Problems with Solar Energy - Why It Is Not More Widely Used

The sun offers the most abundant, reliable and pollution-free power in the world. However, problems with solar energy, namely the expensive cost and inconsistent availability, have prevented it from becoming a more utilized energy source.

Solar power makes up less than 0.5% of all power produced in North America even though there are vast regions of the continent where the sun continuously shines. To harvest more of this free energy, we need to discover new materials, develop new production techniques and solve the problem of storing energy when the sun isn't shining. What is hampering solar power has everything to do with cost. It is five to eleven times more expensive to produce electricity from the sun than it is from coal, hydro or nuclear sources. The first problem is with the cost of the technology:

- Solar panels use expensive semiconductor material to generate electricity directly from sunlight. Semiconductor factories need 'clean' manufacturing environments and are expensive to build & maintain.

- The efficiency of solar cells is only about 22%. The rest of the sunlight that strikes the panel is wasted as heat. More efficient photovoltaic cells have been discovered (up to 43% efficient - see How efficient is solar energy? - but these are still in relatively new and are expensive to manufacture).

It will likely take decades to discover new materials and methods of making solar panels less expensive. How long it takes depends on how much time and money is invested into solar energy research both by government and private industry.

But even if the fundamental cost hurdles of the technology are overcome, there are still other issues:

Installing solar panels on a house is expensive and requires experienced people. These systems used fixed solar panels since alignment systems (see: How to determine the correct angle for solar panels) are too expensive for the average homeowner. The initial investment outlay is a significant factor in why there is a lack of support for solar power from consumers.

Giant solar farms have been built in desert regions and have reduced the installation cost since a larger economy-of-scale is created (parts, material & installation people are in one location). But these large, inexpensive tracks of lands are found far from cities where the power is needed. Expensive transmission lines are needed to bring the power to a distant market.

Maintenance costs and time can add-up since every inch of a solar panel must be kept clean and clear of debris for them to operate at their most efficient. Their efficiency drops drastically even when a small portion is blocked by a leaf or a thin film of dust.

The main problem with solar power that has stifled its use is the fact that energy production only takes place when the sun is shining. Large storage systems need to be developed to provide a constant and reliable source of electricity when the sun isn't shining at night or when a cloud goes overhead.

When solar panels are not producing energy, it takes longer to recoup their installation and maintenance cost. Countries that rely on expensive solar power will be at a severe disadvantage compared to ones that don't or can't use solar power.

Finding a Solution

Scientists need to discover more efficient semiconductors that are more efficient at electricity production. Doubling the efficiency of a panel will reduce the size of the array which will in turn means less space will be required to produce the same amount of power.

Engineers need to develop more efficient production techniques. Mass production of panels in efficient factories will help bring down production costs and make them cheaper for consumers to buy.

New transmission technology is needed to bring the clean energy to market. Energy storage systems will also help smooth out the production bumps caused by climate and atmospheric interruptions.

Until all of these problems with solar energy are overcome, the promise of pollution-free energy from the sun will continue to be only marginally used in our society.

focused on the average cost of solar panels, not specific all-in costs of going solar in your specific location. So, you might be wondering, how much does solar power cost in total?

Naturally, the huge fall in the cost of solar panels has resulted in much lower all-in costs, but those costs vary tremendously across the US due to differences in solar power incentives, solar permitting requirements, other solar power regulations, and the maturity of the solar market in different places.

Really, there's no substitute to simply getting a solar quote. Your situation will be unique. But some research has been conducted to determine average savings and payback times in various places. Actually, as this infographic below shows, research has been done for all 50 states. (Important Note: this research was based on data from 2011 — as I noted on Monday, solar power costs have dropped considerably since then. How much does solar power cost in your state today? You'd have to get a quote and check.)

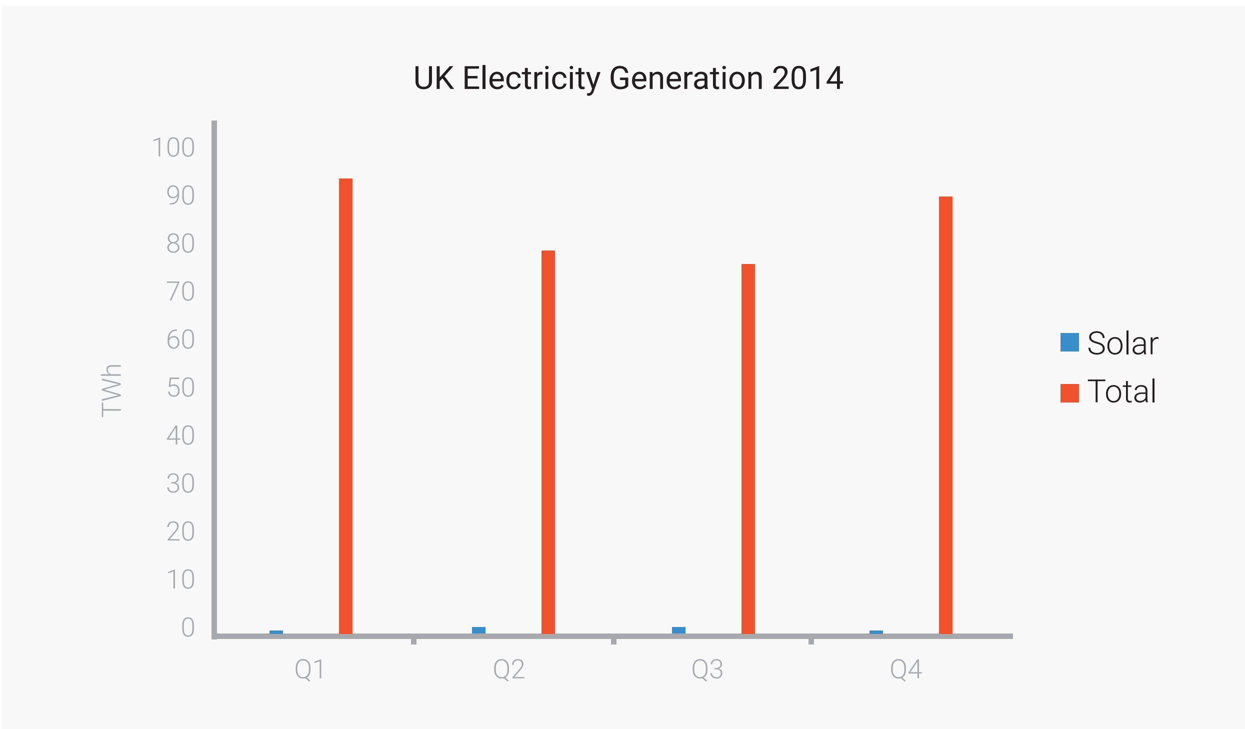
As you can see in the infographic, according to this research, it cost about $10,000 on average for a homeowner to go solar in California in 2011, while at the same time it cost about $25,000 on average for a homeowner to go solar in Florida, the Sunshine State! Again, this is because California has much better solar policies. Nonetheless, even the average Floridian would save $30,000–$39,000 over the course of 20 years by going solar. In California, New York, Nevada, New Mexico, and Arizona, those savings would actually reach beyond $40,000 (on average), but in almost every state in the country, the savings would at least be over $10,000, and would more often than not be over $20,000. Who wouldn't want to cash in on such savings?

So, how much does solar power cost? I think the more important question is, how much does solar power save you?!

What The Solar Industry Forgot To Tell You!

The solar industry has apparently been bragging about how much power it has been producing recently. Unfortunately, they seem to have forgotten to tell us the full story.

In overall terms, solar only generated 1.2% of UK's electricity last year.

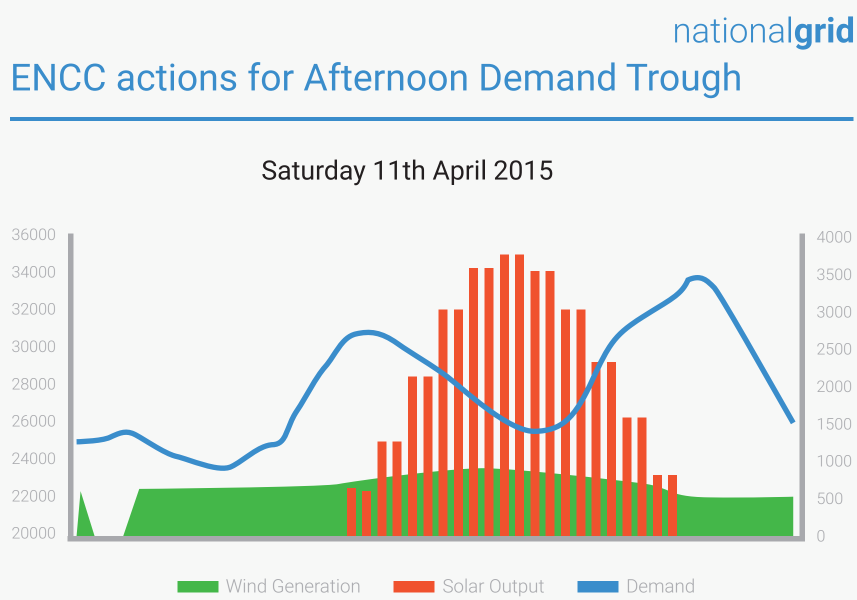


https://www.gov.uk/government/statistics/electricity-section-5-energy-trends

https://www.gov.uk/government/statistics/energy-trends-section-6-renewables

But worse still, in Q1, when demand is at its highest, solar only provided 0.51%.

And if that was not bad enough, when solar power does ramp up on sunny days, it simply provides problems for the grid, as this presentation from the National Grid earlier in the year showed:



At its peak around 2.00pm, solar was contributing about 14% of the UK's total demand on 11th April, which would be around half the peak in winter months. This brought many problems with it, which required these actions from the National Grid:

nationalgrid

ENCC actions for Afternoon Demand Trough

- 2 additional machines bought for coltage management
- Pump storage machine synchronised to meet inertia & downward regulation requirements
- 2500MW wind bought off to create downward regulation
- 8 Wind BMUs held on response

So two additional conventional power stations were brought online for voltage management and 2,500 MW of wind 'bought off' (i.e. constrained) to make room for solar.

According to the Renewable Energy Foundation, "constraint payment records show that payments to wind topped £500,000 on that day. Not all of that will have been caused by solar, but NG's figures suggest that a large part of it was so."

Nobody with more than one brain cell would design an electricity network in this way.

Solar power: the unexpected side effect

The solar ambitions of developing nations look set to deliver more than just electricity. How real are lead poisoning fears?

As the UK lights up its 200th megawatt of solar power, China and India have revealed breathtaking solar ambitions that cast a shadow on the rest of the world. Come 2020, China intends to add 1.6GW of solar capacity while India plans to install a massive 12GW as well as 20 million solar lanterns by 2022. But this wealth of low-carbon renewable energy may have unexpected environmental consequences.

In September last year, US researchers reported that rapid solar power growth in China and India could lead to an unsavoury side effect: lead poisoning. As Professor Chris Cherry from the Department of Civil and Environmental Engineering, Tennessee University, explains, many of these installations will not be connected to the nation's electricity network, but will rely on lead acid batteries to store excess power. This is where the problems start.

Rapidly developing nations do not yet have the tightly regulated recycling infrastructure of, say, Europe and the US to safely process spent lead-acid batteries. Instead, a thriving cottage industry already exists in which hundreds of thousands of informal recyclers collect used lead-acid batteries, mostly from cars and electric scooters, and either take them to small-scale factories where they are crudely smelted or simply break them up themselves. Valuable lead is retrieved – reports estimate the lead in a single battery can provide a month's salary – but at the same time lead powder and fumes leak into the local environment.

The painful results are well documented. Excessive amounts of lead in the blood can damage the digestive, nervous and reproductive systems, and cause stomach aches, anaemia and convulsions. Growing children are particularly vulnerable with moderate lead exposure causing behaviour problems and brain damage.

Already, China has witnessed numerous mass poisoning incidents from domestic lead battery manufacturing and recycling. Most recently, in June last year, at least 600 people, including 103 children, were found to be suffering from lead poisoning in Zhejiang. The Chinese government responded by shutting down nearly 90 per cent of lead-acid battery makers, but industry sources say many have since reopened.

Health reviews carried out by academics in China and India support these tragic incidents with research indicating some 24 per cent of children in China, and 34 per cent in India, have blood lead levels exceeding World Health Organisation safe levels. At the same time, nearly 10 per cent of China's 1.22 million sq kilometres of farmland is reported to be polluted with the remnants of lead as well as zinc and other metal production.

Clearly, the rapidly growing motor industry has fuelled these problems but, realistically, how much will a booming solar industry contribute to what is an already burgeoning problem? A lot, believes Cherry.

"China has an extremely rapid rate of electric scooter adoption... there are more than 100 million electric bikes, each with a car-sized battery that is changed every couple of years, that is a tremendous amount of lead," explains Cherry. "But now on top of that you have this solar ambition and that could bring in another big slug of lead."

According to Cherry's figures, come 2020 China will have produced some 386kt of lead emissions while India will produce 2,030kt thanks to its more ambitious solar plans and 20 million solar lanterns.

Cherry's calculations take into account the lead lost to the environment during battery production and recycling, the number of expected solar installations and how long an actual lead acid battery will last. He adds: "These losses total around one-third of 2009 lead production. They will contribute to soil and dust contamination in these countries and result in exposures to children and workers in manufacturing and recycling operations."

China and India's solar ambitions are likely to be repeated. For example, huge swathes of Africa's population do not yet have access to electricity, so small-scale solar technology holds great promise. Worryingly, lead-acid batteries are the only energy storage technology in this region but as Cherry says: "Africa is even more dire in terms of its ability to recycle the batteries that would support solar power."

Network connections

But despite the trends for developing nations to install more solar capacity, the impact on lead emissions largely depends on how much of the yet-to-be-installed generation will be connected to the grid and how much will stand alone, providing off-grid power to communities not connected to an electricity network. Only the latter strictly requires back-up power, most likely a lead acid battery.

Cherry is certain a lot of off-grid solar power systems are coming, as factored into his calculations. As he says, both Chinese and Indian governments are pouring money into electrifying rural regions not connected to the grid. In India, though, almost 25 per cent of its 80,000 villages currently without electricity cannot be connected to the grid, and will therefore require some form of renewable generation.

Meanwhile, China has far fewer areas off the electricity grid but more than 700 small village power stations are already installed. Indeed, in 2006, only 3 per cent of the nation's solar capacity was grid connected, compared to 88 per cent globally.

As Cherry also points out, photovoltaic systems may still use lead-acid battery back-up power even if connected to an electricity network. His studies indicate some 75 per cent of all existing photovoltaic units in China have a lead-acid battery. Here, many grid-connected units use lead acid batteries for storage as not all utilities buy power back from small-scale solar units. In addition, battery storage mitigates technical issues such as localised voltage fluctuations, voltage flicker and fluctuating power loads.

But what does the solar power industry make of Cherry's assertions? At present, key players either disagree or appear unaware of any potential issues.

When the European Photovoltaic Industry Association was asked to comment on the increasing use of solar cells in developing countries and problems with lead acid battery recycling, head of political communications Craig Winneker replied: "I'm sorry but I don't really have any information to provide you on this subject."

Communications manager, Pia Alina Lange from the European photovoltaic recycling organisation, PV Cycle, says: "We offer take-back and recycling services for PV modules but do not cover batteries in our services."

Several photovoltaic manufacturers declined an interview, although Brandon Mitchener, communications director from Belgium-based First Solar, stated his firm's panels will be grid-connected and as such he was unaware of batteries being used. First Solar develops cadmium telluride thin-film solar modules and has recently won several contracts to install systems in India.

Meanwhile, Dan Davies, chief technology officer of SolarCentury, which designs, makes and installs solar panels purely in the UK, also stated that most of the solar panel systems planned in China and India will be grid-connected. He believes Cherry's research is only relevant to off-grid solar panel systems and the calculations on lead emissions depicted a "worst-case scenario".

Only time will tell how much of India's and China's new wave of solar generation is connected to the grid, and how many lead acid batteries are used. But as Davies also points out, Cherry has 'raised a flag' to an environmental issue that could take place as more solar power is installed in developing nations. So what should happen next?

Davies says the automotive industry has not yet solved the problem of lead poisoning arising from the recycling of car batteries, so why burden the solar industry with this responsibility? He suggests the solar industry works with battery and automotive industries to develop better recycling.

For his part, Cherry believes solar companies must now incorporate the collection of used lead acid batteries into their business models. "Good product stewardship must include tracking the location of batteries in these systems and offering a reward or deposit system for returning the battery to a central location," he says.

However, as Cherry concedes, geography is a problem in China and India; lead batteries are widely distributed across each nation, making it easy for the informal recycling sector to retrieve used batteries and smelt them locally. "You've got to develop a pretty sophisticated reverse distribution system to get these batteries back to a centralised location," he adds.

This is where government groups have a crucial role to play. Cherry and colleagues are adamant that governments can also play a role in controlling pollution from backyard recycling operations by regulating the collection of lead acid batteries. Indeed, they have already been working with environment protection agencies in China and Vietnam to develop policies that encourage formal recycling. But as Cherry emphasises, this is not easy.

For one, encouraging formal recycling will lead to unemployment for the thousands of informal recyclers scattered across these nations. As Cherry says, any moves towards official recycling systems must find ways to include these informal recyclers, either as collectors or distributors.

Secondly, government policies need to be reinforced continually to be effective. "Having been to China enough times it is clear that government comes up with policies that often have little teeth. Strict draconian-style regulation will come through and operations will be shut down but a year later everything is back to the way it was," says Cherry. "It's very hard to regulate the informal sector."

Alternative technologies

While governments grapple with regulation, new technologies could help to counter lead poisoning problems. Lower-lead content batteries with improved lifetimes are under commercialisation while storage technologies are being honed that could make the relatively cheap lead acid battery less appealing. For example, lithium ion batteries cost up to four times more per kWh than lead acid cells, but this could change.

Researchers from the UK's University of Cambridge have developed a simple method for recycling lead acid batteries that, according to pioneer Dr R Vasant Kumar, could be easily adopted in developing nations. Spent battery paste is mixed with citric acid to produce crystallites that are then heated to 350°C giving a mixture of lead and lead oxide. This can be used to make new lead battery paste.

Kumar's novel recycling process has already received interest from organisations in several developing nations including China, India, Vietnam and Latin America and his team now plans to set up pilot plants in India and China within the next two years. The academic is hopeful that the process will then be transferred to these nation's informal lead recycling industries, bringing, as he says, "great social improvement".

"I have visited some small plants in villages that recycle lead. They throw away the lead paste - they are not aware of its value but the temperature required to melt it is so high," he says. "Around two-thirds of the battery weight goes into the environment, this loss is tremendously hazardous for the surrounding population."

Kumar's numerous visits to India and China, brought home the painful lead recycling issues plaguing these nations. Like Cherry, he noted the complex problems governments face.

"Have no doubt that what you read about lead poisoning is true. Yes, the rules and regulations exist but implementation is not easy," he concludes. "Hundreds of thousands of people are working in the [informal lead recycling] industry, many families work together to scale the industry. Government does not want to take away the livelihood of these people but at the same time does not want them to be poisoning themselves. It's a very hard task."

To produce 1 MW of solar power using PV cells how much space is required?

With ~250 watt panels the absolute minimum number you would need is ~4000 panels.

At 17.6 sq ft per panel, that means you would need ~70,400 square feet (or 6540 sq meters)

Since that is maximum output in perfect conditions, I would say to consistently put out 1MW of power near solar noon on sunny days you would need to almost double that, so I would say ~ 10,000 sq meters.