ENERGY TRANSITION

Why solar energy must not be underestimated by investors

We know that integrating variable renewable technologies, such as solar, into electricity systems is neither impossible nor ruinously expensive – now is the time for investors to think bigger, write *Dr Charles Donovan* and *Dr Ajay Gambhir*.

The Paris Agreement, now more than three years old, is moving beyond pledges and good intentions and facing the realities of implementation. Overall, things are not going well. Against the backdrop of the IPCC's recent report on stabilising global temperatures at 1.5 °C, there's a growing sense of alarm at the yawning gap between business-as-usual and the scientific limits described by the IPCC.

Perhaps most troubling is the fact that policymakers still cannot describe how trillions of dollars of new investment in zero-and-negative emissions technologies will be mobilised from the private sector. That said, pessimists tend to overlook that crucial gains are being made. The brightest spot in an otherwise cloudy picture is solar energy.

Cost competitive

Imperial College London is presently working to articulate strategic pathways by which solar power generation can increase between 50 and 100 times in the next three decades. While exponential rates of growth may sound outlandish to those rooted in the energy sector, it must be recognized that solar – specifically solar photovoltaics (PV) – is fundamentally different from any energy technology that has come before.

In terms of meeting targets for deep and rapid decarbonisation, we see few examples of low-carbon technologies that have reached commercial maturity; are well understood by private sector investors; have proven capability to attract low cost debt capital and, perhaps most crucially, are limitless in scale.

One could be easily forgiven for being surprised at just how much solar power has advanced in terms of cost-competitiveness over the past decade. Not even the most bullish forecasters from 10 years ago would have bet that solar power is today, on an unsubsidised basis, the cheapest way to generate industrial-scale electricity in most countries around the world.

While there is clearly no single technology that could ever fix a problem as complex and varied as greenhouse gas emissions, contradictions are beginning to emerge from a 'technology-neutral' policy agenda.

Economic sense

A look at the emissions reduction scenarios in the IPCC report reveals a significant role for solar in a low-carbon future. In fact, across 42 scenarios which limit long-term global warming to 1.5°C, solar makes up on average one-third of total global primary energy by 2100. In some scenarios, it makes up as much as two-thirds of primary energy. That's a big load to carry for a technology which was invented to power space stations, not replace petrol stations. Is it possible?

We think the answer is yes. But to get there, we need to start thinking a lot more seriously about the variety of technologies that utilise sunlight for energy provision, as well as the economic, financial and market implications of bringing that amount of solar into our energy systems.

It's an often-cited fact that we only need 0.1–0.2% of solar radiation striking the Earth's surface annually to provide our energy needs for that year. With that amount of resource availability, solar has a technical potential to play the leading role in a zero-carbon energy system. Now, we have another reason to believe in solar: its economics.

The solar cost reduction miracle will soon become the stuff of energy folklore. We've seen a relentless ride down the learning curve since the late 1970s, with a near constant 25% cost reduction for each doubling of installed capacity. Now we're seeing solar PV outbidding all other electricity generation technologies in many parts of the world.

Even the oil and gas majors no longer deny its potential dominance in the energy system, with some players moving aggressively back in the solar value chain through acquisitions. This trend will accelerate.

We know that integrating variable renewables like solar PV and wind into electricity systems is not impossible, nor ruinously

One of the earliest uses for solar panels was to provide power to satellites and space stations

expensive. Look at Denmark and California, which see huge shares of intermittent generation put onto the grid without sending the system operator into meltdown.

Grid-integration tools and technologies already exist and are being used to good effect. These include low-cost system planning and operational procedures, such as: better weather forecasting, shorter supply-demand market settlement windows, enhanced coordination with interconnected grids and affordable electricity storage technologies.

There is also a greater role for smarter grids, which employ autonomous demand-side response procedures and near-term convergences with demand from transportation markets (e.g. electric vehicles), industrial markets (e.g. hydrogen) and residential markets (e.g. space heating). Such grids make the incorporation of variable renewable technologies both technically and economically viable.

Integrating solar

So far, so good. But there is a downside – not all low-carbon technologies will necessarily co-exist happily with solar on the grid. Large-scale energy systems models – which are used to forecast our energy future through to the end of the 21st century – have traditionally shown a role for every major low-carbon energy source: renewables, nuclear, biofuels and fossil fuels with carbon capture and storage (CCS). Many models show all of them taking a significant share of generation at the same time, but real-world market dynamics will make this co-existence difficult to achieve.

Owing to their near-zero marginal electricity generation costs, solar PV output will have to be used whenever available. Otherwise, the virtually free units of electricity generated will be wasted, thereby squandering part of the systems' up-front investment costs.

What, then, is the role for fossil fuel plants with carbon capture infrastructure? CCS is a technology that experts know a lot about, but it remains a complete mystery to private sector capital providers. Given the limited track record of projects to date, we know little about the long-term performance and viability of CCS schemes – and even less about how it will perform in a market dominated by variable renewable energy output.

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There has been a near constant 25% cost reduction for each doubling of installed solar capacity

Would nuclear do a better job of baseload generation? Perhaps, but it's difficult to see any commercial bank stepping up to fund a nuclear plant – large or small – when renewables are already undercutting them on price.

In short, without some fundamental changes to the way electricity markets work, there may be no viable economic case for CCS or nuclear. This could create a recipe for disaster in terms of meeting climate targets.

Some tough decisions will need to be made, sooner rather than later. A technology-neutral approach to decarbonising the electricity sector, whether through an emissions performance standard or carbon price, may not be as elegant as it initially seems. We see access to finance as an important lens on energy policy that has, to date, not received enough attention.

Powering a 'moonshot'

Which technologies can be supported by the private sector, given deep uncertainties about how the energy system will evolve? Which regulations and market structures could best unlock predictable returns on investment? Finally, how should access to finance be incorporated into the scenarios we create about the future energy system?

With wind and solar tumbling down their respective learning curves, CCS failing to get near to commercial-scale deployment and nuclear costs rising across many industrialised countries, it may be time to place a bigger bet on solar.

While solar may not be a universally-ordained prescription for successful decarbonisation of the global economy, it's worth re-thinking many existing assumptions about it. So far, many of these expectations have turned out to be wrong. Without more focus on what works for investors, we run the risk of wasting time with a scattergun approach that creates more uncertainty about the road ahead. An 'all-of-the-above' approach to reducing carbon emissions sounds nice, but it may not work.

Solar's inexorable march towards electricity dominance has the potential to spill into disruption of other industries in ways we simply cannot imagine. Just as few predicted the shale oil and gas revolution, many people seem to discount solar's potential for further innovation. Yet big developments are on the horizon.

Solar-generated hydrogen is increasingly exciting researchers and energy planners as a way of creating a long-term, energy-dense fuel store that can be deployed in hard-to-decarbonise sectors such as heating, freight transport and potentially aviation. The electrification of transport through electric vehicles, and the potential to electrify building heating with heat pumps, opens up new pathways for solar PV to dominate primary energy supply.

Given the mistakes that mainstream forecasters have made about solar in this decade, it seems high time to refresh our collective view on solar's innovation potential. In our modern financial system, the greatest sums of capital flow towards low risk, fixed-income investments.

If we're asking the private sector to fund a zero-carbon 'moonshot', then solar may be the best chance we've got. Solar surprised everyone with its incredible improvement in cost performance this decade. We've not got time to miss that boat again. ●

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