The Economist

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# Solar energy

*Can solar energy save the world?*

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# Opening statements

## Defending the motion

**Richard M. Swanson**

*Founder, SunPower Corporation*

Photovoltaics prices have declined 50% in the past five years, and plans are in place for another 50% decrease. When achieved, photovoltaics will be among the lowest cost options for generating electric energy.

## Against the motion

**Benny Peiser**

*Director, Global Warming Policy Foundation*

Despite more than 30 years of research, development and deployment, solar energy has been unable to solve the inherent and obdurate problems that make this technology uneconomic for the foreseeable future.

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# The moderator's opening remarks

Oct 29th 2013 | Mr Geoff Carr

As Richard Swanson observes, this motion depends on whether the world needs saving, and if so, from what?

There are two conventional answers to the second question. One is, "from the effects of climate change brought about by man-made global warming". The other is, "from dependence on fossil fuels that are, by definition, a finite resource".

Both of these answers are challengeable. Few informed people doubt that humanity's outpourings of greenhouse gases, particularly carbon dioxide, are altering the climate. But there is doubt over both how big that effect will be and whether the response should be to try to stop the change or to adapt to it. The former would certainly require an all-hands-to-the-pumps approach to alternative energy, in which solar power would play an important—and probably eventually dominant—role. The latter would argue for business as usual, with access to the cheapest energy sources (ie, at the moment, fossil fuels) to help bring about the economic growth that will (inter many alia) help pay for adaptation to an altered climate.

Similarly, as the rise of fracking has shown, previously inaccessible sources of fossil fuels can be made accessible by technological advance. And yet more untapped resources are known to exist even now, such as methane trapped at the bottom of the sea in icy structures called clathrates. With such abundance, why invest in solar power?

But demand for energy is growing fast—doubling every 40 years. Put another way, human beings will, unless something changes drastically, use about as much energy over the next four decades as they have done in the whole of the past. Humanity and nature, then, are playing a game similar to the wheat-on-the-chessboard game proposed in fable by a cunning subject to a mathematically naive monarch who wanted to reward him. Some of those who see this game ending in disaster for Homo sapiens suggest anticipating the problem by honing solar technologies now—even though they are not sustainable without subsidy—so that they can be deployed rapidly when needed.

Intriguingly, both proposer and opposer have focused on the case of Germany—and have managed to draw diametrically opposing conclusions in doing so.

Mr Swanson notes that renewables supply a quarter of Germany's electricity needs; that solar alone supplies 5% (and on sunny summer days, up to 40%); and that a third of the world's solar cells are installed there. Clearly, in his view, those cells are a force for good.

Benny Peisner, by contrast, points out that Germany has the second most expensive electricity in Europe; that its subsidy bill for green energy is €20 billion ($28 billion) a year; and that during the winter it has to import power from its neighbours. In his view, the country is teetering on the edge of suffering blackouts.

One reason for the imports is obviously that Germany is not a particularly sunny place, especially in winter. But countries farther south are. With a suitable intercontinental power grid, it would be possible for northern European countries to switch to solar energy by importing it, rather than generating it in situ.

For Europe, that would bring other problems, since many of the sunniest nearby countries have governments of questionable stability and unquestionable noxiousness. But places such as America, which have sunny deserts within their territories, might find moving solar energy around in this way more feasible.

That leads to another possibility, which is that the world does not actually need solar power to save it but will get it anyway—simply because it will prove better than the alternatives. This argument depends on the fact that sunlight is free, and the running costs of at least the simplest sort of solar power-station, one made of photovoltaic solar cells, are thus minimal. Get the capital costs of such technology low enough (which does seem to be happening) and solve the problem of overnight storage (a harder task, but one that many are working on, with ideas from using holes in the ground to store compressed air to building huge batteries from cheap materials), and market economics will do the rest.

The question of the future role of solar energy is thus rich with possibility. It should be a fascinating debate.

Skip to... **Moderator** | **Pro** | **Con**

# The proposer's opening remarks

Oct 29th 2013 | Richard M. Swanson

"Can solar energy save the world?" Solar energy surely cannot save the world (assuming it does need saving) all by itself. I assume that our debate moderator is speaking somewhat hyperbolically for the purpose of dramatic impact. The world is, however, in the midst of an evolution in its energy infrastructure. As we strive to decrease the pollution damage inherent in our current fossil-fuel-intensive society, there is an exciting smorgasbord of technologies stepping up to contribute. These include solar energy, but also a dizzying array of options such as energy-efficiency improvements in building, industry and transport; other renewables such as wind (which is solar after all), geothermal and biomass; smart grids with features such as demand-side management; distributed and central storage to handle the variability of wind and solar; and improved long-distance power transmission to further smooth this variability. Even traditional sources are evolving to better compete, with the continuing advance of natural gas, displacing coal and its higher emissions, cleaner coal with the possibility of carbon capture and sequestration, and even nuclear with the possibility of new concepts that may greatly reduce cost and risk. All these technologies will be competing in a dynamic marketplace. The relative importance of each over time will be determined by how well their developers continue to reduce costs, and to a lesser extent by government policies.

Indeed, this transformation of our energy system is well under way. It often surprises people to learn that during the past three years within the European Union, photovoltaics, wind and natural gas contributed nearly all the new installed electric generation capacity. In 2012, photovoltaics added 17 gigawatts (GW), wind 12GW and natural gas 5GW (net of retirements). Coal and nuclear were negative due to plant retirements. To better foresee how this may play out, one need look no further than Germany as a case study. Germany, with over six times the population density of America and half the solar resource per unit area, has become the global renewable-energy leader among large countries. Sceptics often state that solar and wind cannot provide sufficient energy to run a modern economy. Last year, renewables supplied over 25% of Germany's electric energy consumption. Photovoltaics alone supplied over 5%, up from zero ten years ago. (One-third of the world's photovoltaic modules are installed in Germany.) On sunny days photovoltaics often supplies 30-40% of the electricity demand. The German electricity grid has dealt with this influx without the significant disruption also predicted by sceptics. The German government plans for continued expansion of renewable energy. The 2050 target is for renewables to account for 80% of electricity production.

So it can be done, but how about costs? Photovoltaics has historically been much more expensive than conventional generation; however, thanks in part to the large German market, massive increases in manufacturing scale have resulted in rapidly decreasing prices. In 2012 a historic milestone was reached where German residences were compensated for their rooftop photovoltaic production at less than the prevailing residential electricity retail rate. By June 2013, the feed-in tariff for residential generation had dropped to €0.15 per kilowatt hour (kWh) while the average retail electricity purchase rate was €0.25/kWh. Despite being paid less than the retail rate, homeowners continue to install systems because they still generate attractive returns. Large ground-mounted photovoltaic plants are now compensated at about €0.10/kWh. This is comparable to the cost from coal power when externalities (health costs, etc) are included, and similar to what large industries pay for their electricity. A further 40-50% cost reduction is needed for photovoltaics to compete with the coal cost when externalities are not included. Few in the industry doubt that this is achievable within ten years. System prices have declined 50% in the past five years, and plans are in place for another 50% decrease. When achieved, photovoltaics will be among the lowest cost options for generating electric energy, even in sun-starved Germany. Much of the sunny parts of the world will enjoy this benefit sooner, or, as in Italy, already do.

It is true that German consumers have supported this remarkable story by surcharges on their electric bills. Did this surcharge hurt the German economy? Hardly, as it is the strongest in Europe. Did it create unemployment? No, the German unemployment rate of 5.3% is quite low, lower than in America or the UK for example. What it did help create is a new, non-polluting and renewable energy source for the world. I believe we owe Germany a debt of gratitude for shining a bright light on what is possible with renewable energy. Fortunately, other countries are also now beginning to take up the challenge, with particular success of late in America, Japan and China. The renewable revolution is well under way.

Skip to... **Moderator** | **Pro** | **Con**

# The opposition's opening remarks

Oct 29th 2013 | Benny Peiser

Despite more than 30 years of research, development and deployment, solar energy has been unable to solve the inherent and obdurate problems that make this technology uneconomic for the foreseeable future.

The pitfalls of solar energy are fourfold:

• First, solar energy remains too expensive and can subsist only with the support of government handouts or solar subsidies.

• Second, its multibillion subsidies are causing economic hardship and social conflict as huge amounts of money are being transferred from poor and ordinary families to wealthy green investors.

• Third, photovoltaic energy generation is too irregular and causes huge knock-on problems as a result.

• And finally, where large-scale solar energy competes with conventional energy at a sizeable level, the entire electrical grid faces disruptions and economic damage.

Germany, which has long been the world leader in generating solar electricity, is the best and worst case in point. It demonstrates why solar isn't working.

More than half of the world's solar panels are installed in Germany. But solar energy is notoriously unreliable as a power source no matter how much a country has installed. Solar subsidies for German financiers are extremely generous. They guarantee investors an 8-10% annual return for 20 years. Given such an unparalleled offer, it is not surprising that more than a million German families already have installed solar panels.

However, Germany's unmatched solar boom has saddled the country with obligations of more than €130 billion in subsidies, leading to ever-rising energy prices. These billions are being paid by ordinary families and small and medium-sized businesses in what is undoubtedly one of the biggest wealth transfers from poor to rich in modern European history.

Germany's renewable energy levy, which subsidises green energy production, rose from €14 billion to €20 billion in just one year. Since the introduction of the levy in 2000, German consumers' electricity bills have doubled. Germany has the second most expensive electricity in Europe, with an average price of €0.27 per kilowatt hour. No wonder the chancellor, Angela Merkel, has warned that the rapid expansion of green energy programmes is weakening Germany's competitive advantage in the global economy.

As wealthy homeowners and businesses owners install solar panels on their houses and commercial buildings, low-income families, living in rented apartments, have to foot rocketing electricity bills. Many can no longer afford to pay, so the utilities are cutting off their power.

The German Association of Energy Consumers estimates that up to 800,000 Germans have had their power cut off because they couldn't pay the country's rising electricity bills. As Der Spiegel warned last month, solar subsidies are turning electricity into a luxury good, threatening to bring down the country's green energy transition.

On June 6th this year, Germany's solar power production touched a new record of 23.4 gigawatts, meeting almost 40% of the country's entire peak electricity demand. But to understand that this world record is quite meaningless, consider the grid's narrow escape last winter. For many weeks in December and January, Germany's 1.1m solar power systems generated almost no electricity. During much of those overcast winter months, solar panels more or less stopped generating electricity. To prevent blackouts, grid operators had to import nuclear energy from France and the Czech Republic and power up an old oil-fired power plant in Austria.

The government is increasingly concerned about the detrimental impact of solar energy on electricity prices and the stability of the national grid. To stop the solar boom, the government has reduced feed-in tariffs for photovoltaic schemes in the past few years. Since 2010 more than 5,000 companies involved in the solar business have closed, shedding tens of thousands of green jobs.

During the past 12 months, the wave of bankruptcies in solar has devastated much of German industry, while solar investors have lost almost €25 billion on the stockmarket. Now that the new government plans to phase out subsidies altogether, the solar industry is likely to disappear by the end of the decade.

Of all the unintended consequences of Germany's Energiewende perhaps the most extraordinary is the devastating effect of solar (and wind) power generation on the price of electricity generated by natural gas. Almost 20% of gas power plants in Germany have become unprofitable and face shutdown as renewables flood the electricity grid with preferential energy. To avoid blackouts, the government has had to subsidise uneconomic gas and coal power stations so that they can be used as a back-up when the sun is not shining and renewables fail to generate sufficient electricity.

No wonder that a growing number of European countries are cutting back subsidies while others, such as Spain and the Czech Republic, have ended support for renewables altogether. Germany too has been scaling back its generous state support. Mrs Merkel has promised to phase out solar subsidies altogether in the next few years. And once the gravy train stops, the future of solar will darken.

## Audience participation

**Comments from the floor.**
**Featured guest:** Matthew Stepp

# Featured guest

Amory Lovins

Solar photovoltaic cells (PVs) produced about 0.7% of global electricity in 2012 from 100 gigawatts (billion watts) of capacity, wind power 3% from 283GW and other renewables (excluding big hydro dams) about 1.5% from 97GW. Yet many utilities consider these modest sources' plummeting costs, increasingly competitive prices and swift scaling to pose a mortal threat, or a transformational opportunity, or both.

Solar-cell prices fall 30% with each doubling of cumulative production. They fell at least 30% in 2012 alone. Once $100 per watt, then $10, they are now around $0.60, soon will be $0.40. Already halved "balance-of-system" costs—customer acquisition, approvals, interconnections, installation, wiring, inverter—keep falling too. By adding 30GW, Germany cut installed system costs to half the American average for the same equipment. Yet even at twice the German cost, utility-scale solar power in sunnier American regions has fallen below $70 per megawatt hour (mWh) net of a 30% federal tax credit (smaller than many non-renewables' subsidies). That's three times the lowest Mid-Western wind-power price, half the Hinkley Point nuclear price and cheaper than efficient new gas-fired power plants.

Gas prices are rising, and the market value of their volatility adds at least $10-20/mWh. Yet solar power, like wind power, typically sells on 30-year fixed nominal-price (declining real-price) contracts, hedging the gas-price risk. Moreover, solar power on your roof, like most in Germany, avoids a $30-50/mWh delivery cost.

Bloomberg New Energy Finance recently forecast solar power would reach grid parity in three-quarters of world markets in 18 months. Today in 20 American states, private firms install rooftop solar power with no down payment and beat utility prices. As solar costs fall and utility tariffs rise, "no-money-down" could turn to "cash-back", further speeding adoption. The San Diego utility expects solar output to idle its fossil-fuelled power stations on sunny afternoons by 2015-16. And by 2015, China aims to boost its solar power to 35GW—about what the world installs each year.

Solar power increased by 60% a year during 2007-12 because it is a mass-produced manufactured product. In the decade needed to build a multibillion-dollar electricity-generating cathedral, you can build each year a PV factory, making solar cells each year that can produce each year as much electricity as your central station. Thus solar cells are proliferating faster than mobile phones. In poor countries, 1.4 billion people without electricity can sidestep power lines. In all countries, solar power and other equally unregulated products can add up to a "virtual utility", bypassing electricity companies just as mobile phones bypassed wire-based phone companies. This gives utility executives nightmares and venture capitalists sweet dreams.

In liberalised power markets, wind and solar power are destroying utilities' traditional business model: competition makes central stations run less and get lower prices. Germany's wholesale power price has fallen by three-fifths since 2008, and on hot afternoons when electricity is often most valuable and profitable, solar output is greatest. Some wrong-footed utilities and fuel vendors spread disinformation about their renewable rivals—especially about Germany's impressive successes.

A persistent fiction holds that because PV and wind power are variable, they are unreliable, needing back-up by "24/7" or "base-load" fossil-fuel and nuclear stations. Actually, those giant stations' intermittence (unforecastable failures) requires costly reserves so the grid can back up failed plants with working ones. But well-designed renewable portfolios often need less back-up. The grid can offset varying solar and wind output (both more accurately forecastable than demand) by diversifying their type and location, then integrating other renewables (dispatchable whenever needed), flexible demand, and distributed storage in smart electric vehicles and ice-storage air conditioning. Such a portfolio can reliably power the isolated Texas grid with 100% renewables, with no bulk electricity storage and only 5% leftover renewable energy.

As flexible demand and distributed intelligence make the grid more agile, such choreography made Europe's most reliable electricity (in Germany and Denmark) respectively 23% and 41% renewable in 2012, and in the first half of 2013, Spain's electricity 48% and Portugal's 70% renewable. Ignoring such data, flat-earthers still proclaim minuscule renewable potential.

The renewable revolution is accelerating. Half of American and 69% of European capacity added in 2012 was renewable. China, Japan, Germany and India now produce less electricity from nuclear power than from non-hydro renewables, which in 2012 added more Chinese electricity than all nuclear and fossil sources combined. Globally each year, non-hydro renewables win $250 billion of private investment and add more than 80 billion watts, with solar expected to pass wind power this year.

Modern renewables are taking over the market because they have lower costs and risks than fossil or nuclear energy. Together with rapidly evolving energy efficiency, they more than suffice to power the world profitably and resiliently.

Rocky Mountain Institute's 2011 synthesis "Reinventing Fire" showed how a 2.6-fold bigger 2050 American economy could eliminate coal, oil and nuclear energy and cut natural gas use by one-third, treble energy efficiency, shift from one-tenth to three-quarters renewable supply, emit 82-86% less carbon, make the grid resilient and save $5 trillion—all without internalisation, new invention, or acts of Congress, the transition led by business for profit. So far, solar costs have fallen much faster than we assumed. Efficiency and renewables could well save the world, not at a cost but at a handsome profit. We just need to notice what's happening.

**Reader Comments**
**Featured guest:** Matthew Stepp

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