Renewable energy can power the world by 2030

Renewable energy sources could produce all the energy the world needs in as little as 20 years from now and at a lower cost than the present energy mix, two American experts claim.

Renewable energy can supply all the energy the world needs by 2030, and it will cost less than keeping the energy mix we have, according to two US energy system researchers in *Scientific American*.

A plan for a sustainable future. How to get all energy from wind, water and solar power by 2030 read the cover story of the November 2009 issue of *Scientific American*.

The article, written by the energy researchers Mark Z Jacobson at Stanford University and Mark A. Delucchi at UCLA, claims that not only can renewables do the job: they can do it without nuclear power or carbon capture and storage, without biomass and with only technology that works now.

And it won't cost any more than sticking to the energy mix we have now.

The way they do it is very simple. They want us to build 3.8 million wind power stations at five megawatts (MW) each, 49,000 concentrating solar power plants of 300 MW each, 40,000 photovoltaic plants also of 300 MW, 1.7 billion rooftop photovoltaic installations, 490,000 tidal turbines, 720,000 wave power converters and 5,350 geothermal plants.

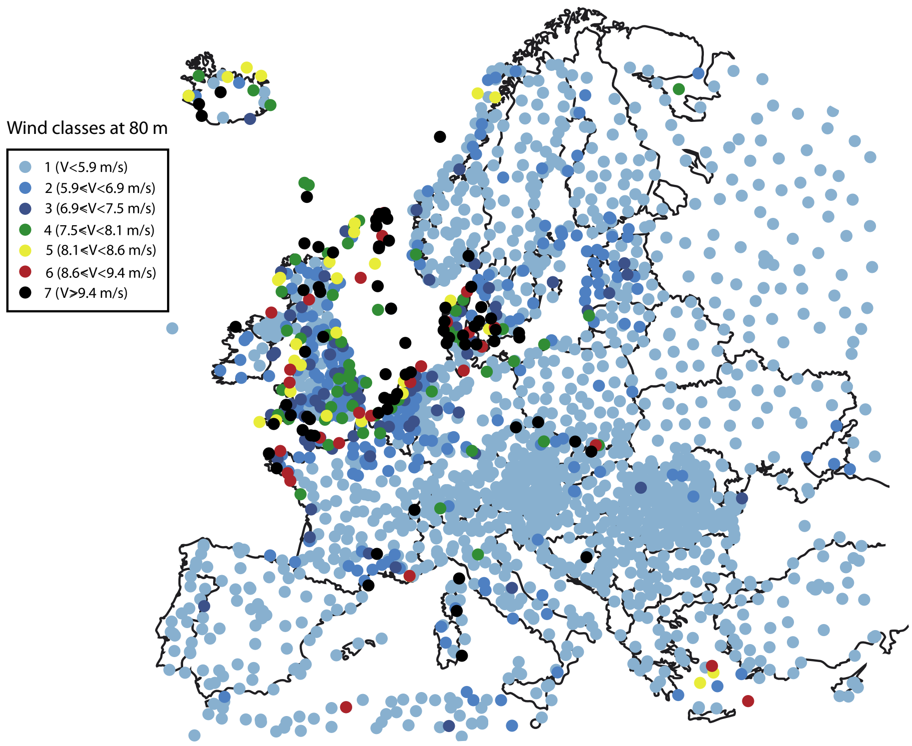
Their plan is all-electric. Electric vehicles, electric heating. This has several advantages.

- One is that it is easier to follow: in this vision all energy is equal. The energy or rather average output is expressed as terawatts (TW), i.e. thousands of gigawatts, a gigawatt being the typical output of a nuclear or coal power unit.
- It is also inherently conservative: there may be cheaper, simpler and faster methods to heat buildings, for example by solar water heating or by energy efficiency measures, so parts of the electricity will not be needed. If so, fewer wind turbines etc will be needed.
- Electricity can save energy, especially for vehicles. The authors take the projected world energy demand in 2030 calculated by the US Department of Energy as16.9 TW (from 12.5 TW today), which for this reason is reduced to 11.5 TW. For example, only 17 to 20 per cent of the energy in gasoline is used to move a vehicle (the rest is wasted as heat), whereas 75 to 86 per cent of the electricity delivered to an electric vehicle goes into motion.

There is no doubt that the resources of wind and solar are adequate. But there are a number of question marks.

Can so much be built so fast? To build that much new power capacity in 20 years is certainly a huge undertaking. But it can be done, according to Jacobson and Delucchi. Taking a historical parallel: "During World War II, the US retooled automobile factories to produce 300,000 aircraft, and other countries produced 486,000 more."

Will the world run out of some rare materials? The authors identify six possible hurdles: silver for solar cells, neodymium for wind power gearboxes, tellurium and indium for some



Energy Technology	Rated power/plant (MW)	Per cent of energy 2030	Number needed, world
Wind turbine	5	50	3.8 million
Wave device	0.75	1	720,000
Geothermal plant	100	4	5,350
Hydroelectric plant	1300	4	900
Tidal turbine	1	1	490,000
Roof PV[1] system	0.003	6	1.7 billion
Solar PV[1] plant	300	14	40,000
CSP[2] plant	300	20	49,000

Table: A vision of the global energy situation 2030.

1 PV=Photovoltaics

2 CSP=Concentrating Solar Power.

solar cells, platinum for hydrogen fuel cells and lithium for car batteries, but envisage methods to either bypass or reduce the problem, such as more efficient recycling of materials, or wind power without gearboxes.

Won't it cost the earth? It will not come cheap: the authors estimate the price tag as being on "the order of 100 trillion dollars", excluding transmission. But anything else will also cost: coal power (with carbon capture and storage, CCS), nuclear, etc. And though renewable energy is more demanding for the grid than just building new plant on the same sites as the old ones, this is not always an option and huge investments in the grid are foreseen anyway. As for wind power, the cost is already about the same as for new coal or natural gas power. If external costs for pollution and climate change are included, wind power is cheaper. The other major component, solar, is expensive now, but costs are expected to fall considerably over the next ten years.

And when the wind does not blow? The authors see several methods to deal with this, i.e. to mitigate the intermittency of most renewables. One is to have steady flow from geothermal and tidal power. One is to use hydropower (for which they envisage some expansion) for flexibility. One is to let wind power even out itself: if the wind is weak in one place, it is often stronger at some distance. "For example, interconnecting wind farms that are only 100 to 200 miles apart can compensate for hours of zero power at any one farm should the wind not be blowing there." Also, wind and solar are usually complementary, windy weather is often cloudy weather, and hot days with little wind will produce more solar power.

This may sound optimistic, but on real electric grids, the operators keep proving that even extreme intermittencies can be handled. Just after the article was published, in the early hours of November 8, Spain for a moment got more than 50 per cent of its electricity from wind power. Three months earlier the wind power contribution was at a low of just one per cent. On neither occasion did the grid collapse.

The demand can also help to match varying supply. The scenario calls for a phase-out of fossil fuel transport to be replaced by electric cars. By use of smart meters, more cars can be charged when supply is strong. In a more detailed analysis, submitted to Energy Policy[1], Jacobson and Delucchi also point to the possibility of storing surplus energy as hydrogen or in thermal storage, for later use.

Obviously, the study is a kind of thought experiment. It shows one possible future, not an optimized future, as that demands detailed discussion far beyond the reach of the interested layman or legislator.

The realism can be contested. But it is robust in the sense that it does not depend on speculative technology. True, five-megawatt wind power turbines are not commercial yet, but three-megawatt turbines are, so the extrapolation is reasonable. Even larger turbines are clearly conceivable and will surely be more efficient and in all likelihood more economic. Electric cars have not yet established any significant market, but even the imperfect electric cars of today (with respect to range and charging difficulties) would win great acceptance if the alternative is fossil cars without fuel or with extremely expensive fuel.

As the ensuing debate (152 comments published on the Scientific American web) shows, some elements of the scenario are contested. Some of them are however more supportive than disruptive: people have pointed to unused options, such as sustainable biomass, geothermal heat by heat pumps, innovative transit technologies and the fact that energy efficiency is not credited enough. (Many commentators also missed nuclear power.)

As for nature conservation NGOs, tidal power is controversial to say the least and more hydro is not welcome. But they are not decisive: tidal and additional hydro combined represent just two per cent of the Jacobson-Delucchi scenario.

Is it realistic to have four per cent from wave power? We will probably know within a few years, as testing is underway. If the wave power converters work reliably, they will need lower subsidies than solar cells to make money and less need for balancing than wind power.

The Scientific American article can be downloaded from www.stanford.edu/group/efmh/jacobson/sad1109Jaco5p.indd.pdf

1 www.stanford.edu/group/efmh/jacobson/PDF%20files/JDEnPolicy24Jan2010.pdf

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