World Rivers Review

Volume 21, Number 6 / December 2006

Published by International Rivers Network

Rethinking Africa's Solar Market

by Mark Hankins

I was struck recently by an industry graph showing global demand growth for solar photovoltaics (PV). It revealed sharply rising sales in Europe, America, Japan and China – but Africa sales didn't even register. In the heady early days of PV market growth, Africa was an important market and there was much talk about how PV would help solve the low access to power throughout rural areas of the continent. Today, Africa does not even feature in PV executives' worldview and we are no closer to widespread electricity access, PV or otherwise.

In 1995, Africa accounted for about a quarter of the annual 75 MW world PV demand. Many of us in the PV sector then thought that Africa's place in the market was secure. Since then, world demand for PV has skyrocketed to over 1,500 MW per year, while PV demand in Africa has remained virtually stagnant. In fact, the demand for off-grid PV systems has not grown substantially, few national PV programs have taken off and, with the exception of the telecom sector (which is thriving), the PV sector in Africa has become less and less interesting to international players and the private sector in general.

Why has PV in Africa been such a non-success? Several reasons are proposed below, which have to do with the strategies, policies, multilateral projects and use of incentives for PV in Africa. Some of the key decisions made by donors and governments have held back the PV industry in Africa. For example, why has development of PV in Africa been limited to the off-grid sector only? Why have PV initiatives in Africa been so closely tied to poverty alleviation? And most importantly, why have PV subsidies been largely disallowed, when it can be shown that they are the key to growth everywhere else in the world?

Special Focus
Renewable Energy

Photo: Mark Hankins

A PV owner in Mtwara, Tanzania.

Just about any supplier – even those enjoying the billions of dollars pumped into northern countries' on-grid programs each year – will agree that eventually Africa must be an important market. Investment in real growth strategies makes sense. Might there be a better approach to the development of Africa's PV market?

Off-grid Only

While grid-connected PV has dominated sales in developed countries, in Africa the focus has remained almost exclusively on small off-grid, stand alone systems – especially the 50 Wp solar home system (SHS). PV has much to offer the rural electrification strategies of Africa. On a continent where electrification rates are typically less than 10%, providing any form of power for rural people is of interest.

Since the early '90s, international policy makers and energy planners (this writer included) promoted PV as a first step to rural electrification. But PV was never a substitute for the grid, and power planners and consumers were not as enthusiastic about 50 Wp systems as were donors, multilaterals and NGOs.

For the most part, permanent secretaries, government ministers and utility CEOs intent on extending wires see little role for 12 volt PV systems – for them it is a second-class technology for the rural poor at best. Unaware of the rapid advances on-grid PV is making around the world, planners are preoccupied with the pressing problems of managing decaying national electric grids, using conventional solutions such as hydropower and thermal stations. They do not have enough resources to innovate or find creative uses of PV.

There are at least 80 million rural families off-grid in rural Africa – a huge market, it would seem. Nevertheless, in 10 years, the PV industry hasn't penetrated more than a half percent of this market. There are only a few hundred thousand SHS installed in

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COMMENTARY

Power to the People

The renewable energy technologies featured in this issue have many virtues: they produce clean energy, can be better scaled to meet demand than large dams, reduce dependence on problematic energy sources such as fossil fuels and large hydro, and can be used in rural areas far from the grid, where most of the world's un-electrified communities are located. Renewables create more jobs, and more localized jobs. As the article on page 7 reveals, Nepali activists campaigned against a large dam in the 1990s mostly from the standpoint that they wanted to use local experts to design, build and maintain energy projects – something that wasn't possible with the huge Arun Dam then being considered by the World Bank. Today, micro-hydro, biogas, solar installations, and efficient cooking stoves are bringing power to the people.

These technologies fit well into national rural electrification plans, but they can also help supply power in areas already connected to the grid. A new push for decentralizing energy supply systems calls into question the "bigger is better" mantra that has been the norm for energy planners and utilities the world over for more than a century – ever since Thomas Edison lost the battle of direct current (which requires power plants every mile or so) to an alternating-current grid system at the turn of the 19th century. Books reviewed on page 14 explain the many advantages of decentralizing our energy supply, not the least of which is reducing the terrible waste that results from transporting electrons over long-disance wires.

Except for rural electrification, where the prohibitive cost of extending the grid gives renewables a price-edge, many renewable technologies cannot yet boast of low cost (wind is close to reaching parity, and in some cases is already cheaper than fossil fuels). Solar PV – one of the most costly of renewables – is now starting to take off in many richer countries because incentives are being offered by governments like Germany and Japan, which have put a value on PV's clean energy and ability to reduce demand on overburdened national grids. Yet Africa – the world's sunniest, and least electrified, continent – is getting virtually nowhere with solar. Our cover story describes some of the reasons for this lag, and urges a new approach for bringing solar PV to African nations. Incentives tops the list of needed changes. Will the world's richer nations come forth to help pay for this kind of green-energy kickstart for Africa? Reports out of the recent climate change meeting in Nairobi reveal that thus far, Africa has been left out of the benefits from carbon funds intended to reward green energy.

Clearly, the cost of renewables depends on what you account for, and generally the cost of traditional energy has not included the cost of "externalities" such as pollution or the indirect subsidies given it, such as roads and railroads to transport oil and coal. In the US – one of the world's biggest emitters of greenhouse gases – we have had our heads in the sand when it comes to accounting for the environmental and economic impacts of our high energy consumption and our contribution to climate change. In the article beginning on page 8, energy expert Dan Kammen describes what is needed to substantially de-carbonize the US economy. The status quo – the US is now de-carbonizing at just 1% a year, primarily due to energy efficiency – can be increased significantly with an increase in research and development. Kammen is calling for a "Manhattan Project" (based on the crash program that led to the development of nuclear weapons in the 1940s) to improve existing technologies and find new ones.

The chances of this happening are so close, yet so far. Voters in California (a bellweather state on energy issues) recently rejected a proposal to raise $4 billion for renewables R&D through a tax on the oil industry, yet California also has one of the most progressive subsidy programs for solar, and a groundbreaking new law to reduce greenhouse gas emissions. A California group called Vote Solar (interviewed on page 12) is lobbying for statewide initiatives to promote solar, with the idea that by creating a large enough market for solar panels, their cost will drop to the point that solar is competitive with conventional energy. If they succeed, the nation's energy future could look sunny indeed.

Lori Pottinger

World Rivers Review

Volume 21, Number 6

ISSN Number 0890 6211

Editor: Lori Pottinger

Design/Production:
Jeanette Madden

Printing:
Hunza Graphics

Contact IRN:
1847 Berkeley Way
Berkeley, CA 94703 USA
Tel: (510) 848-1155
Fax: (510) 848-1008
E-mail: irn@irn.org

Printed on Re:Vision
10% tree free kenaf/
90% recycled pcw

Visit IRN's Website:
http://www.irn.org

WRR is indexed in the Alternative Press Index.

India's Wind-Energy Sector Soars

by Uwe Hoering

India's first Prime Minister, Jawaharlal Nehru, once called big dams the "Temples of modern India." If he were alive today, he might call India's numerous wind parks the wings for India's future.

Economically as well as ecologically, a new energy policy for India is needed. India has a peak shortage of 12% in spite of billions of rupees pumped into the state-owned power sector, and economic growth of around 8% is adding new pressure every year. Demand is rising from a growing middle class and flourishing industries. In 2002, the New Delhi central government announced the ambitious target of nearly doubling the presently installed capacity of about 118,000 MW by 2012.

With more than half of India's energy coming from dirty coal, the nation has become one of the world's big climate killers and now ranks fourth in greenhouse gas emissions. The decision by the government in 1992 to set up a Ministry for Non-conventional Energy (MNES) to strengthen renewables was hailed by many environmentalists as the breakthrough toward a safe, clean and green energy future. Various subsidies and incentives were offered to kickstart a wind revolution, especially for private-sector investors.

The states of Maharashtra and Tamil Nadu pioneered wind energy, and today boast of the biggest wind parks. Both benefitted from wind-friendly terrain – vast areas with strong winds during the monsoon – and from a well-developed infrastructure. Tamil Nadu's Muppandal region, for example, near the southern tip of the subcontinent, has several thousand turbines with an aggregate wind power capacity of 540 MW in an area covering 60,000 acres. Maharashtra introduced special tariffs for "green energy," determined by the Regulatory Commission and guaranteeing investors a 16% return on equity. Independent Power Producers (IPP) and manufacturers of equipment have started to run windparks for private investors.

As a result, installed capacity increased tremendously. In 2005 alone it grew by nearly 50%, to 4,434 MW, more than half of it in Tamil Nadu alone. India became the fourth largest wind energy power after Germany, Spain and the US. Wind energy has overtaken India's nuclear power generation, which according to the Nuclear Power Corporation website has a capacity of 2,710 MW. The nation's wind potential is currently estimated at up to 45,000 MW, which is expected to increase with improved technology.

The policy also kick-started the development of an indigenous industry. Indian manufacturers of towers, blades, generators and gear boxes have full order-books. To attract customers, manufacturers offer turnkey projects and complete after-sales services and management. All the big players – including Enercon, Vestas, GE Wind – now have at least a foothold in India, and most of them are expanding their production facilities. The Indian company Suzlon is now one of the top 10 manufacturers in the world, setting up offices and production facilities in China and elsewhere.

Challenges and Concerns

Although wind energy is much less problematic than thermal, big hydro and nuclear energy, it also has some drawbacks in India. First, the power actually generated is limited by periods of low wind speeds. In Maharashtra, for example, the windy season is mainly restricted to the monsoon, from mid-May to mid-September. In Tamil Nadu, wind energy accounts for 26% of installed capacity, yet contributes only 5% to generation.

India's wind boom has also done little to bring energy to the rural poor. Power from the big wind farms flows into the grid and on to cities and industries. The millions of poor now without modern electricity services would benefit from decentralized mini-grids fed by a mix of renewable, locally available energy sources like biomass, small windmills, solar and micro-hydro. It is to be hoped that the central government's proposal for such a program will be as successful as the wind energy development program, though it is hard to imagine it will be adequately fueled by the private sector's profit motive, which is the model for the wind program.

Another problem is the availability of suitable locations. Areas with sufficient wind speeds and easy access are becoming scarce. Land prices are skyrocketing – in Tamil Nadu, for example, land costs have increased 20 times and more in the last few years. Poorer communities like toddy tappers, herdsmen, or marginal farmers have been further marginalized, losing access to land and other means of livelihood. This pressure on land and prices will increase when the demand for investment opportunities by private capital and manufacturers, who have to offer locations to their clients, increases further. More farmers will be tempted to sell valuable agricultural land to the more productive use of harvesting the wind.

Finally, in spite of a ministry devoted to non-conventional energies and some well laid-out policies and economic incentives to foster wind energy as an attractive commercial renewable, there has hardly been a turnaround in the energy policy. Of the planned 62,000 MW in additional conventional energy sources to be added by 2012, 38,000 MW would come from coal-based projects, 16,000 MW from hydro, 6,000 MW from gas/LNG and 3,000 MW from nuclear, according to the *Business Standard* (Feb. 27, 2006). By comparison, the aim of increasing renewables to 12,000 MW by 2012 pales in significance.

Compared to the subsidies and public investments into thermal, hydro and nuclear, the success of wind energy has come at a low price for the public exchequer. Direct subsidies and fiscal incentives are slowly being reduced. G.M. Pillai, director-general of the Maharashtra Energy Development Agency, said two years ago, "Wind power should be fully viable in the next three to four years. In fact it might be cheaper than other sources," because of falling capital costs and improving efficiency with advancing technology.

If India wants to establish itself as a clean energy leader, it will need to shift these numbers so that wind and other renewables are a larger slice of the pie, with a commensurate shrinking in the coal and large-hydro segments. ■

Micro-Hydro's Big Potential

by Hans Hartung

Decentralized micro-hydropower is an excellent way to supply electricity to rural populations in hilly areas of the world. Micro hydro is one of the most environmentally friendly power resources presently known. In addition, its advantages include:

- It opens opportunities for income generation by supplying energy to small industries such as grain milling, oil expelling, battery charging and lumber milling;
- It supports education by allowing electric lights for studying;
- It has health benefits by supplying power to health centers;
- There are many examples where a micro-hydro project has assisted in strengthening the village organization.

Micro-hydro ranges from a few hundred watts (for example, for battery charging) to up to 100 kW (for a village or rural industry).

This article looks at some of the lessons learned from microhydro hotspots – and potential hotspots – around the globe.

Bolivia: Wolfgang Buchner, a Bolivian national of German origin, helped kick-start the use of micro-hydro on the east side of the Andes in Bolivia. He trained a craftsman in the area to build cross-flow turbines; this person now makes his living building and installing turbines in local villages. Each system supplies up to 100 families with electricity, mostly for lighting, a few fridges, TVs and some commercial work during the day (for tools to work wood and metal). Interested villages have to form an association and collect money for the investment. People buy shares for their village electricity station and get a cheaper rate for their electricity consumption later. A typical installation costs around US$10,000 for materials (including the turbine and generator) and can produce up to 8 kW. These are very simple systems and the villages do all construction work. Many villages have built a village hall from the surplus electricity revenues, or other civic improvements.

Germany: An estimated 100,000 water mills and micro-hydro plants were in use some 80 years ago in Germany. The nation's industrialization started with small hydropower as the main source of energy. Only 10,000 are left today. But increasingly, citizen-owned plants are coming on-stream, where people get together to form an association in order to rehabilitate or build a micro-hydro plant. They sell the energy to the electricity company and are proud to make some money while at the same time producing "green" energy. Micro-hydro and other renewables got a real boost after the German government passed a renewable energy law a few years back. By law, electricity companies have to buy the energy produced by renewables and have to pay a nationwide fixed tariff, depending on the kind of renewable energy source and its environmental status.

Building a community micro-hydro plant in Cameroon.

Photo: Terri Hathaway

Nepal: This mountain kingdom has a long history of micro-hydro. There are at present an estimated 20,000 traditional water mills ("ghattas") and around 1,200 micro-hydro power plants using turbines. These plants are usually mechanically driven mills for grinding grains, rice huskers and oil presses. But more and more, generators are added to produce electricity at least at night, when no milling is done. All the turbines are manufactured in the country – at one time there were nine manufacturing workshops earlier (there are fewer now).

A long-standing program based on the provision of subsidies to micro-hydro through the Agricultural Development Bank of Nepal has been key to success. A significant part of the sector (especially turbines for milling grain) is financially self-sustaining, and receives no subsidized support. The strategy, driven by NGOs, combined building up the capacity of local turbine manufacturers with the development of a number of technical improvements.

Lessons Learned

Micro-hydro projects and programs in some countries in Africa, Asia and Latin America have been evaluated and some lessons have been learned. The following issues are key:

Financing: The capital cost of decentralized rural electrification is best met in the medium term from a mixture of local equity capital (community or private), and a loan component from a bank or other conventional credit organization, at commercial rates backed if necessary by loan guarantee funds. Subsidies should ideally only be used where there is a possibility of their being phased out.

Institutional Support: Successful decentralized rural electrification requires a coordinated institutional approach with an enabling policy environment created by government, and suitable local organizations supported by a regional or national intermediary body, which is charged with a variety of coordinating functions.

Energy management: It is most important to provide a framework which will allow rural users to articulate their own demand patterns and to decide how these can best be met from a range of energy supply options.

Don't try to compete with an established electric grid. When considering a micro-hydro installation, always make sure that the grid is not too close (say, more than 3 km) and there are no plans to extend the grid to

continued opposite

Micro-Hydro in the Amazon Faces Uphill Struggle

by Glenn Switkes

In Brazil, some twelve million people (mostly in remote communities) have no access to electricity. One of the principal social programs of the Lula government has been its efforts to increase access to electricity across Brazil, through a project called "Electicity for All." While extending power lines to rural communities in the central and southern regions of the country can be expensive – costing up to $2,000 per family in some regions, many of whom will consume less than 50kWh per month – in the vast Amazon region, where nearly 90% of rural communities lack reliable electricity, the task to connect people to a central grid is widely acknowledged to be pretty near impossible.

Off-grid options for these communities include solar photovoltaic systems (still quite expensive in Brazil), modern biomass energy and, most promising of all in watery Amazonia, micro-hydro. According a national thinktank on small hydro, there are about 1,000 small and micro-hydro dams in Brazil, with an average capacity of 300kW.

Unfortunately, micro-hydro currently faces regulatory barriers meant to protect regional electrical utilities, which historically enjoy a monopoly on providing electricity within their region. Even micro-hydro projects can require a level of financing that requires communities or cooperatives to pool their funds and, often, sell energy to nearby communities in order to recoup investment. When they do, it brings the projects into conflict with energy concessionaires.

A 2002 law that created national incentives for energy alternatives was primarily intended for biomass, wind, and small hydro projects selling electricity to the grid. It also, however, had provisions permitting new generating "agents" to provide electricity coverage in regions where existing power utilities cannot guarantee access to energy within a reasonable timeframe. Under the law, these alternative energy providers would be reimbursed for their investments out of public funds. But four years later, the law has still yet to be put in force. Other investors in micro-hydro have looked forward to new opportunities resulting from the government's "Electricity for All" initiative for providing electricity to all Brazilians. However, they complain that energy concessionaires still dominate rural electrification planning, elbowing small operators out of the picture.

There are some positive examples for communities to look toward. In the region of Santarém, where the Tapajós River flows into the Amazon, micro-hydro systems are becoming so popular that a small industry has sprung up to manufacture turbines. Antonio Nazareno Almada de Souza founded the Idalina Company 10 years ago to build low-head turbines and design community micro-hydro systems, and the plant now employs 30 workers. "Our turbines provide constant energy, at a far lower cost than trying to hook up the communities to the grid," says Nazareno. Idalina's turbines range in size from 4 to 40 inches in diameter. Nazareno estimates there to be 80 micro-hydro systems operating in the region currently. "We still hope that the government will open up more room for a broader range of companies to be able to take advantage of government subsidies for electrification, which would have a very positive effect on promoting micro-hydro in the Amazon," he says.

The nearby community of Açaizal pooled the resources of 45 families, who contributed $700 each to generate and distribute 60 kW to four communities, replacing diesel generators. Investing members can consume up to 60kWh per month, paying for any excess consumption, while non-members pay for the energy they consume. The mini-hydro project has greatly improved the quality of life in Açaizal, providing electrical lighting and appliances, and pumped drinking water to homes. Another important impact in a region where large soy producers are displacing small farmers is that access to electricity now permits the community to process grains that can be sold to local markets, helping the farmers remain on their land. ■

Micro-hydro continued

near where the micro-hydro power plant is to supply electricity. The investment cost for micro-hydro will in almost all cases be higher than extending the grid by a distance of 1-2 km and the price for micro-hydro electricity might be higher than grid electricity.

Community participation, while complex, is critical. Community participation in planning for electrification is likely to lead to more successful and sustainable schemes. Careful preparation is needed and locally appropriate guidelines prepared, and an external facilitator is recommended. As far as actually managing the project, community management of a relatively complex system such as a micro-hydro plant is difficult but can succeed when some of these elements are considered:

- Cash contributions in addition to in-kind contributions will help people take more interest in the plant in which they have invested so much.
- Local leaders (traditional, religious) should be engaged, to ensure they help promote the system.
- Have a contract between main actors (local industries, each household willing to get connected, the equipment manufacturer, project builder, and any intermediary). The contract specifies the rights and obligations of each actor in detail.
- Every household who cannot pay a connection fee in cash gets a credit from a micro-finance institution; or, alternatively, the whole village gets a credit for part-financing of the micro-hydro power plant.
- The local manufacturer of the turbine or builder of the system should be responsible to the village to complete and service the plant according to specifications.

Specifications are not a luxury. When a micro-hydro power plant and electrical distribution system is planned, a design study (it can be simple and standardized) is a good idea. Specifications might include the minimal power output, details about the electricity (e.g., voltage variations), the diameter of the penstock pipes, and the guarantee period.

Photo: Hans Hartung

A Bolivian craftsman builds a turbine.

Experiences exist worldwide, with some small plants running for more than 100 years with the same equipment. Let's not reinvent the wheel, but make good use of the lessons learned in order to light many more villages in the global south. ■

Hans Hartung is the water coordinator for FAKT, a German nonprofit (www.fakt-consult.de). He can be reached at hansfhartung@aol.com.

China: Picking Up the Pace on Renewables

by Yang Jianxiang

Photo: Yingli Solar

A young admirer inspects a panel installed under the China Brightness Project.

Statistics show that in 2005, a total of US$38 billion was invested in renewable energy development worldwide. China topped the list with a commitment of $6 billion, excluding spending on large hydropower projects.

China has good reason to speed up its renewable development, as the country is fairly poor in many energy resources in per capita terms. China's proven reserves of petroleum, natural gas and coal could last 15, 30, and 80 years, compared with world averages of 45, 61, and 230 years.

At a Sino-European economic summit held in September in Germany, Chinese Premier Wen Jiabao assured the world that China would rely mainly on domestic supplies to meet energy needs. The government's energy policy would aim to integrate development and conservation, giving priority to the latter.

China is currently weak on energy efficiency. The eight industries which account for 75% of the country's industrial energy use recorded an average energy consumption 40% higher than the world's advanced standard. Energy-efficient housing in China is just a tiny fraction of urban residential construction. And the energy intensity for heating was two to three times higher than developed countries under similar climates.

China has vowed to cut down on energy consumption per unit of GDP by 20% by the end of 2010. Judging by recent performance, some observers voiced skepticism that the goal could be achieved. But the government has been taking tougher measures.

The new path would have to include energy from renewable resources, which China has in abundance. Exploitation of wind, solar, and biomass energies has just started. In 2005, China had 61 wind-power plants with a total generating capacity of 1.26 million kW, 1,500 or so biogas projects and 70,000 kW of solar facilities.

Compared with China's total capacity of 508 million kW for all forms of energy, however, the overall share of renewables remains small. This means enormous room for development.

In April, Premier Wen Jiabao urged all relevant government departments to take effective measures to accelerate the development of renewable energy, so as to "raise the share of quality, clean energies in the total energy mix." Renewable energy is expected to account for 16% of China's total energy supply by 2020, more than double what it was in 2005.

New Renewable Energy Law

China's renewable energy development is guaranteed under the nation's first Renewable Energy Law, which came into force on January 1. In February, the government issued a set of rules to implement the law. In addition, officials have decided to raise the rate for electricity consumption by a small fraction that will go toward the development of renewable energy. And in early October, the Ministry of Finance released details of a new fund dedicated to the development of renewable energy sources, which will use grants and interest subsidies to give government support to renewables' development in three main areas: oil alternatives, construction, and power generation.

In general, local government officials are enthusiastic about promoting renewable energy projects. Their motives vary from securing a lucrative source of government tax revenues, building up a "green" government image, to adding a "bright spot" to their work performance records. Factors such as the embrace of new energy technologies now bear considerable weight in an official's promotion.

Jiangsu Province in eastern China is particularly active in the renewable energy game. The prosperous region appears determined to take the lead in wind power exploitation. In less than five years, it plans to boost its wind capacity from virtually zero to 1,500 megawatts. The region is also an important base for the solar industry, where more than 180 companies are involved in the development, manufacturing, and servicing of solar heating appliances.

Shanghai announced earlier this year a plan to build 100 MW of offshore wind energy capacity. The metropolis hopes to raise it share of renewables to 5% by 2010. The capital city of Beijing has vowed to lift renewables' share from the present 1% to 4% by 2010.

Companies across China – whether state-owned or private, domestic or foreign-funded – are eager to embrace renewable energy projects. Many believe the sector will soon be a gold mine.

Earlier this year, Longyuan Electric Power, the biggest wind player in China, announced a plan to raise its wind-power generating capacity from an existing 416 MW to 3,000 MW by 2010, and to 7,000 MW by 2020. Other major energy developers like Huaneng, Guodian, and the Three Gorges Corporation have set up subsidiary companies dedicated to new or renewable energy development.

Foreign companies have been active as well. The world's leading wind equipment suppliers – Vestas, GE Energy, Gamesa, and Suzlon – have set up wholly owned manufac-

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Nepal's Micro-Energy Revolution

by Bhola Shrestha

Born in rural Nepal, the first time I experienced electricity was at age 11, when I visited a town bordering India where my father worked. Twenty five years later, when the Arun Dam campaign began to press for a more sustainable path to hydropower development, seven out of ten Nepalis did not have access to electricity. All those years, I heard a lot about Nepal's hydropower potential being second in the world after Brazil, and wondered why so many still lived in dark.

After restoration of democracy in 1991, a group of Nepali professionals, the Alliance for Energy, for the first time questioned a large development project's rationale. The project was the World Bank-financed Arun III hydropower project, a 200 megawatt large dam planned for Nepal's Arun River. At the time, Nepal had an installed capacity of less than 400 MW. The US$1 billion project (including cost of the access road) dwarfed the national economy, and the cost of its energy was prohibitive.

The campaign was not primarily about the dam and its environmental impacts. It was about the path Nepal had taken to develop its hydropower resources. Campaigners were pushing for a shift from the donor-dependent path this big dam typified, to a locally driven development path. Arun III was to be built with foreign money, foreign expertise and on the donors' terms. The campaigners argued that this path was just not right for Nepal. The high cost of its electricity meant that the project would fail to benefit the Nepalese.

The Nepali experts argued Nepal must build smaller projects that it could handle with its own resources and capabilities. This approach would cut project costs in half, build local capabilities, foster local industry and rid Nepal of the dependency syndrome.

After years of debate, the World Bank withdrew its support and the project was shelved. Since then, Nepal has had a micro-energy revolution.

A Rural Solution

About half of Nepal's 26 million people live in the mountains. Rural electrification through grid extension to these remote and scattered communities is prohibitively expensive. Decentralized energy systems such as micro-hydro, biogas and solar PV are more cost effective.

Since 1996, when the government's Alternative Energy Promotion Centre was established, decentralized energy systems have taken a great stride. The many small efforts of NGOs became a mainstream national program to support promotion of these technologies through private sector service providers. The market mechanism to provide such services is one reason for the program's success.

Today, 1,588 micro-hydropower plants generating 8.8 MW supply electricity to about 88,000 rural households. About 75,000 households are electrified by solar home systems. Over 168,000 rural households cook on biogas, which uses animal dung to generate methane gas. Over 200,000 cook on improved stoves that save firewood and prevent respiratory disease from smoke in the house.

As the true cost of each of these technologies is still beyond the reach of the rural poor, the government subsidy program helps bring down the cost. No subsidy is provided for improved stoves, however.

The design, manufacture and installation of micro-hydro plants are carried out by local firms. Biogas plants are installed by more than 50 companies spread all over the country, and similarly for solar home systems. The improved cook stoves are built by thousands of trained builders, including many local women.

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China continued

turing facilities in China. And seven foreign development banks, including the International Finance Corporation, Germany's DEG, and France's Proparco, have invested in China's renewable energy projects.

The 30,000 MW wind-power goal for 2020 represents a market of $26.6 billion, and the country's combined renewables targets amount to $100 billion. The coming years are likely to witness rapid development of these energy sources, and the targets might even be reached ahead of schedule, industry analysts say.

Barriers Remain

Yet several major barriers are preventing more rapid development of renewable energy in China. One is the weakness the country has shown in independent technology development. To date, most of the renewables equipment being used – whether for wind power, biomass, or solar – has been imported, resulting in higher production and consumption costs. A recent government study designates energy as the top area needing urgent R&D support, and lists a host of government-supported plans covering key fields of study, cutting-edge technologies, and basic research.

China is one of the 48 countries in the world that have enacted laws for renewable energy development. But industries have given only a cautious welcome to the country's laws and accompanying rules of implementation. For many, the wording is too general to be practical. And some measures remain controversial. For instance, new regulations for wind power decree that the grid feed-in tariffs be decided through a tendering process. The measure has been criticized by industry players, who fear the practice will result in price cuts and thus deny companies a reasonable profit.

Human resources are another problem. According to experts, China aims to engage hundreds of thousands of people in its wind power industry by 2020. The number of specialized workers alone would be in the tens of thousands. But China currently has a very meager supply of such experts. Only one of the country's more than 1,000 institutions of higher learning provides a four-year program dedicated to wind energy. The situation for other renewables is not much better. Solving this problem will require the joint efforts of many government departments and social institutions, experts say.

While the shortage of conventional energy resources is the main driver behind China's push for renewable energy, the country is also making the transition out of environmental concern. The nation's coal-dominated energy system has caused severe pollution in many regions, which has compelled the government to turn to cleaner energy resources. ■

Jianxiang Yang is a journalist specializing in energy with China Features. This article was coordinated through the Global Environmental Institute (GEI) in Beijing.

Can We Awaken the Sleeping Giant?

A Renewable Energy Future for the US is Achievable

The sorry statistics are by now well-known: the United States has just 5% of the world's population, but produces 25% of its greenhouse gas emissions. Efforts to reverse this trend have lagged significantly, and the US continues to block efforts toward international progress. Here, ***Dan Kammen*** *– one of the nation's top energy experts – lays out a plan to de-carbonize the US economy.*

Renewable energy science and technology has undergone dramatic advances over the past several decades. Renewable energy and energy efficiency have now come of age to the point where cities, states and nations plan and implement low – and even near zero – carbon energy systems.

At present the US economy is decarbonizing at just over 1% per year, largely due to advances in energy efficiency. Despite a history of successes in energy efficiency – efficient lighting, refrigeration, heating and cooling, and appliance standards – increased demands for electricity as well as energy for transportation continue to drive energy needs markedly upward. In this context, low- and no-carbon sources of energy are critically needed along with carbon sequestration and long-term dedication to continual advances in energy efficiency. Only with a major commitment to low carbon supply-side technologies can we realistically achieve the needed decarbonization of the global economy, an 80-100% reduction in carbon emissions by mid-century. This is now achievable, but will require scientific, technical, political, and economic commitment. We are now in an era where the economics and political opportunities for renewable energy sources are unprecedented, making this a moment of opportunity to dramatically advance clean power for decades to come.

Significant differences exist at the state and federal levels in the US in terms of what goals are realistic and achievable. The federal government plan for an 18% decarbonization by 2012 from 2002 level in tons of carbon per unit of GDP would actually allow emissions to grow by 12-16%. This target would thus represent a larger increase than the 10% increase that occurred in the previous decade. By contrast, California plans to reduce greenhouse gas emissions to 2000 levels by 2010, and by 80% by 2050. The focus of this article is on the technologies and policies available to meet targets more akin to California's plan, as well as those under discussion in the US northeast and Europe.

Renewable Energy Technologies

The global solar cell (PV) industry has grown by over 20% per year for the past decade, and on a percentage basis is the world's fastest growing supply-side source of energy. In 2005 the global PV market grew by a remarkable 50%, reaching a total production volume of over 1,100 MW.

Solar PV represents a particularly easy to use form of renewable energy. The state of California has joined Japan and Germany in leading a global push for solar installations, with a new "Million Solar Roof" commitment that will bring 3,000-10,000 MW of new solar PV. The potential for this technology is virtually unlimited. Work in my research group, the Renewable and Appropriate Energy Laboratory, reveals that the current 0.5 GW of solar PV installed in the US could grow to over 700 GW in only 20 years.

Currently, PV is relatively expensive, with costs of 20-25¢/kWh for crystalline cells. By comparison, coal-fired electricity is 4 -6¢ per kWh, natural gas is 5-7¢/kWh, biomass-fired power costs 6-9¢/kWh, and nuclear, where the most disagreement over costs exists, is between 3-12¢/kWh, depending on what is included in the analysis.

Large PV installations have installed costs as low as $5/watt. Costs have been falling consistently over the past decade. Aggressive programs in Japan (where 290 MW of solar was installed last year) and California (where 50 MW was installed) have each observed significant year to year cost reductions, of over 8%/year in Japan and 5%/year in California.

Thin film and amorphous silicon solar cells are also in commercial use today, with Kenya, surprisingly, the global leader in solar systems (not watts) installed per year. Over 30,000 very small (12-30 watt solar panels) systems are sold in Kenya each year, at costs as little as $100/system. More Kenyans make new electricity connections through solar each year than through new connections to the grid. The efficiency of amorphous solar cells are lower than crystalline by a factor of two or more, but the costs are less by a factor of at least four, making these more affordable and useful for the two billion people on earth without access to electricity.

Photovoltaics may be the most prominent form of solar power, but solar thermal systems are also undergoing a resurgence. Solar thermal systems focus mirrors on a working fluid such as oil. Stirling Energy Systems (SES) has contracts to build two large solar-dish power plants in southern California.

As part of its fulfillment of the state of California's Renewable Portfolio Standard (RPS), Southern California Edison signed a 20-year power purchase agreement with Stirling Energy Systems for a 500 MW solar plant to be built in the Mojave Desert. The plant will consist of 20,000 dish concentra-

tors arrayed over 4,500 acres, producing approximately 1,000 GWh of electricity annually. The plant could be expanded to 850 MW. The utility signed a second contract with San Diego Gas and Electric to build a 300 MW plant in the Imperial Valley (with possible expansion to 600 MW).

Costs for the California Stirling plants have not been made public, but estimated levelized electricity costs for current concentrating solar power technologies are: 5-9¢/kWh for towers, 7-11¢/kWh for focusing troughs, and 9-13¢/kWh for dishes (the California Stirling projects). Projected costs, assuming reasonably attainable cost reductions in the next 10 years are: 3.5-5¢/kWh for towers, 6-9¢/kWh for troughs, and 4-6¢ per kWh for dishes. With their very large scale and long-term contracts, the two projects are likely to have costs closer to 4-6¢.

The Wind Revolution

Growth in the wind industry has been nothing short of explosive. In 1994 there was a mere 1,600 MW of wind installed in Europe, but now reaching 40,000 MW in 2005. An aggressive construction and installation program in Germany has resulted in over 18,000 MW installed. The north German state of Schleswig-Holstein currently meets 25% of annual electricity demand with over 2,400 wind turbines. In addition to Germany's progress, there is 10,000 MW in Spain, 3,000 MW in Denmark, and over 1,000 MW in Great Britain, the Netherlands, and Portugal.

The US has also seen a dramatic increase in installed wind power, with a 43% growth in 2005, and total capacity at 9,100 MW. The US however has a tremendous land-based wind resource with about 11 trillion kWh of achievable production – more than three times the total of all electricity produced in the US last year. The global wind industry has also been producing increasingly large and efficient turbines, with 4, 5, and 6 MW turbines now in production for land- and ocean-based applications. North Dakota, for example, has a larger wind resource than Germany, yet only 98 MW is installed. Wind is also, in many locations, the cheapest form of new power, with costs generally in 4-7¢ per kWh range.

Excitement also exists around tidal power, the ability to utilize the emerging field of synthetic biology to cleanly and cheaply create biofuels, hydrogen for use in fuel cells, and novel means of power storage.

Each of these technologies are now at or near what is often called tipping points – technological and economic stages in their evolution where investment and innovation, as well as market access could move these attractive but generally marginal contributors to playing major roles in the regional and global energy supply.

At the same time aggressive policies to open markets for renewables are taking hold at city, state, and federal levels around the world. These policies have been adopted for a wide variety of reasons: promoting market diversity or energy security, investment in local industries and job creation, and the protection of the environment. More than 20 US states have adopted significant standards for the fraction of electricity that must be supplied with renewables, while Germany and Sweden are committed to plans to reduce the use of fuels by 80% and 100%, respectively, in two decades. The world of renewable energy is changing.

Financing in Retreat

The US federal government and private industry are both reducing their investments in energy R&D at a time when geopolitics, environmental concerns, and economic competitiveness are all increasing the need for a major expansion in our capacity to innovate in this sector. Our ability to respond to the challenges of climate change, or to the economic vulnerability of the nation to disruptions in our energy supply have both been significantly weakened by the lack of attention to long-term energy planning.

Calls for major new commitments to energy R&D are now common, and calls for energy "Manhattan Projects" have become frequent. Strong correlations exist between public and private sector R&D, and innovation as represented by patenting activity. The scale of the energy economy, and the diversity of potentially critical low-carbon technologies to address climate change, all argue for a set of policies to energize both the public and private sectors.

My lab reviewed spending patterns of the six previous major federal R&D initiatives since 1940 and compared them to scenarios of increasing energy R&D by factors of five and ten. Based on IPCC assessments of the cost to stabilize atmospheric CO_2 at 550 ppm, and other studies that estimate the probable success of energy R&D programs and the resulting savings from the technologies that would emerge, $15-30 billion/year in the US would be sufficient. We found that the fiscal magnitude of a large energy research program – dramatically increasing our meager $3 billion annual national investment in energy research – is well within the range of programs in other sectors, each of which have produced demonstrable economic benefits. US energy companies could also increase their R&D spending by a factor of 10 and still be below average relative to R&D intensity of US industry overall.

Where Do We Go From Here?

The challenge we face is larger than simply increasing energy budgets, public or private sector. First and foremost, the country needs an energy plan and a goal. The US addiction to imported fossil fuels comes not only at an environmental price, but geopolitical and economic ones as well. Climate change, which promises to be a disaster if we continue our present path, can also be the rallying point for an economic clean-tech revolution.

We can and should make energy a national priority, and to do that we must:

Make energy and the environment a core area of education in the US. We must develop in both K-12 and college education a core of instruction in the linkages between energy and our social and natural environments.

Establish a set of energy challenges worthy of federal action. Establish what could be called Sustainable Energy USA awards that inspire and mobilize academia, industry, civil society, and government to take action on pressing challenges. Challenges could include campaigns to design and deploy:

- Buildings that cleanly generate significant portions of their own energy needs ("zero energy buildings").
- Commercial production of 200-mile-per-gallon vehicles, as can be achieved today with prototype plug-in hybrids using low-carbon generation technologies accessed over the power grid, or direct charging by renewably generated electricity, and efficient biofuel vehicles operating on ethanol derived from cellulosic feedstocks.
- Zero Energy Appliances (which generate their own power).
- "Distributed Utilities": challenges and milestones for utilities to act as markets for clean power generated at residences, businesses, and industries.

Invest in clean energy commensurate with its importance. Public sector spending alone will not solve our crisis of underinvestment, but a healthy private sector requires us to "prime the pump."

Expand international collaborations that benefit developing nations. Greenhouse gases emitted anywhere impact us all, not only today but for decades to come. In many cases, tremendous opportunities exist to offset future greenhouse gas emissions and to protect local ecosystems both at very low cost, but also to directly address critical development needs such as sustainable fuel sources, the provision of affordable electricity, and clean water. My laboratory has recently detailed the local development, health, and global carbon benefits of research programs and partnerships on improved stoves and forestry practices across Africa. We find that dramatic decreases in

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Africa. Few large PV companies are excited about prospects, and they have been unwilling to invest in infrastructure for delivery of PV to off-grid areas. Without incentives, should they be expected to?

In the few places where PV SHSs have been moderately successful (Kenya, Morocco, Zimbabwe), markets operate in an informal manner outside of government or power company control. Like bicycles and gen-sets, PV systems are sold over the counter. Although this private sector market might be the preferred approach, it is often accompanied by a downward spiral in quality and performance. The rural poor buy components, not designed systems, and the poor performance of these often slipshod systems does not help the technology's reputation.

For an expensive technology, the off-grid rural poor market segment poses challenges that thus far have not been surmounted. Rural spending power is quite limited. Although the cellular phone boom provides hope that PV SHS markets can be expanded on the continent, the expansion is not happening fast enough.

The spectacular growth of the PV industry in the North has come as a surprise even to Europeans – but in Africa, governments still do not have PV on the radar. For most, PV has been a "donor thing," with no real role in electricity sector planning. Even for off-grid PV, donors are usually the champions – PV has not been taken seriously at policy levels.

Poorly implemented donor projects

As of 2005, there is relatively little to show for the investment of over US$100 million in PV in Africa from multilateral donors such as the Global Environment Facility (GEF), the UN and the World Bank over the past decade. Although failure of PV projects is linked to development failures in Africa in general, there are some fundamental project issues that need to be re-thought.

In the mid-1990s, donors began designing a number of PV projects throughout the continent. Using GEF funds, the UN launched national PV efforts in Zimbabwe, Ghana, Uganda, Malawi, Lesotho, Namibia, Tanzania and elsewhere. The World Bank and IFC used GEF funds to build PV into energy programs in Kenya, Ethiopia, Mozambique, Zambia and Uganda.

From day one, "barrier removal" was the guiding mantra of GEF-supported PV projects in Africa. The theory was that renewable energy technologies would be viable if key market barriers were removed. What was needed, said the economist project designers, was elimination of these barriers so that renewables could compete on an even footing. For PV, high investment costs, low awareness, lack of technical skills and capacity were seen as the chief barriers.

So GEF funding, channelled through government, ended up funding activities that – it was hoped – would remove these barriers. In reality, most of the funds supported international workshops, vehicle purchases, hiring of project managers and consultants, and a whole range of awareness-raising activities, while comparatively little was spent on actual installations. In fact, to date, much of the allocated money hasn't even been spent! Clearly, removal of barriers does not mean that the private sector will enter the sector or that investments will occur.

A look at some of the "major" projects that were supposed to stimulate markets reveals a litany of failure – and sadly, there are many more:

- A $5 million 1995 UNDP GEF project in Zimbabwe resulted in the PV marketplace growing from four to over 60 companies overnight. After the project, most of the companies fell out of the market, and the fund was quickly depleted and closed.
- A $5 million 1998 IFC project in Kenya sought to make PV financing funds available to banks and PV companies to "transform" the market. Even at the project's concessional rates, PV companies and banks were not interested in the loans. In a market where 15,000 systems are sold per year commercially, less than 500 systems have been installed by this project.
- A multi-million dollar 2003 World Bank GEF effort to expand the PV market in Ethiopia, offered as part of a $120 million energy sector loan, was designed by consultants and handed over to a government department that did not have the capacity to execute the project. No systems have been installed thus far, but the project is listed as "active" on the GEF website.
- The Solar Development Group was a $45 million GEF/IFC program aimed at accelerating private sector reach into rural areas. It made several million dollars of investments and grants to PV companies in East Africa, with a relatively small impact. It had trouble finding companies that were interested (or could qualify) for the loans. Eventually its portfolio was handed over to a Dutch bank.

In the aid business, nobody likes a muckraker. Typically, we say little about the failures and move on to the next project. The danger, though, is that we get cynical, and begin to believe that development of the PV market is not possible.

Among the projects completed in the last decade, there were a lot of good ideas on how to build markets, but there wasn't really that much money and even less commitment to make things happen. PV company directors in Africa tell of days spent working with project designers and managers in vain hope that they could make something happen. Too often, projects were designed and handed over to entities, such as small government departments, that could not possibly execute them.

Often, multinational organizations simply went ahead with the business of implementing projects because (in the case of the World Bank) they are green window-dressing for much larger loan packages or (in the case of the UN) they are part of a political process of doling out internationally agreed funds. Even the most enthusiastic government officials and PV companies were thwarted by GEF's faceless bureaucracy, committee decision-making and endless paperwork.

Lack of incentives

The most important single reason for PV's lack of progress in Africa is the lack of incentives for companies and consumers. The phenomenal growth of PV in Japan, Germany and elsewhere is almost entirely due to incentive support and policy drivers that come from governments.

For Africa, the GEF – the largest single investor in PV – has said that subsidy is forbidden in its projects. From the beginning, this was the rule. Elaborate financing and guarantee mechanisms have been designed, pilots have been executed, new marketing methods introduced and productive uses proposed. Every gimmick imaginable to build markets has been incorporated into multilateral projects except subsidies.

Without the type of subsidy that has stimulated western markets, it is impossible to expect rural African markets to start buying PV on even modest scales. If the rich in the North can only be convinced to buy with a subsidy, how can the poor be expected to pay full price? How can PV companies be expected to invest huge amounts to set up infrastructure to sell one module at a time in remote villages when they can sell them by the thousands in Germany?

Government rural electrification funds – which might have subsidized thousands of systems – have not been made available for PV. In most countries, there is not even enough funding for grid electrification. Existing resources are too scarce to extend the hundreds of kilometres of 30 kV lines required,

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and renewable energy departments didn't want to split funding with PV companies.

Finally, from the overall needs perspective, PV as a technology has never been a priority. Alleviation of poverty is the big theme. In the development community, there are many who believe that PV has received too much development assistance already. In a continent where health, shelter, education, water, income generation and other basic human needs are so poorly served, it is difficult to make a direct case for PV.

Still, when Germany, California and Japan invest billions in PV – places with hundreds of times more kilowatt-hours per capita than Africa and scarcely half the solar radiation – doesn't the idea of building the Africa PV market make a kind of moral sense? Of course it does! PV must play a role in the future of Africa's power supply. The question is: How to do it.

Real niches for PV in Africa

Unlike Germany or Japan, few (if any) African countries have a coherent plan or strategy for the PV sector. PV in Africa has always been a small-project affair, without long-term champions or deep-pocketed supporters. National governments do not have serious interest, except where rural electrification wires can't reach. The sectors that matter – the private and utility sectors – are almost universally unaware and unwilling to invest in PV.

Perhaps the focus on PV for rural electrification only has taken the focus off – and diverted resources from – other viable and important PV markets. While grid-connected growth worldwide has outstripped off-grid PV market growth, similar important and strategic niches for grid-connect PV in Africa have been ignored.

Nevertheless, growing PV production and falling costs will eventually reach Africa and new niches will surely develop. As they do, key stakeholders in African power markets who presently view PV only as a tool for off-grid electrification will become more interested in the PV technology.

Although much of the potential impact of PV remains in small off-grid systems, there is considerable potential for use of PV in more elaborate off-grid systems. Maximizing access means looking at the public sector (as the World Bank is currently doing in a number of countries with projects that install PV in clinics, schools and pumping stations) as well as the private sector. Tourism, small business, telecom and agriculture would invest in PV if provided with the necessary incentives and capacity building. If on-grid PV makes sense in countries where there is excess power, then surely PV makes sense where grid power availability and fluctuations are a problem, in places like Kampala, Dar es Salaam and Nairobi. Today, there are tens of thousands of battery backups in east African cities where power supplies are fragile.

As happened in Germany, grid-connect programs will be critical to development of the PV industry in Africa. Grid-connect system capacity will build skills in an industry that has been focusing on small off-grid systems, and make the sector more interesting to investors. Finally, grid-connect PV will enable PV companies to diversify their business and, in the long term, enhance their ability to serve rural customers.

What is needed

There is an urgent need for support of both off-grid and on-grid PV activities. A market that has not grown significantly in 10 years will not grow spontaneously.

Support by donors and governments for PV projects and the achievement of agreed targets should go hand-in-hand. Supporters must mandate accountability on numbers of systems installed and sold. Africa knows how to install PV – what is needed are supporters concerned about the entire process of design, execution, monitoring and evaluation.

As in Europe, the US and Japan, subsidy will be a key element to the development of the market. With the drying up of GEF PV support, there is a need to seek new sources of subsidy funding. Some countries may be able to support modest PV subsidies with locally raised revenue. Others will require support from donors. The $20 billion PV industry should consider allocating support for Africa from within its own coffers.

Off-grid, PV needs to become part of the rural electrification planning process, and governments need to be clear about the limits of rural grid expansion.

Intelligent incentives must be made available. Subsidies should be available for a range of PV systems. A long-term vision is needed.

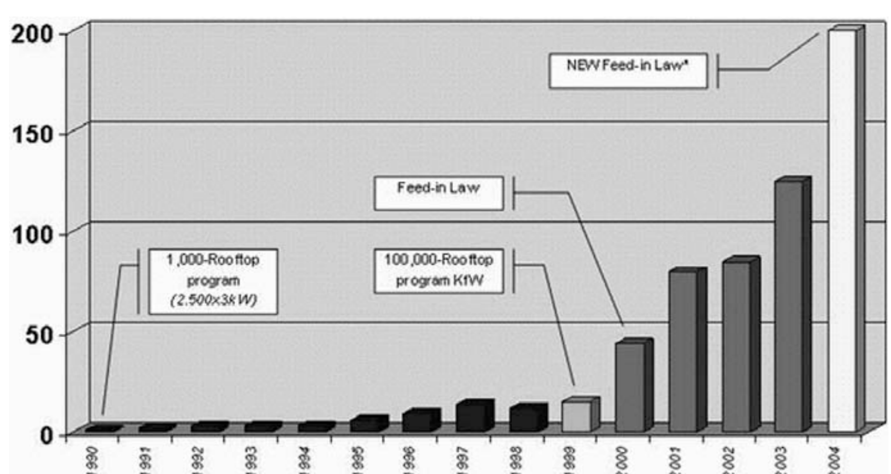
On-grid, there is a need to develop experience and treat PV as an electricity source that it highly valued and easily deployed. Clearly a situation where there is over a gigawatt of grid connected PV in developed countries and nothing in Africa is not tenable.

- government and utility policy must be adjusted to provide incentives and clear procedures for connecting PV to the grid
- targets must be set by ministries to promote use of PV on-grid
- investment by the private sector must be supported and encouraged
- creative financing tools must be developed (including carbon finance)
- a group of knowledgeable champions among African power utilities, ministries, private sector and regulators needs to be developed and supported
- existing global experience in grid-connected PV needs to be incorporated into the African market.

More that in any other part of the world, solar energy must play a role in Africa, as alternatives become increasingly expensive. New efforts in PV must take different approaches that learn from successes in the North, and mistakes of past projects. An Africa with a large PV market benefits everybody. ■

Mark Hankins is an energy consultant based in Kenya (email: mhankins@africaonline.co.ke). A longer version of this article appeared in Renewable Energy World (http://www.renewable-energy-world.com/)

Subsidies Could End Africa's Solar Eclipse



Annual PV installation in Germany: A "Feed-in Law" has resulted in a solar boom there.

Source: © RWE Schott Solar GmbH and EPIA

Building a Solar Nation, State by State

The California nonprofit group Vote Solar began after voters in San Francisco overwhelmingly approved a $100 million solar bond measure in 2001 to bring renewable energy to the city grid. Vote Solar has worked to replicate that initiative's success in cities and states around the country. Today, the group works on policy and regulatory issues to bring down the costs of solar power so it can be brought up to scale. We talked with ***J.P. Ross,*** *one of Vote Solar's three staff members, about their dream of a Solar Nation.*

What is Vote Solar trying to accomplish?
Simply put, we're trying to bring solar into the mainstream. Our mission is to make solar competitive with conventional electricity generation so we can have a self-sustaining solar industry. Once it hits that cost-effective level, the amount of solar that can be installed is gigantic.

We have a straightforward strategy for doing this. In the short term, while solar is more expensive than conventional electricity, financial incentives will be the engine that gets the solar market going strong. In addition, we are clearing the road of regulatory barriers, to make solar easier to install now and so that solar energy can cover every rooftop once the price reaches parity with conventional sources.

The cost curves will continue to move in solar's favor. Fossil fuels are going up, and solar will continue to come down in price as more people use it. The price of natural gas in this country has increased four times since 2001, and the volatility of its price has been even more pronounced. Once those lines on the cost comparison chart cross, there will be no stopping solar. Our job is to make that cost curve decline at an even faster rate. We want to see it be cost-competitive by 2012, not 2025.

What's your biggest challenge?
Convincing some decision-makers and utilities that this is a worthwhile path to take. A lot of people just want the cheapest power possible, even if that means dirty coal. Some utilities and regulators are a bit afraid of the loss of control that will come from such a decentralized system, in which individual homeowners and businesses are the drivers of investment in the electricity sector. We try to show them that even though solar is more expensive now, the long-term benefits are huge. There are strong job-creation benefits, robust system-distribution benefits (because of less strain on the grid system when houses and businesses have their system on the roof), and clean air and climate change benefits. There is tremendous momentum and public support for solar now, so our job is getting easier.

What is needed for solar power to really take off?
Nationally, we need to increase the number of state governments committed to solar. The California Solar Initiative was by far the largest commitment to solar in this country (it will bring 3,000 MW to the grid in the next 10 years). California is the sixth largest economy in the world, and it sets the example for other states on a lot of energy policies. Arizona just voted to increase renewable energy in the state, creating a market for up to 2,000 MW of new solar capacity – a program that is far larger on a per-capita basis than California's. New Jersey and Pennsylvania also have programs underway. The most likely scenario will be 10-20 states with major commitments to solar in coming years.

The federal government has also taken a big step to support solar. The Energy Policy Act of 2005, which created a 30% solar investment tax credit, was the first federal commitment to solar energy in 20 years. But the problem is that it was only for two years, and is set to expire at the end of 2007. We need a long-term commitment from the federal government to give solar a big boost and we'll be working to extend the tax credit for a full 10 years.

As state and federal governments commit to solar power we'll continue to see prices fall. The cost of modules comes down about 20% for every doubling of units produced, and the cost of panels is the single biggest cost of installing a solar system. However, we need to do more than just reduce the cost of the panels to bring solar into the mainstream. We need to remove all the regulatory barriers that can stop solar in its tracks, such as permitting and interconnection, as well as eliminating utility rates that are prejudiced against solar.

What are you working on now?
We are focusing significant attention on utility rates, which are the key to making solar cost-effective without subsidies. This year we were successful in getting a major southern California utility to offer solar-friendly rates to customers who install solar. They are now offering a solar-friendly tariff that increases the value of solar by 30-40%, just by properly valuing the cost of electricity. In effect they're putting a monetary value on solar's benefits to the utility, such as the reduced need to upgrade the transmission and distribution system (because solar adds power without adding burden to the grid), the reduced need for peaking plants for busiest electricity-use times, and the reduction in smog during the summer peak smog season (which is also the peak solar-power season). These kinds of rate deals are a key driver in getting solar to be self-sufficient.

What lessons have you learned from your campaign that might be useful to activists working on cleaner energy around the world?
Persistence. It took four years to get the California initiative passed. We tried to hustle it through every possible route. Also, when trying to convince skeptical policy leaders, we've found that it's important to utilize every possible argument in your favor. You never know when a key point will be taken up and championed by someone in power – some people will be drawn to the argument that solar creates more jobs, others will be more concerned about fossil fuel's cost volatility, while still others will be most interested in avoiding building new power plants or reducing air pollution. It's important to use your full set of tools and use facts to back them up.

We are on the right track. The level of growth in the solar industry has been phenomenal, with the market growing between 35-60% every year. This is the kind of growth that solar advocates have been dreaming of for years. The costs of installing solar are continuing to come down and we know we will be successful in bringing solar into the mainstream. The only question is will it be soon enough to avoid the worst consequences of global warming and more fossil-fuel-related wars. That is what motivates us to be successful in our work. ■

Africa's Sweet Harvest: Energy from Sugar

by Terri Hathaway

Sugar is king in Mauritius, accounting for 90% of cropland, 25% of foreign exchange earnings, and supporting 1 in every 18 residents of this tiny island nation. But sugar is not the only export coming from the cane fields – electricity is a valuable byproduct of the harvest.

For nearly 50 years, Mauritius has been using agricultural waste from its sugar industry to help electrify the nation. Not only does Mauritius have the highest electricity access rate in Africa – often cited at 100% – but more than a third of its electricity comes from power plants using bagasse, the fibrous waste from sugar cane. With 10 power plants in operation and even more planned, bagasse could provide over half of the country's electricity by 2010.

"Bagasse energy development has enabled the country to displace its reliance on imported fossil fuel, diversify its energy base, and reduce electricity generation investments by the utility," said Dr. Kassiap Deepchand, technical manager at the Mauritius Sugar Authority. "It has also improved the viability of the sugar industry by allowing its modernization and rehabilitation, enabled savings in foreign currency by decreasing fossil fuel imports, and reduced our greenhouse gas emissions."

How it works

Cogeneration is the process of generating both electricity and heat simultaneously in a single power plant. By using agricultural waste – sugar is one of the most efficient – cogeneration uses a renewable source of biomass. The fibrous cane stalk can be burned to make steam and generate electricity. Sugar factories can easily meet their own energy requirements with bagasse, and well-designed, efficient plants can generate a surplus for sale to the national grid or to support a mini-grid in rural locations.

Unless some of the bagasse is stored for use during the non-crop season, another fuel must be used to produce electricity year-round. A renewable energy fuel such as ethanol could be used; otherwise, a fossil fuel is used. In Mauritius, the power plants were designed to use all available bagasse during the crop season. Only three of the 10 bagasse plants run year round, using coal during the half of the year when bagasse is unavailable.

Keys to Mauritius' success

Mauritius has some unique characteristics that may have helped influence its success with bagasse. The country does not have its own fossil fuel resources and relies heavily on imported fuel. The island was uninhabited before colonization. After periods of Dutch, French and British control, the country gained independence in 1968 and now has one of the highest GDPs per capita in Africa ($13,000). The country is home to just 1.2 million residents. Sugar cane, covering 40% of the island's land, has benefited from preferential trade agreements with Europe, which have paid up to three times the world market price.

Interest in exploiting energy from bagasse began with just one sugar factory in 1957. In the 1980s, two bagasse cogeneration power plants were built and began to export power to the grid. In the 1990s, the combination of successful plants and increasing oil prices led to the development of a Bagasse Energy Development Programme, a collaborative effort between the government and the private sector.

For over a decade, government policy has continuously supported building a successful cogeneration energy system, not only integrating bagasse into the country's energy planning, but prioritizing it. A clear policy on use of bagasse for electricity was developed, and supporting policies and legislation, such as removing income tax for bagasse electricity revenue, were put in place. Targets for growth were set. Barriers to meeting those targets were identified and addressed along the way.

Small cane growers have not been ignored. A Sugar Investment Trust, comprised of small growers and industry workers, was established in 1994 and owns a 20% stake in all of the cane milling companies, 20% in the seasonal bagasse plants, and 14% in the year-round plants. The shareholders are then entitled to a dividend based on the profits of the trust. About a third of the nation's bagasse energy comes from small growers.

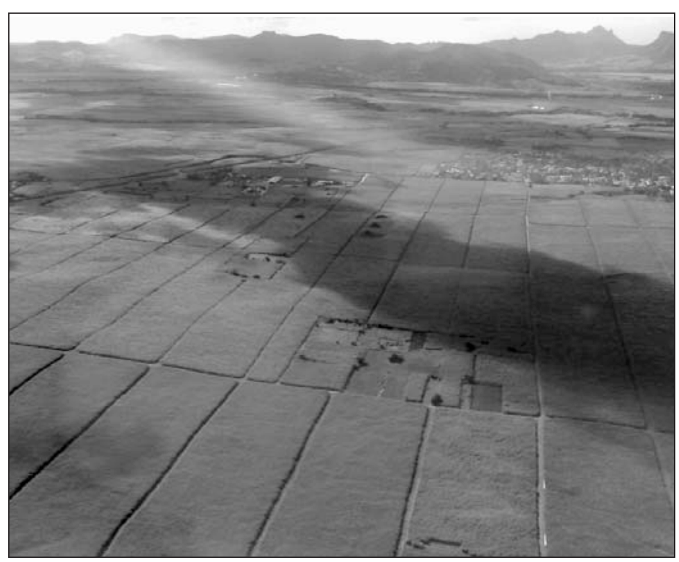
Mauritius' sugar industry does, however, face risks. Sugar production costs are on the rise, and global prices are projected to drop by about a third in the next few years. But Deepchand doesn't see this as a risk. "The drop in sugar prices offers an opportunity to mitigate the impact on revenue by enhancing electricity export to the grid," he said, predicting that mill centralization and technological upgrades will make the bagasse plants more efficient.

African expansion

Researchers estimate that there is great potential for bagasse cogeneration in many African countries. Total cane production in Africa is 90 million tons, representing 10,000 GWh of potential bagasse-generated electricity. Sudan has possibly the highest potential, with approximately 644 GWh (just greater than Mauritius's 600 GWh potential); Kenya has 530 GWh; Ethiopia, 150 GWh; Uganda, 173 GWh; and Tanzania 101 GWh of potential.

While it is believed that many African countries could produce bagasse-based electricity, commercial viability requires an estimated 200-300 tons of cane to be crushed per hour, which is far more than many countries currently produce. It also requires careful management of a country's sugar industry, something often neglected by many African governments.

Deepchand believes that creating an enabling environment for independent power producers to build cogeneration power plants is a key step to successful bagasse generation elsewhere in Africa. "The success achieved in Mauritius can be replicated in the region, the African continent," he says with confidence. ■



Mauritius' sugar cane fields.

IN PRINT

Small is Profitable: The Hidden Economic Benefits of Making Electrical Resources the Right Size, by Amory B. Lovins et al. (Published by Rocky Mountain Institute, 2002, 399 pages, US$60 soft cover/US$30 PDF, www.smallisprofitable.org)

In 1976, Amory Lovins published a paper in *Foreign Affairs* that caused a storm in the US energy industry. In it, he argued that the industry faced a choice between two mutually exclusive paths. Choosing the "hard energy path" would lead to further investment in gigantic, centralized nuclear and fossil-fuel fired power plants and high-voltage transmission networks, unavoidably accompanied by massive energy wastage and other social and economic problems inherent to such systems. On the other hand, the "soft energy path" entailed transition to renewable energy technologies, whose smaller scale more closely matched the needs of consumers, accompanied by much greater emphasis on energy efficiency. Ultimately the US energy industry continued along the hard path. Yet, as Lovins and co-authors demonstrate in their recent book *Small is Profitable,* electricity industry restructuring since the early 1990s in the US has led the market's invisible hand to gently reroute the industry in the direction of the soft energy path to the point that the authors feel able to proclaim: "The era of the giant thermal power plant has quietly ended."

Small is Profitable begins by tracing the ascendancy of the centralized model of power generation in the US and finds that key assumptions that led to the industry's fixation with gigantism are no longer valid. (While the book focuses exclusively on the US electricity industry, the authors suggest that many of the lessons learned may extrapolate globally.) In an attempt to lower consumers' electric bills through reduced generating costs, engineers obsessed with building increasingly larger centralized power stations, eventually reaching well beyond 1,000 megawatts in size. The engineers treated the network of transmission and distribution wires needed to get the electricity from remote centralized power stations to consumers as an unavoidable fixed cost.

Yet, according to this team's analysis, the wires business is now the dominant factor in consumers' electricity bills, not the cost of electricity generation itself, and most blackouts result from grid failure, not generation failure. The economies of scale predicted for centralized plants have also failed to materialize in plants larger than one hundred megawatts or so in size. The authors' conclusion, therefore, is that cheaper and more reliable power is best produced close to where it is consumed and at a scale the right size for the job.

The central message of *Small is Profitable* is that economic and other benefits of distributed electricity (also known as decentralized electricity) are becoming irresistibly attractive. Distributed electricity generators are typically renewable, but not necessarily so, and include photovoltaic cells, wind turbines, fuel cells, and efficient gas-fired cogeneration plants. Among other advantages, distributed generating technologies benefit from reductions in cost associated with mass production rather than massive individual plant size. In places like the US, with nearly complete coverage by existing grids, distributed systems can supply supplemental electricity to areas that require more power and are already served by transmission grids in place of expensive grid upgrades. In remote areas where the grid is yet to reach, distributed electricity systems can operate independently at the household scale or through mini-grids.

Distributed electricity is not just about improved generating technologies and distribution arrangements, but also optimizing the electricity services provided to the end-user, including improving the efficiency with which electricity itself is used and providing power of a quality suitable for the task at hand. According to *Small is Profitable,* the net result of the distributed electricity approach is system-wide savings on operating and external costs.

Small is Profitable details 207 benefits that can be derived from distributed electricity. Benefits range from the strictly financial (No. 6: Smaller, faster modules can be built on a "pay as you go" basis with less financial strain, reducing risk) to the esoterically technical (No. 110: Distributed resources can reduce reactive power consumption by shortening electron haul length through lines and by not going through as many transformers – both major sources of inductive reactance). Recognizing that decisions are often not made on a financial or technical basis alone, the book also explores the numerous values that, although not readily quantified, can be decisive in making energy choices. These include the benefits of green sourcing, security of supply (No. 171: Distributed resources can significantly – and when deployed on a large scale can comprehensively and profoundly – improve the resilience of electricity supply, thus reducing many kinds of social costs, risks and anxieties, including military costs and vulnerabilities), and stakeholder conflict avoidance.

Although the list of benefits is aimed more at energy-industry professionals, the book's intended readership also encompasses public policy makers, concerned citizens, and business leaders. The latter are becoming increasingly influential decision-makers, bringing their market logic to bear on a traditionally conservative yet increasingly business-orientated industry. The book goes to some length to highlight the profitable opportunities available to businesses investing in distributed electricity, as well as outlining practical policy changes that are required to enable distributed electricity to realize its full value. Lay readers are assisted with numerous tutorials and boxes explaining technical concepts.

Fundamental changes are underway in the US electricity business and Small is Profitable seeks nothing less than to nurture a revolution, recognized by Lovins three decades earlier, that would return the power industry back to the neighborhood level from where it originated more than 100 years ago. While *Small is Profitable* persuasively entices business leaders and policy makers with the language of economics, the authors' long affiliation with the sustainability movement make it clear that one underlying motive of the book is to help ensure that electricity will not end up bankrupting the planet.

Carl Middleton

Decentralizing Power: An Energy Revolution for the 21st Century, by Greenpeace UK (2005, 72 pages, free from www.greenpeace.org.uk/MultimediaFiles/Live/FullReport/7759.pdf)

"We can be pretty certain what unsustainable electricity looks like," asserts Walt Patterson of the UK's Royal Institute of International Affairs. "It looks like most of the world's present-day electricity systems."

Patterson's critique sums up the central message of *Decentralizing Power,* which presents a scathing critique of Britain's centralized, inefficient and outmoded power grid system, and outlines a contrasting vision of a decentralized, efficient and environmentally friendly alternative.

One of the report's more stunning revelations is that 78% of energy produced in the UK is wasted. Energy loss occurs through heat loss or inefficient power production in power plants; losses in transmis-

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When Pulimarang village was electrified with solar home systems in 1996 – the first solar village in Nepal – people came from all over to see. Because smoky kerosene lamps were replaced with quality electric lights, the project had benefits for health and education. Students now study past dark, and villagers began adult education classes. The battery power also allowed people to listen to radio and watch television – a source of information and entertainment. Women started knitting shawls in the evening, adding to their incomes.

Against the backdrop of this micro-energy revolution, the picture for the megaprojects handled by the government utility is dismal. The cost of the 70 MW Middle Marshyangdi Hydropower Project has doubled, the completion date delayed. Nepal will face power shortages for a few years because of this project's problems. The complexity of large projects like Middle Marshyangdi and its predecessors raise more questions than hope for affordable electricity for the people.

Efforts by government to attract foreign investors to build megaprojects are underway, but it is too early to predict the outcome. A Power Summit was held in Kathmandu in July to attract Indian developers, and today a number are vying for licenses for large dams total 14,000 MW for power export to India. Little information regarding the environmental impacts of some of these large dam projects has been discussed publicy. Thus far, no big dam projects have reached the implementation stage.

The scenario in the small hydro sector (up to 15 MW) is different. As the hydropower sector opened to the private sector after the Arun debacle, about half a dozen power plants, mostly small hydro, have come online. Local finance, local expertise and the local hydro industry are being mobilized in the process. With the success of the first few projects, the banking sectors are also keen to invest in new projects. Local consulting firms have more jobs, and local contractors and fabricating workshops too. All of this is building local capacity. The first generation of private sector small hydro projects have some inevitable problems, but the Nepali hydro industry is gaining strength from the experiences. ■

The author is a mechanical engineer working on hydropower in Kathmandu.

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respiratory illness, and much more sustainable forest management is possible across much of Africa through program and policies that emphasize best practices in legal, managed, charcoal production as well as programs to disseminate improved stoves. Far from an isolated example, such opportunities exist everywhere.

Recognize and reflect economically the value of energy investment to the economy. Clean energy production – through investments in energy efficiency and renewable energy generation – has been shown to be a winner in terms of spurring innovation and job creation. This should be reflected in federal economic assessments of energy and infrastructure investment. Grants to states, particularly those taking the lead on clean energy systems, should be at the heart of the federal role in fostering a new wave of clean-tech innovation in the energy sector.

And finally, we must put economics to work and begin a serious federal discussion of market-based schemes to make the price of carbon emissions reflect their social cost. A carbon tax and a tradable permit program both provide simple, logical, and transparent methods to permit industries and households to reward clean energy systems and tax those that harm our economy and the environment. Cap-and-trade schemes have been used with great success in the US to reduce other pollutants, and several northeastern states are experimenting with greenhouse gas emissions trading. Taxing carbon emissions to compensate for negative social and environmental impacts would offer the opportunity to simplify the national tax code while remaining, if so desired, essentially revenue-neutral. A portion of the revenues from a carbon tax could also be used to offset any regressive aspects of the tax, for example by helping to compensate low-income individuals and communities reliant on jobs in fossil-fuel extraction and production.

In summary, R&D is an essential component of a broad innovation-based energy strategy that includes transforming markets and reducing barriers to the commercialization and diffusion of nascent technologies. The evidence we see from past programs indicates that we can effectively scale up our energy R&D effort substantially. We recommend a sustained increase in funding by *at least a factor of five* to meet the energy challenges of the 21st century. The economic benefits of such a bold but long overdue move would help transform our economy into what at one time seemed impossible: a vibrant, environmentally sustainable engine of growth. ■

Daniel Kammen is the "Class of 1935 Distinguished Professor of Energy" at the University of California, Berkeley, and founding director of the Renewable and Appropriate Energy Laboratory (http://rael.berkeley.edu). A longer version of this article appeared in Scientific American.

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sion and distribution systems; and through leakage, poor insulation and inefficient end use by homes and businesses.

Decentralizing Power provides a step-by-step description for the lay reader on how to implement a decentralized energy system. It requires more than just plugging wind, solar or geothermal systems into an existing grid. A complete revamping of the energy system is necessary so power requirements can be met locally and use of the national grid is limited to being a backup, rather than primary, source of energy.

The report acknowledges substantial institutional barriers that need to be surmounted, both from an entrenched industry hostile to change and a regulatory system rooted in the status quo. The report urges using the British tax system to reward homeowners and businesses that install decentralized energy systems, while penalizing inefficient centralized power stations.

The ultimate goal is to create energy use and production patterns where end users also become producers. Such a strategy is operational in Woking, southwest of London, where the town council has installed a network of 60 local cogeneration plants, photovoltaic arrays and even a hydrogen fuel cell station. Woking is now 99% energy self-sufficient and has reduced its CO_2 emissions by three-quarters.

As Jeremy Rifkin, President of the Washington, DC-based Foundation on Economic Trends, put it, "Once the consumer, the end-user, becomes the producer and supplier of energy, power companies around the world will be forced to redefine their mission if they are to survive."

Tim Kingston

Sharing the Air: Making Wind Power Safer for Winged Creatures

by Elizabeth Sabel

Scientists and environmentalists are working to reduce the number of bats and birds killed by wind turbines. Although estimates vary, a 2003 report from the National Renewable Energy Laboratory stated that over 1,000 birds were killed annually in the Altamont Pass of California, the oldest and one of the largest wind farms in the US. A 2004 study by the Bats and Wind Energy Cooperative (BWEC) concluded that over 1,300 bats were killed in a six-week period at a wind center in West Virginia.

Many of the species being killed are threatened or endangered, and critical to the health of the planet. Bats, for example, support more than 300 plant species in the tropics alone through pollination and seed dispersal. Bats also eat tons of unwanted insects, decreasing the need for pesticides.

BWEC, a collaborative effort between wind energy companies and bat specialists, is in the middle of a five-year research program to determine the best methods for minimizing the risks wind farms pose to bats. Their efforts include studying bat behavior at current wind energy sites, identifying potential low-risk sites for building new wind facilities, and experimenting with audio signals that would deter bats from flying in the path of the turbines.

Groups such as the Ornithological Council and the Wildlife Society are co-sponsors of a joint statement issued in March supporting renewable energy development and urging energy firms to collaborate with independent scientists in order to minimize the impact of their technologies on wildlife. Conservation groups are also encouraging wind energy investors to only invest in firms that demonstrate a commitment to resolving wildlife problems associated with wind farms.

Bird deaths at the Altamont Pass wind farm spurred the debate on the impact of wind farms on birds. Studies have shown that Altamont Pass has the world's worst bird-kill record for windfarms. The pass is a major migration route for birds of prey. Many of the original turbines built at the pass are also less efficient than their modern counterparts, requiring many more turbines to produce energy, thereby increasing the threat to birds.

In response to growing protests, the local government adopted a plan in 2005 to close half the turbines at Altamont Pass for three months during winter migratory season. Older turbines will be shut down permanently.

Because they are much more efficient, modern turbines pose less threat to birds and bats than the first wave of large wind turbines built in the 1980s. Fewer turbines are required to produce energy and the blades of the turbines move slower, which helps prevent flying creatures from getting caught in them.

Although there doesn't seem to be a quick fix to the problem, further research, learning from past mistakes and collaborative efforts with wildlife experts are important steps toward making sure the wind power industry can continue to expand while keeping the skies safe for birds and bats. ■

For further information: www.nationalwind.org, www.batcon.org

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