

Small

is Powerful

AMORY B. LOVINS describes how the decentralised and efficient use of renewable energy is the key to clean development

Decentralised renewable energy is finally coming of age and is already serving tens of millions of people. In 2004 nearly 17 per cent of the world's primary energy and 19 per cent of its electricity was renewable. Most renewable energy came from noncommercial biofuels and big hydroelectric dams, but an eighth of the primary energy and a sixth of the electricity came from decentralised renewables. Two million households now have solar lighting, 16 million have biogas, and nearly 40 million have solar water heaters.

Global investment

The remarkable *Renewables 2005 Global Status Report* spells it out. Some 8.2 per cent of the world's hydroelectricity, for example, came from small hydropower (involving units up to 30 million watts, or MW) in 2004. That year China alone added nearly as much small hydro (4 billion watts, or GW) as the whole world added nuclear power (4.7 GW).

By the end of 2004, renewable 'micropower' of all kinds added up to 160 GW—4 per cent of the world's total power; some 44 per cent of this, or 70 GW, was in developing countries. These technologies received about \$30 billion of global investment, much of it from private investors. This amounted to 20-25 per cent of the power sector's global total and is more than the \$20-25

billion invested in big hydro—and many times the total investments in nuclear power, none of which risked private capital.

Decentralised powersources—both renewables (counting small hydro units only up to 10 MW) and low-carbon fossil-fueled combined-heat-and-power—overtook the capacity of nuclear power worldwide in 2002, and its output in 2005. In 2004, decentralised generators added 2.9 times as much output and 5.9 times as much capacity as did nuclear power; they are expected to add about 160 times as much capacity in 2010. By 2006, or soon thereafter, even the smallest and costliest renewable source—photovoltaics (PVs), which has only about 5 GW of installed capacity, but grew by 60 per cent a year between 2000 and 2004—may add more capacity than new nuclear construction.

Bioethanol and biodiesel—made at both small and industrial scale—passed 33 billion litres in 2004, equivalent to 3 per cent of the world's gasoline. In Brazil these fuels displaced 44 per cent of the country's gasoline, and now compete without subsidies: this is partly because most new cars are 'total-flex', able to burn anything from pure gasoline to pure ethanol, allowing their owners to choose rather than be captive to any specific fuel. The money saved from using less oil repaid the subsidies Brazil used to start up the biofuels more than fifty



times over. Fuels made of blends of bioethanol and gasoline are legally required in Brazil, China and India, and already account for 30 per cent of the sales of gasoline in the United States.

Renewable sources

Renewable energy provided 1.7 million direct jobs in 2004, over half of them in biofuels and most of those in rural areas. At least 48 countries—14 of them developing ones—officially promote it. Europe aims to get 21 per cent of its electricity from renewable sources by 2010. China plans to obtain a tenth of its electric capacity from decentralised renewables by the same year, and will also probably install 30 GW of windpower by 2030 (industry thinks it can achieve 40 GW).

Such advances are no mere artefacts of EU and U.S. government subsidies: after all, those only amounted to \$10 billion in 2004, vs. several hundred billion dollars' subsidies to fossil and nuclear energy. Indeed UNDP estimates that all renewables ►



experiences a 100 per cent shut down for an average of 36 days every 17 months, sometimes unpredictably.

Nor need land-use be a problem. Unshaded U.S. roofs could hold over 710 GW of solar cells: more could be placed on car-park shades, road verges, reservoirs, etc. All the electricity consumed in the U.S. each year could be produced from a patch of desert 160km by 160km, half-filled with inefficient solar cells, or by windfarms occupying the equivalent of a few Dakota counties.

Hidden benefits

As power markets become more transparent and competitive, they start to recognize the hidden benefits of making electrical resources the right size for their task: the book *Small is Profitable* identifies 207 such 'distributed benefits'. Typically these increase economic value by about tenfold—enough to tip almost any investment decision. Small, fast technologies, for example, carry less financial risk than big, slow ones; renewables bear none of the risks brought by volatility in the price of fuels: and making power at, or near, customers avoids the costs, losses and failures of electricity grids.

Integrating renewables with efficient energy use is especially lucrative because most of the energy now used is wasted. In the U.S., for example, existing technologies could save half of the country's oil use at a fifth of its price, and half of its consumption of natural gas at a sixteenth of its price. Similarly, they could cut its electricity use by three-quarters at less than the cost of running, and delivering the power from, a free nuclear or coal plant. The potential percentage savings are somewhat smaller, and more costly, in the most energy-efficient countries—but far bigger and cheaper in developing ones. For every dollar of GDP (at

Renewable electric sources have a practical potential equivalent to many times today's electricity consumption

got only about 8 per cent of the energy subsidies paid out over the past three decades. Rather, decentralized renewables' rapid growth reflects steadily improving costs, technologies, markets, delivery mechanisms, and increasing official acceptance. (Citizen acceptance is seldom a problem.) Radical technological jumps will speed the shift. Clever optical concentrators that are poised to enter production can yield very cheap power from today's solar cells, and PVs that are several times more efficient still are already in the lab.

Market behaviour

Critics' claim that renewable energy is too small and slow to matter is collapsing under the evidence of actual market behaviour. So they now increasingly contend that, though necessary and desirable,

renewables are limited to a minor role. Yet the Earth's surface receives solar energy amounting to 6,700 times humanity's total energy use. Renewable electric sources have a practical potential equivalent to many times today's electricity consumption. Indeed the International Energy Agency believes that they could be ripe by 2030 to produce potentially 30 trillion kilowatt-hours a year, roughly equal to total projected 2030 global electricity use.

China, the U.S. and the world could get all their power from the wind. European experience and utility studies confirm that using intermittent sources like wind and solar, even at very large scale, need not make supplies less reliable than at present if they are properly diversified, dispersed, forecasted, and integrated with the existing grid and with demand response. In fact, all power sources are intermittent: they only differ in how often and how long they are off-line and in why they fail, how predictably, and on what scale. The average U.S. nuclear plant, for example,

purchasing power parity), China uses about nine times as much energy as Japan, five times as much as Europe, and three times as much as America, so energy efficiency is now its top development priority; and even Japan has great efficiency potential still uncaptured.

Energy efficiency

Since achieving efficient use costs less than the fuel and electricity saved, the problem of climate change can be solved at a profit, rather than at a cost. And since making electricity-saving technologies needs about 10,000 times less capital than generating more electricity, the power sector—now a black hole for a quarter of the world's development capital—could become a net exporter of capital to meet other development needs.

Energy efficiency can greatly expand and speed renewable supplies by making them smaller, simpler, cheaper, and more effective:

■ A house that saves hot water can get most of its water-heating from solar energy using only a small collector with little or no backup. My home, high in the Rocky Mountains, which experiences up to 39 days of continuous midwinter cloud, gets 99 per cent of its hot water from the sun, with the help of a stratified five-cubic-metre storage tank.

■ A house that enjoys all modern conveniences, but uses electricity with elegant frugality, can get all its power from only one to two square metres of PVs. Those and the associated equipment can cost less than just connecting to the grid a few meters away.

■ A building lit by daylight, and heated by passive solar energy, needs little electricity, and can pay even for costly forms of onsite generation, such as PVs, with money saved by reducing the size of heating and cooling systems. Those systems have been eliminated altogether, with better comfort and lower construction cost, at temperatures from -44 to +46°C.

■ The Santa Rita Jail in Alameda County, California, installed efficiency and load management measures before adding 1.18 MW of PVs to its roof. As a result it needed less power at peak-load periods, and could sell more back to the grid at the best price, gaining benefits 1.7 worth times the unsubsidised costs.

Beyond oil

The U.S. could eliminate its use of oil over the next few decades—and that transition could be led, for profit, by business. Half of U.S. oil consumption could be saved through efficiency, including cars, trucks, and planes three times as efficient as now. The rest could then be replaced by advanced biofuels, which need no cropland, and saved natural gas. Such

A. Bucz/UNEP/Still Pictures

an oil-free America would save \$70 billion a year, even with oil at the low price of \$26 a barrel. Other countries could do much the same. Indeed some, like China, may well leapfrog the West to help lead the world beyond oil.

Problems like climate change and oil dependence are therefore artefacts of unnecessarily using or supplying energy in a way that wastes money. If we simply buy the cheapest energy options first, most energy-related problems will fade away, leaving a healthier, fairer and safer world ■

Amory Lovins, a physicist, is co-founder and CEO of the Rocky Mountain Institute.

Additional Resources:

Rocky Mountain Institute

<http://www.rmi.org>

Renewables 2005 Global Status Report

<http://www.ren21.net>

Small is Profitable

<http://www.smallisprofitable.org>

Winning the Oil Endgame

<http://www.oilendgame.com>