018 show an increase in monocrystalline silicon's market share to almost 50% of the market, up from a low of 20% in 2015. China's Top Runner "auction programme" aiming at "high efficiency and high volume" is behind this trend, said Izumi.

She has noticed a trend towards higher efficiency. PERC has been fully adopted by the industry. The first lines producing heterojunction cells are now appearing.

She thinks economies of scale "are approaching the limit" and that future cost reductions will be found in technological improvement.

She thinks modules will be produced close to the places of installation.

Link to presentation: https://drive.google.com/open?id=18O3HCmkEpLVATz0n3KcvCW051ZJCBvfR

Pablo Ralon – IRENA

In the period 2010-2018, the cost of a kWh of electricity PV has declined faster than the cost of electricity from other RES technologies and now is cheaper than fossil fuel technologies. On average across all regions, LCOE has fallen from 0.37 USD/kWh to 0.09 USD/kWh.

Like Izumi, Pablo noticed a trend towards higher efficiency modules: module prices were declining (in USD/W_p), but more slowly than in previous years as producers switch to more expensive (but more productive) modules.

Link to presentation: https://drive.google.com/open?id=1UJYLnKK6ri6qGSRiF456d9IEEQpaecMW

Eero Vartiainen – Fortum Growth Oy

Pablo had pointed to India as the country with the lowest total installed costs of PV. Vartiainen went further saying India is the country in the world where PV is most competitive.

Module costs will decline faster than Balance of System costs (including for inverters and installation). There will continue to be jobs in installing PV for many years to come.

Even if, as Pablo had shown, the *LCOE* of wind and PV is the same, on average across the world in 2018, Eero showed that in Finland the average *price* paid for PV electricity is higher. This is because PV is generated during the day, when spot market prices are higher, while wind electricity is also generated at night, when they are lower.

Eero argued for always stating explicitly alongside any LCOE figure the WACC (weighed average cost of capital) and inflation used in the LCOE calculation, as LCOE is very sensitive to these parameters. In Helsinki the LCOE of a PV system will be 10 €/MWh by 2044 if finance can be arranged at a WACC of 2% or only by 2050 if WACC is 4%. PV needs to be at this LCOE of 10 €/MWh to create the headroom needed to pay for batteries, storage or grid intelligence (see also Ballif's comment that PV can't be too cheap).

In the time it took him to make his presentation, he said another 10 000 modules had been produced – enough for 3 MW.

One speaker thought his 5 c€/W_p projection for the cost of PV in 2050 was too optimistic.

Link to presentation: https://drive.google.com/file/d/1VI13sWVQlOuwYsEJxu-RWHK2XDm6NAI9/view

Grégoire de Pierpont, CEO – Enerdeal

Enerdeal is active on the African market, providing PV power to areas off the grid. The potential market is large: 600 M people are not connected to the grid in sub-saharan Africa. Projects in Africa take time and a company like Enerdeal needs the cashflow from other projects running in parallel to stay afloat. There are risks everywhere, including political risk (Democratic Republic of Congo elections midway through a recent project created danger), legal risk, commercial risk (Client doesn't pay). Having a trusted local in the project is a *sine qua non*. It is very difficult to find finance in Africa for a project, but easy in Europe.

Solar PV is more competitive than diesel generators.

"Our projects create substantially improve people's lives: our lights make streets safer, help companies to be created. Now there's a night-time market in the town where we installed our system. People find uses for the electricity and they want more," he said

Link to presentation: https://drive.google.com/open?id=1rVbNDLpqBCkJgoj8rIgItiAdm99IocCL

Cédric Philibert – IEA

The amount of renewable energy capacity added to the grid each year has remained constant for the past three years, which the IEA thinks is insufficient to meet "long-term climate goals".

By 2040, wind, PV and hydro will be the big three sources of electricity under the IEA's SDS scenario (a scenario for limiting global temperature rises to 2 °C by 2050), each accounting for a roughly equal share of TWh.

Renewable electricity provided at 30 €/MWh makes hydrogen production from water electrolysis cheaper than reforming natural gas without CO_2 capture and storage (and of course more sustainable).

The IEA sees hydrogen being used to green industry before it is used in fuel cells for transport. Philibert listed these areas as the ones "most relevant" for green hydrogen use:

- Greening ammonia and methanol for their current industrial uses
- Refineries (contribute to cleaning fuels)
- Direct iron reduction in steelmaking
- Ammonia as a fuel (shipping, balancing power plants, industrial furnaces)

Christian Breyer – Professor for Solar Economy, LUT University

Breyer and has team have produced several 100% renewable energy scenarios in the past three years. His latest shows that "wind and solar will dominate the 100% world" by 2050. On average, solar (meaning PV to a much greater extent than CSP) will provide 69% of primary energy by that time.

Concerning Europe, whereas Philibert (IEA) expects more growth in Europe in wind than in PV (because, he says, it matches seasonal demand for electricity better), Breyer thinks only a minority of European countries will run "wind turbine-based" energy systems: France, Poland, Finland and the Baltic states. Other European countries will be PV-based systems or mixed (wind + PV + hydro).

"100% renewable energy worldwide is more cost-effective than the current energy system and leads to zero emissions before 2050," he claims. However, the world will need to go carbon negative in the second half of the century to limit temperature rises to 1.5°C.

Link to presentation: https://drive.google.com/open?id=1U-gsgHTkFg9Sk5kTtDRkheeCcTAkRtdn

Jose Donoso – General Director UNEF

Jose pointed to inefficiency in the current market model in Spain, where the spot price is determined from bids coming from all different kinds of energy technology: nuclear and hydro (which have low marginal cost), energy technologies that rely on fossil fuel (which have high marginal cost – they account for 23% of the generation mix). 47% of the time, the clearing price was set by hydro power. At least some hydro bids were therefore well above their typical marginal costs. Prices for consumers are being pushed up by manipulation, he reckons.

The need for capacity payments is a further sign that the market is not "giving the right price signals to encourage the investments needed for the energy transition."

He argued for a split of the spot market into at least two markets "to ensure that competition is held among similar agents, that is, plants of homogeneous technologies with comparable cost structures", also that "Capacity payments should be established through auctions according to the actual needs of the system"

(There is also a market for 'merchant renewables' (e.g. energy supply contracted with PPAs) and renewables supported by regulated tariffs.)

Link to presentation: https://drive.google.com/open?id=18gPv_gbnNNcC3oNQ2YzskULhUDiSpwMl

Annex 2 – Conference conclusions

Marko Topič, Chairman of ETIP-PV, summed up the conference:

Hope for the PV industry in Europe

Challenging the concern expressed by DG ENERGY that the EU had fallen too far behind the rest of the world in the manufacture PV technology, he said that DG ENERGY's analysis focuses on module shipments when there are other measures of success. For example, the PV industry in Europe generates 30 bn EUR per year, Staübli has 45% of the world market in connectors for PV systems and Wacker produces 60 ktonnes poly-Si / year, enough for 15 GW of PV. Meanwhile, ENEL develops projects around the world offering PV power at very low prices via PPAs and Singulus is a provider of top-quality equipment. Representatives of many of these companies were on the panel, and he described them as a PV 'Champions League', pledging ETIP-PV's support for initiatives to strengthen the PV value chain in Europe. He also recalled that Europe has 40% of all patents related to PV, meaning the industry has a good heritage on which to build.

Forecasts

Philibert from IEA had estimated that the world's first TW of PV would come within 4 years, but his institution seems to be pessimistic about the rate at which future TWs will be added, estimating only 6 TW by 2040. IRENA is also pessimistic, with 8 TW/y 2050. These are a long way off Prof Breyer's estimate of 60 TW by that time, which Marko is convinced will be closer to reality – the industry already has half a TW to its name.

New products and markets

Christophe Ballif's speech had been inspiring, showing how R&D is necessary for cost reduction, allowing the integration of PV into new products. These include BIPV, which can help a building's energy performance in some configurations.

Laws must change to make it easier to 'prosume' and to help collectives share access to a system (i.e. foster "energy communities").

Figure 1 Marko Topic delivering conference conclusions in front of a panel he described as the PV Champions' League in Europe because of their activity in PV manufacturing

Annex 3 – Press release

Press release of the ETIP PV conference:

https://etip-pv.eu/news/press-releases/press-release-the-etip-pv-annual-conference-2019-took-place-on-28-may-in-brussels/