**We take solar panels almost completely for granted nowadays, don’t we? I mean they’re literally all over the place, aren’t they? But as recently as fifteen years ago, if I’d predicted that level of market adoption for what was then a prohibitively expensive and rather cumbersome technology, I’d have been laughed out of the room. Some market analysts actually WERE making those kinds of predictions, most notably a visionary called Tony Seba, who I’m sure you’ve heard of and at the time they WERE mostly being laughed out of rooms. Rooms that were populated predominantly by comfortable and rather complacent representatives of the fossil fuel industry, whose strangle hold over global energy markets at the time was absolute and unassailable. Things have changed a bit in the interim though, haven’t they, and to paraphrase an old joke…they not laughing now, are they?**

**You’d be forgiven for thinking that technological advancements and cost reductions in solar photovoltaic technology are nearing the end of their journey by now. I mean, there’s surely not much road left after a price drop of more than ninety percent in ten years, is there? But those in the know say the opposite may be true. They’re suggesting we may be on the cusp of yet another steep market disruption S-curve. And one of the key reasons for that prediction is a little-known material called Perovskite.**

**So as part of our twenty-twenty-four sustainable technology review series, I think it’s time we dived back into the solar PV world to see what all the fuss is about in twenty-twenty-four.**

**Hello and welcome to Just Have a Think**

**When I went back to re-watch my PREVIOUS two videos on the subject of perovskites in solar photovoltaics as part of my preparation for this one, I realised I‘d forgotten just how complex and mind bending the science of capturing photons to make electricity really is. Rather than putting you good folks through the agony of yet another attempt at a fully animated and slightly long-winded explanation of the intricate detail, I’ve left links in the description section below to both of those videos, and instead I’ll just give you the ‘TLDR ‘ summary.**

**One : Physics imposes a limit on how efficient a solar photovoltaic cell can become. It’s all to do with which wavelengths of light physically interact with the receiving material in the cell. Materials that absorb a very wide range of wavelengths typically only deliver a very small voltage, and materials that produce very high, and therefore very useful, voltages typically only capture a very small range of wavelengths, which means most of the energy in the sunlight is wasted.**

**It’s nature’s way of having a bit of a laugh with us.**

**Two: The trade off between voltage and wavelength was established in nineteen-sixty-one by two physicists called William Shockley and Hans Joachim Queisser, and it sets the maximum theoretical efficiency of a photovoltaic cell at about thirty percent, with silicon coming out as the ideal absorber. That’s why the vast majority of solar PV cells today are based on silicon.**

**Three : Perovskite is an inorganic compound that can be produced very precisely and inexpensively at low temperatures in laboratories. It can be chemically manipulated, or ‘tuned’ capture different wavelengths of light to silicon and it does a very nice job indeed of converting that light into electrical energy. It is far more tolerant of imperfections in the production process and because of complicated reasons involving photons and phonons which you can hear all about in my previous videos, it can be made much thinner than a silicon-based cell. A one micrometre thick piece of perovskite film can apparently convert almost as much light to electricity as a two hundred micrometre wafer of silicon.**

**Four : About ten years ago, some clever science types realised that if you applied a thin layer of perovskite film on top of a wafer of silicon you could absorb a far wider spectrum of light, maintain a good working voltage, and in theory overcome that Shockley-Queisser Limit of thirty percent efficiency.**

**Five : In reality perovskites have mostly been a bit of a let-down really. They work beautifully on a lab bench but as soon as you take them outside and expose them to things like moisture and heat and…ultra violet sunlight they tend to degrade extremely quickly.**

**It’s nature’s way of having a bit of a laugh with us!**

**So, the challenge of the last decade, in a nutshell, has been to eradicate the annoying deficiencies of perovskite and amplify the useful advantages. When we last checked on progress, it was a UK company called Oxford PV who looked like they’d come closest to that goal. In twenty-twenty they were just starting to transition from years of laboratory experimentation to a full-sized commercial version of their silicon-perovskite tandem cell, and I’m very pleased to say that, at the time of making this video in early twenty-twenty-four not only are they still going, which is more than can be said for many post-pandemic enterprises, but they’ve now built a new production line at an existing solar PV facility in Brandenburg an der Havel, near Berlin in Germany and they are well on their way to fully automated production of a market ready panel with an efficiency of twenty-eight-point-six percent and a proper outdoor working lifetime of somewhere between twenty-five and thirty years. Achieving that crucial commercially acceptable longevity is actually what has taken up the majority of the company’s time and money over recent years.**

**According to Chief Technology officer, Dr Chris Case -**

 **“The biggest challenge by far is durability and reliability. We already have great efficiency – much greater than current silicon cells – so most of our research and development is spent enhancing reliability.”**

**In January twenty-twenty-four the company was featured in the Global Cleantech one hundred – an annual list of private companies most likely to make a significant market impact over the next five to ten years.**

**The Oxford PV team are not resting on their laurels though. They reckon a commercially affordable perovskite-silicon tandem cell will soon break through the thirty-percent Shockley-Queisser limit and achieve cost-competitive efficiencies as high as thirty-five percent in the not-too-distant future, which brings us neatly to a whole raft of other contenders that have been making a lot of noise in the tech press recently.**

**Never one to miss an investment opportunity, old Bill Gates has sunk a bit of cash into perovskites, via his Breakthrough Energy Ventures project. He’s backing a Massachusetts-based outfit called CubicPV, who are an already well-established solar PV wafer manufacturer. They’re developing a trade-marked technology called Direct Wafer™ manufacturing, which apparently eliminates several of the costly and energy hungry steps in the production of light absorbing wafers today, and instead creates high performance versions of those wafers directly from a bath of molten silicon. They’re now working to combine that with perovskite materials to create their own tandem modules which they claim will offer at least a thirty percent increase in efficiency over the very best conventional silicon modules available on the market today. And in typically bullish free-market style they’re telling the world that they’ve got ‘the strongest patent portfolio in North America’. In particular, they reckon they’ve really nailed the whole durability thing, although the explanation on their website of precisely how they’ve achieved that elusive goal simply tells us that by using ‘better chemistry’ they have built intrinsic stability into the material itself, making it far more robust. Which makes MY EARLIER interpretation of TLDR look a bit like War and Peace.**

**Anyway, the company is taking full advantage of the financial incentives offered by the US Inflation Reduction Act and, according to this twenty-twenty-three article in PV Tech, it’s also secured a hundred and three million dollars of private investment towards the construction of a brand new ten-gigawatt silicon wafer production facility that will also support the development of perovskite tandem cells. So, definitely one to watch for the future I would say.**

**Next up is a group based at the Helmholtz Centre in Berlin, led by Professor Steve Albrecht. They recently published this paper explaining how a single layer of organic molecules can be used as an extremely efficient additional layer to collect charges excited by sunlight in the inorganic perovskite layer below. I’ve linked the paper in the description section of this video so if you enjoy the challenge of making sense of complicated scientific language then, you know – have fun!**

**The layperson’s summary is that Albrecht’s team has achieved efficiencies of up to thirty-two-point-five percent in a silicon-perovskite tandem cell that retained ninety-five percent of its initial power after three hundred hours of operation. Their research forms part of a wider project called Pepperoni, funded by the European Union and the Swiss federal agency SERI. The project includes sixteen other partners with the ultimate aim of building a European pilot line for these ultra-high efficiency perovskite-silicon cells.**

**Another European group, led by Dr. Xin Yu Chin at the Federal Institute of Technology in Lausanne, Switzerland, published THEIR research in twenty-twenty-three explaining how they had been able to modify two different phosphonic acids to improve the crystallization of the perovskite itself, all of which has apparently resulted in an overall cell efficiency of thirty-one-point-two-five percent, albeit from a laboratory cell sample that was only 9:38 one square centimetre in size and with a real-world survival time of only about sixty-six hours.**

**Now we couldn’t do a video about solar PV without mentioning our friends over in the Peoples Republic of China, could we?**

**Fun fact : According to recent analysis by Bloomberg Green, just in twenty-twenty-three alone, China installed an eye- watering two hundred and seventeen gigawatts of additional solar capacity, smashing its own previous record of eighty-seven gigawatts set in twenty-twenty-two and, get this, exceeding the one hundred and seventy-five gigawatts of solar capacity that the United States has installed in its entire history!**

**So, it should come as no great surprise that China has got teams of people beavering away on the perovskite challenge.**

**One of those teams is based at the world’s largest solar panel manufacturer, LONGi, based in Shaanxi Province. In November twenty-twenty-three they claimed to have set a new world record of thirty-three-point nine percent efficiency for a silicon-perovskite tandem cell, beating the previous record of thirty-three-point-seven percent, set in May twenty-twenty-three by the King Abdullah University of Science & Technology in Saudi Arabia.**

**These thirty-percent plus claims are all very impressive and encouraging of course, but there’s a massive caveat with all of them, which is that they’re all coming from those tiny little one centimetre square lab-based experimental cells, so until any of them come rolling off the end of a production line in a real factory with a manufacturers twenty-five year warranty, it seems reasonable to suggest that Oxford PV is surely the most convincing of the current crop of competitors with a real world product that you may well be able to buy for your house in the very near future.**

**It’s not hard to see why so much furious activity in perovskite research is going on though. As I said at the start of the video, solar PV is already the cheapest way to generate electricity in almost every country in the world now. There’s really not much more that can be done to make the manufacture of the panels themselves any cheaper than they already are, so the only other way to keep that graph line falling is to improve the efficiency of power output from the same sized panel, which perovskites appear to be achieving. According to analysis by market consultants Precedence Research, the market for perovskites was worth just ninety-four million US Dollars in twenty-twenty-two, but it’s projected to explode up to something like two-point-five Billion dollars in the next seven or eight years, as more and more experimental research prototypes reach full scale production readiness.**

**So, what d’you think then? Will perovskites transform the market or are they just another flash in the pan? If you’ve got news and views on the subject, then I’ll be very interested to hear them. And as always, the place to leave them is in the comments section below here.**

**That’s it for this week though. A massive thank you to our Patreon supporters, for providing feedback and essential corrections on the early-access versions of all my videos and for helping me keep them free of ads and sponsorship messages.**

**If you’d like to get involved with that activity and influence the direction of the channel’s content, then you can find out all about it at patreon.dot.com forward slash just have a think.**

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**Most importantly, as always, thanks very much for watching! Have a great week, and remember to just have a think.**

**See you next week.**