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Vietnam Village Hydro - a strategic rural development model

by Katsuhiko Otaki, Proact International Inc., Japan

By the end of 2000 about 75% of rural communes in Vietnam had been connected to the national power grid, but substantially less than 75% of rural households are connected thus far and there are many areas where the grid cannot be extended due to technical or financial difficulties. In February 2001, Japan International Cooperation Agency (JICA) initiated the “Renewable Energy Master Plan Study” targeting northern Vietnam, and aiming at developing sustainable models for off-grid rural electrification based on renewable energy sources such as micro-hydro or photovoltaics.

Northern Vietnam belongs to the tropical monsoon climate, but has a change of seasons. During the rainy season from May to October, it is hot and humid. During the dry season from January to March, cloudy days continue with haze and drizzle. Most of the un-electrified communes that want off-grid projects are located in remote and mountainous areas and often inaccessible by vehicles. On average, each commune has ten villages and 500 households.

Although northern Vietnam is endowed with rich water resources, micro-hydro development has been fairly stagnant. This is attributed to a lack of systematic inventory surveys on potential micro-hydro sites, shortage of experienced project implementers, absence of financing guidelines for off-grid rural electrification projects, and underdeveloped domestic engineering and manufacturing capabilities for micro-hydro.

Demand estimation

In remote villages, the peak electricity demand occurs at night, when many villagers use electricity for lighting and small appliances at the same time. Typical elec-



Photo: Katsuhiko Otaki

Overview of a low-head type Village Hydro (2kW) built at Tu Do Commune in Hoa, Binh Province, Vietnam

trical uses are lights, radios and TVs. At the initial stage of electrification, the villagers’ demand for electricity is small and its growth rate is low. Table 1 (shown below) is a summary of an electricity demand survey conducted in remote areas of Vietnam. The survey shows that a unit demand of 50W per household would be reasonable.

Overestimation of electricity demand in off-grid electrification projects has in the past led to an unnecessary expansion of supply, over-capacity, and high investment costs. The over-capacity results in insufficient revenues to cover the capital and recurring costs, which leads to poor maintenance and possible breakdown of the systems.

Step-by-step development

In the past, overseas donors preferred relatively large-scale plants for rural electrification. For example, 100kW micro-

hydro plants were often developed to electrify several villages, with the idea that bigger systems were more reliable and because Vietnamese manufacturers did not yet offer micro-hydro components. Less attention was paid to operation and maintenance, which often posed problems for the villagers.

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Table 1: Estimated electricity demand per household

Appliances	Power (W)	Units	Total Power (W)	Ownership (%)	Peak-time Coefficient (%)	Power demand (W)	Remarks
Fluorescent Light	20	2	40	100	88	32.0	Main room Kitchen
TV	30	1	30	80	80	19.2	B/W TV
Radio-cassette	10	1	10	40	10	0.4	
Electric fan	30	1	30	30	30	2.7	Small (20cm)
Total						54.3	

In the JICA study, we took a different approach, focusing on smaller plants ranging from 1kW to 10kW and using a low-cost but robust micro-hydro design. We used step-by-step development to meet the demand increase while minimising idle capacity, based on a series of 5kW plants rather than a single 20kW plant. In this case, the power systems will run with a high load factor and the users don't have to pay for excess

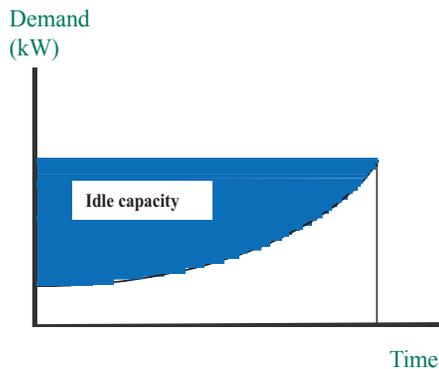


Figure 1a: Initial capacity is too large

Village Hydro

The term "Village Hydro" can be defined as small water-driven systems suitable for power supply in rural communities not connected to the national grid. Systems in rural communities and the demand for power rarely justify larger systems. We worked to develop appropriate Village Hydro models focusing on Vietnamese technologies. Our goal was to achieve "easy to finance, easy to build and easy

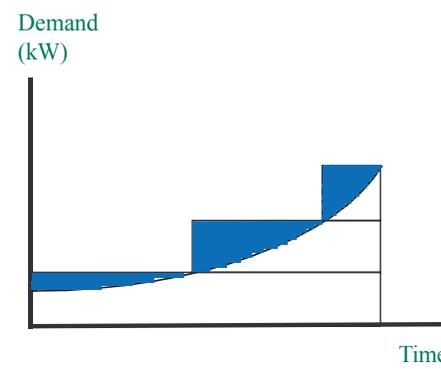


Figure 1b: Capacity added to meet demand increase. (Step-by-step addition of capacity)

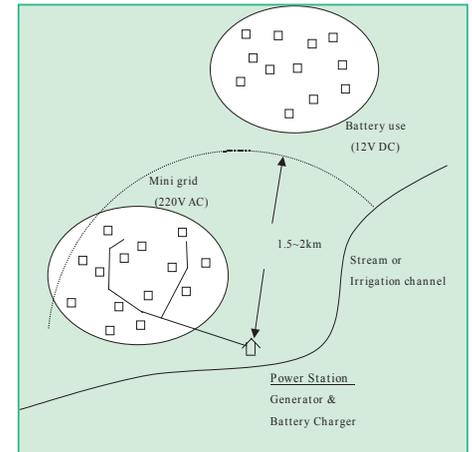
capacity. The step-by-step approach helps to achieve financial sustainability for off-grid systems, which need to be managed with villagers' payments.

to operate" models.

The technical features of Village Hydro developed in the JICA study include a standardised design based on domestic

technologies, domestically available equipment and materials, operation and maintenance by local people, and light-weight components that can be carried by hand (such as PVC pipes). Standardisation effort lowers costs and improves the quality of equipment, and facilitates subsequent replication of similar power systems at other sites.

A Village Hydro system serves a relatively small area, because extending the



Layout concept for rural electrification using Village Hydro

distribution lines beyond the limit - usually less than two kilometres - is very expensive. Villagers living outside of the service area are expected to use battery-charging units installed at the powerhouse, which thereby increases the number of electrified households while minimising additional investment.

Model designs

The first model is a typical "run-of-river" design, which comprises a weir, intake, channel, head tank, penstock, and powerhouse. Even in remote communes, it is not so difficult to find an existing irriga-

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tion channel that can be renovated to incorporate a Village Hydro system. Standard packages of turbine and generator are selected based on the combination of discharge and head at the site. This effort will encourage less experienced developers and villagers, because they need only place an order on a suitable package rather than worry about technical design.

The second model, "Pico-plus generator," is designed for low-head sites to generate an output of up to 2kW. It uses the same technology as pico-hydro generators that are available in the local market. A common form of generator is the permanent magnet type, although a small induction motor can also be used as a generator. It needs special structures to guide the water to the turbine, but a penstock and valves are eliminated.

In both models the generation system is equipped with an electronic voltage controller to stabilize the voltage at 220V, improving the safety and operability of installed power systems. A prototype of the voltage controller has been engineered and is now being tested at a workshop in Hanoi.

Distribution system

Since houses are dispersed in remote areas, the distribution system accounts for a significant part of the capital investment. The voltage level of Village Hydro distribution system is 220V, because high-voltage distribution systems cannot be justified from the viewpoints of economy and maintenance. The total service area of a distribution system is determined by the voltage available at the end of the distribution line. By using larger-size cables, it is possible to expand the service area, however the system cost will rise. One practical idea is to generate at a higher voltage (maximum 250V). Under normal conditions, when the system is loaded, voltages at end-users will drop to 220V. This will save the distribution line cost.

Financial analysis

We aimed for model plans that would be financially sustainable with the revenues from users. A typical 5kW Village Hydro

system serving 100 households can be built for less than US \$10,000 or US \$100 per household, which is significantly lower than that of previous micro-hydro projects. The low capital cost of Village Hydro is attributed to standardisation, domestic manufacturing, low-voltage distribution and local labour. The low cost design addresses the financial constraints of the public sector, thereby supporting the government's efforts to secure development budgets for off-grid rural electrification.

In Vietnam, farmers' electricity tariff is regulated at 700 Dong (US 4.6 cents) per



Photo: Katsuhiko Otaki

A compact turbine and generator (7kW) set produced at Hydro Power Center in Hanoi, Vietnam



Photo: Katsuhiko Otaki

Two generators (1kW each) running in parallel

kWh, which does not reflect the actual incurred costs. Based on expected use profiles, it was assumed that users would pay 4,000 to 6,000 Dong (US 27 to 40 cents) per month, although they might be willing to pay more for stable electricity supply. The battery charging fee would be around 3,000 Dong (US 20 cents) per charge.

A cash flow analysis indicated that Village Hydro would be financially sustainable if a 50% subsidy is given towards the capital investment cost. The 50% subsidy seems reasonable and fits the government's policy framework. The revenues from users will be able to cover the capital repayment (after subsidy) and the running operation and maintenance costs

over the life of the plant. Even with the small payments from each user, the low cost design makes the system financially sustainable and improves the viability of off-grid rural electrification.

The JICA study proposes a strategic development model - Village Hydro, which is suited to northern Vietnam, and it is expected that the government policies will support the model. As the technologies become widely available in Vietnam, off-grid rural electrification projects can be accelerated to improve the living standard of remote villagers. ■

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Conference Report

World Bank Energy Week – can a super tanker change course?

by Jeremy Woods, Imperial College Centre for Energy Policy and Technology (ICCEPT), UK

A Renewed Agenda for Energy was the working title for the latest annual World Bank Energy Meeting that took place 24-27 February 2003. The meeting had two main themes:

- the decreasing role of foreign private investment in developing countries, with particular focus on improving the enabling environment and governance issues; and
- challenges in the energy sector in light of the World Summit on Sustainable Development agenda increasing access to modern energy services for the poor, improving the targeting of subsidies and increasing the role of renewable energy.

The meeting was comprised of a 1.5 day *energy forum* and three workshops. The workshop on *Biomass Energy* was open to the public, while workshops on

erty eradication” had focused or diffused the sense of understanding in finding a way forward. Another question was whether the Bank’s current approach reflects an appropriate sense of urgency on the need to deploy and test the whole array of renewable energy technologies and demand side efficiency options across different sectors and carriers.

Day 1: The true path?

What happens when large organisations like the Bank that are responsible for much of the planning and delivery of energy services aim their “super tanker” at the provision of electricity? Occasionally they might try to alter course when the wreckage of the transport or heat provision sectors blocks their way, but very

ible energy carrier, but past experience shows that a more balanced approach is needed.

The sheer magnitude of the one-track approach was dramatised by the rather chilling assertion from Ian Johnson, vice president of ESSD, that “a tripling or more likely quadrupling of energy provision” was needed to meet the Millennium Development Goals (MDGs) and achieve sustainable development. Knowing that this would require global provision of 1200 to 1600 EJ per year by 2050, one can quickly conclude that stabilisation of a CO₂ at 450 or even 550 ppm could never occur under such circumstances, and the loud crack of threshold mechanisms breaking under the strain would become common to the ears of our children and grandchildren.

Ian Johnson did briefly distract us from electricity by leading us through the challenges facing the agricultural sector in meeting the MDGs. Both the scale of the investment required and the increase in average crop yields needed by 2050 to feed a global population of 9 billion appeared breathtaking but not impossible. Increasing yields and renewed growth in the agricultural sectors of developing countries were shown to be crucial to and compatible with the MDGs, as evidenced by a study two years ago showing that a 10% increase in yields led to a 9% decrease in people living on less than \$1 per day in Africa.

The future of agriculture is also linked crucially with climate change. A 20% yield decrease may result from climate change in sub-Saharan Africa if technology and knowledge remains static. The potential decreases in agricultural productivity from the impacts of tropospheric ozone arising primarily from traffic pollution further darken the picture. However, locally based solutions to these problems can be developed and undoubtedly biomass energy will play a major role in mitigating both areas of concern.

Codeword “Governance”

Soon we were back on board the Washington DC-registered “electricity” tanker heading this time for treacherous waters: regulation of electricity markets. In many



Panellists from major donor agencies discuss the donor perspective on energy poverty and alleviation projects

Energy Markets and *Energy and Poverty* were closed to the public.

Your commentator was investigating the extent to which the World Bank’s energy projects had gained a renewed sense of strategy and purpose and whether phrases such as “poverty reduction” or “poverty alleviation” or “pov-

quickly their autopilot brings them unerringly back onto the “true” path of electricity provision. Such was the case during the first day of the energy forum. Although demand-side efficiency and other issues briefly appeared on the horizon, they were passed by rather quickly. Of course, electricity is the modern, flex-

ways the following sessions were an admission that the previous decade has been a dangerous and mostly failed experiment with "deregulation" in the electricity markets of developing countries. The word "deregulation" was unceremoniously dumped. So much so that Ashley Brown, in his thoughtful and interesting talk on *Improving regulations: some proposals for Brazil* stated that "deregulation should be expunged from all the languages of the world." Regulation is now seen as the only way to save privatised electricity markets in developing and developed countries alike. However, regulation is still a dirty word in the minds of many politicians and so the new codeword "governance" has emerged to replace it.

The previous decade of experimentation with privatised electricity markets has led to calls for new institutional foundations for properly functioning electricity markets, the need for which has been obvious to so many for so long. The most obvious issue is "gaming," which enables private electricity providers to make profits even when the market is distorted to the point of farce. A good example is when "local supply" limitations – due to full capacity utilisation or capacity that cannot be accessed – allows one or two providers to gain an effective monopoly of supply so that they can bid in with a price of their choice. In order to have an efficiently functioning market you need excess capacity even at peak periods of demand, but excess capacity is not "efficient" in market terms - oh dear!

The second obvious lesson that seems to be being learned is that small countries and grids are not the same as large countries with extensive generation. Grid capacity and a model that works in electrified rich countries is not likely to fit well with small, less-electrified developing countries. How do you get an efficient electricity market in countries with only a few generating plants and fragmented grids?

My overriding impression of the day was how complex and clever and yet at the same time transparent the regulatory process has to be in order to function well. The regulatory process must have



African, Chinese and US panellists highlight issues on resource sustainability for the provision of biomass energy services

independence from industry, external monitoring and market surveillance but also the flexibility and teeth to develop local level regulations in a fully transparent and participatory way.

Day 2: Running aground!

Day two offered an exciting day of unexpected twists and turns when the electricity super tanker ran aground. For a brief and exhilarating time, a balanced "energy services assessment" approach emerged under the skilful stewardship of Dominique Lallement and Dick Jones. Heating services, including cooking, were addressed under the auspices of the Global Village Energy Partnership (GVEP). GVEP takes a bottom-up approach, by first "asking the consumers" i.e. the rural poor in developing countries about their priorities. GVEP then evaluates the energy services required to meet those needs and wealth generation activities that must accompany those services before finally asking what energy provision technologies can meet those needs in a sustainable and equitable way.

It became clear that even though "energy" was not specifically mentioned in any of the MDGs, the services required to meet them were almost entirely energy services. Therefore, sustainable, affordable energy services are at the heart of the Millennium Development process and the energy sector needs to understand the implications of this fully and educate the non-energy specialists to the central role of energy service provision.

Susan McDade (UNDP) extolled the virtues of the "Mali multi-platform approach" which is currently a basic diesel engine (manufactured in India) to which a number of important processing systems can be attached, including flour mills, welding apparatus, battery charging, etc. This system appears to be highly successful in allowing "value-added" services for rural areas of developing countries, all that is required is for affordable and robust renewable energy provision to be integrated into the systems.

Electricity regulation did reappear in the second day but this was tempered by an extraordinary 20 minutes of what seemed to be heart-felt apologies by the ex-vice president of the World bank, Richard Stern. In effect, he was apologising for a decade of energy policy arising from the Bank during which a reductionist one-size-fits-all "deregulated electricity market policy" was strong-armed onto a large number of developing countries, sometimes with disastrous consequences.

The multitude of energy services available from biomass were not discussed to much extent in the energy forum, perhaps in part because these issues were to be addressed in the biomass workshop that was open to the public. But the energy forum did seem to set the stage nicely for the biomass workshop by illustrating the problems of transpo-

Continued on p. 6

ing (and/or imposing) large-scale energy systems and institutions from one region or country to another.

Day 3: Biomass workshop

This was a unique and special one-day meeting that was organised by Boris Utria and his team in the Regional Program for the Traditional Energy Sector (RPTES) at the World Bank. It was unique because it was the first time that biomass energy had appeared in its own right in World Bank Energy Week. It was special because of the comprehensive African participation ranging from high-level government ministers to project-based researchers who attended in significant numbers (primarily drawn from the RPTES network). Their expertise and enthusiasm for the potential of biomass energy to engender development and welfare energised the meeting. The workshop covered a whole range of biomass-related issues in the areas of poverty, gender, resources, finances and climate change. Given the complexity of the issues, the workshop was necessarily limited in scope by having only one day.

As the workshop unfolded, it became increasingly clear that biomass is coming of age both technologically and in the attitudes of “biomass experts.” Gone are the claims that “biomass energy can solve everything” and in its place a more detailed and studied approach to understanding where bioenergy has the greatest opportunities and how to match technologies to resources. Central to this new understanding is that the barriers to successful bioenergy implementation are mostly non-technical and that the focus of implementation projects must be on providing the energy services required by the local people and tailoring these services to their needs.

Resource requirements

The message that biomass energy provision is resource hungry in terms of land, labour and institutional commitment was made by the Zambian and Malawian Ministers for Energy and Water Development and Natural Resources and En-

vironment, respectively. With 14 Mha of land required to supply 15 billion litres of ethanol, which would provide a significant share of Zambia’s liquid fuel requirements for transport and cooking, the scale and potential for bioenergy was made clear. What was also clear was the sense of frustration about the difficulties in getting biomass energy production schemes off the ground in Africa and the urgency in getting these biomass energy programmes moving.

Despite the sense of urgency, Sivan Kartha (SEI) sounded another note of caution, reminding us about the intensity of resource use and planning required for successful bioenergy implementation at meaningful scales. He also showed the opportunities in terms of job creation and wealth generation if such schemes can be made technically and economically viable and environmentally sustainable. This rather large “if” highlights the risks and rewards associated with biomass and the need for careful implementation.

The meeting ended with a loud call from the participants for “biomass energy workshops” to continue to be held within the context of the World Bank’s Energy Week. Furthermore, it was proposed that the meeting should be expanded to two or three days, in order to properly address the heterogeneity and broad scope of biomass energy.



African Ministers demonstrate their commitment to biomass as a strategic tool for poverty reduction and environmental sustainability during the opening session of the Biomass Energy Workshop



Robert Matthews and Ralph Overend demonstrate the real carbon sequestration and sink benefits that can result from well-implemented biomass energy programmes

It became clear in the meeting that the wide range of actors in the biomass energy provision chains are beginning to understand that all links in these chains must function successfully for effective provision of modern biomass energy services to those that need them most - the rural poor. The next expanded and improved biomass energy workshop is eagerly anticipated. However, the central question remains. Can the World Bank super tanker change course and embrace the complexity of energy service provision (heat, light, cooling and power) from biomass? ■

For more info, see

<http://www.worldbank.org/energy/week2003/agenda.html>.)

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Solar Service is Rural Infrastructure

by Anders Ellegård (Bioquest HB), Mathias Gustavsson (Göteborg University, Dept. of Human Ecology) and Mattias Nordström (Stockholm Environment Institute), Sweden

Solar Photovoltaics (PV) provide basic lighting requirements and opportunities for education, entertainment, information and business improvement in many rural areas around the world. But solar PV technology provided for free, or heavily subsidised, has proven not to be sustainable. An alternative is to look at solar technology as a consumer commodity, for which rural consumers should bear the full cost.

An intermediate solution

There is, however, an intermediate solution in which solar PV Energy Service Companies provide solar PV services. We argue that this solar power provision should be acknowledged as a part of rural infrastructure and not only as a consumer product. It should not be given away for free, but neither is it fair to demand the poorest people to pay the full price up front for a service that the urban middle class gets at a subsidy.

A shift in perspective could help in developing national policies around solar PV that could boost use of the technology and provide basic electricity services for large numbers of people in shorter time perspectives and at lower costs than traditional alternatives. The two main traditional alternatives have been grid extension to remote areas, or building local mini-grids around an isolated generator, which is usually diesel-powered.

Financing and investment

The grid or isolated diesel provides larger amounts of power than PV and can arguably be used for industrial development. The grid requires a major investment in transmission, transformation and distribution infrastructure. In developing countries, loans for erecting this infrastructure can be obtained from multilateral and bilateral sources at very

favourable conditions. There is usually a grace period of several years at the beginning, interest rates are nominal, and the repayment period is very long. A forty-year repayment period is not unusual. The argument to provide these extremely lenient conditions is that the investment is for durable infrastructure, and the repayment is on par with the actual depreciation of the physical structures. Furthermore, there is a class of credits that is sometimes used for these purposes, called “concessional credits” for which there is not even an intention to acquire repayment.

The investment in diesel stations is not so high, and funding can relatively easily be obtained from donor slush funds to suit political and strategic whims. However, diesel stations have high running costs and also require an adequate road transportation network for supporting supplies and services. Funding for recurrent expenditures can present big problems for the poorly managed utilities that operate these stations. Managers attempt to save by cutting down on spare parts, lubricants, service and fuel, thereby reducing the investment life and the quality of services. Investment in the road network comes under other head-



Photo: Anders Ellegård

Children outside a typical household customer, Zambia

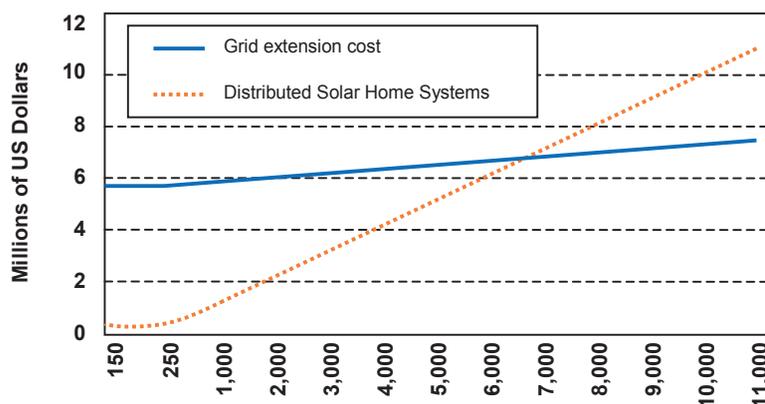
ings in the government budget and does not necessarily coincide with the needs of power production.

Assessing the benefits

In spite of the power and scale advantages, it has not been shown that grid extension and isolated diesel stations are supporting rural industrial and agriculture development as expected. Forecasts of demand evolutions and number of connections are often not met, meaning that less electricity could have provided the services actually used.

A thorough review of rural electrification in Tanzania (SEI, 1992) showed that grid extension had not resulted in

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Number of customers provided with low load domestic electricity services

Generic comparison between cost of providing low load electricity services through 80 km extension of grid to a rural population centre and using distributed solar home systems. Based on figures in AFREPREN (1992), ESMAP (2000), Ellegård and Nordström (2001).

any industrial or agricultural development (Kjellström et al.1992). Recent findings from Mozambique show that apart from substituting existing diesel generators in two industries, household consumption was low and benefits were mainly in light electric services (Åkesson, 2003), which could easily have been supplied with PV technology at a lower cost.

The graph (shown above) gives an example of approximate cost for supplying light electric services with solar and grid power. In this case, the breakeven point falls just above 7,000 customers, i.e. below this number it is more economical to provide electricity services with PVs rather than from the grid. There are many rural areas in sub-Saharan Africa where access to electricity is less than 10%, as shown in the maps below.

Solar PV ESCO companies provide a framework for supplying rural households and commercial enterprises with light electric services. Although power-demanding industries cannot be supported through PV, the small amounts of high-quality energy can provide important benefits for rural households. Lighting allows children to study at night, adults to carry out productive work or attend evening classes, and shop owners to stay open longer.

The availability of simple electricity services improves convenience and living conditions, thereby making it easier to attract skilled civil servants (teachers, police officers, health care workers) to

remote areas. Small devices such as television, radio, video and cassette players provide entertainment. Safety and security at night are improved by external lighting. All these services can also be supplied through grid extension or isolated networks. But PV, through the ESCO concept, can provide them more quickly and at lower investment.

Sustainable provision of energy services

It has proven essential to not only provide the hardware (solar panel, controller and battery), but also to provide spare parts, maintenance, and not least know-how. The ESCO concept caters for a sustainable provision of energy services, since its main pillar is that people pay for services, not for hardware. In this way, the operational cost of the service companies is being covered locally, and independently of external support. While this is the greater achievement, the challenge to recover the capital investment for the hardware also needs to be taken up. In so doing we think it is unfair to compare provision of PV services with that of supplying consumer goods. The services are similar to those provided by the traditional electricity mechanisms, and so the capital provision should be viewed in a similar way.

The argument is not to suggest that rural electrification through grid extension is unnecessary, or that PV can replace grid or isolated diesel, but that real contributions to development and in-

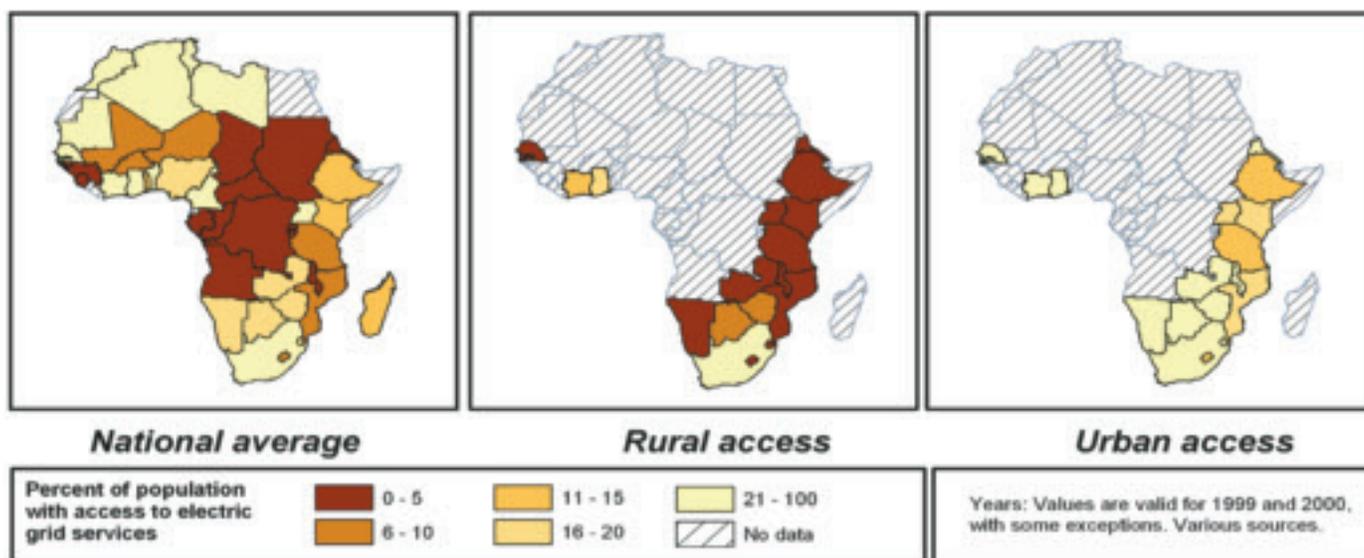
creased productivity do not occur until other conditions are also fulfilled. These conditions include development of financial markets for rural investments, transport infrastructure, education, information, and other enabling conditions.

There is reason to believe that providing light electricity services would speed up the fulfilment of conditions for grid extension. One of the reasons to believe so is that people who have been exposed to electricity services will more quickly come to realize the additional benefits of larger power supply. They will become productive clients much more quickly than the average rural person targeted by a grid.

It is time that governments and financing institutions come to see distributed electricity generation, such as solar PV installations and services, as a useful part of rural development and infrastructure. Solar PV initiatives could thereby benefit from the favourable financing conditions that are presently only provided for traditional electrification efforts. Where good maintenance and operational assistance can be made available in the local area, solar PV need not be a perishable good, but instead a reasonable and cost-efficient step in rural development, and as such should enjoy the financial benefits of other types of infrastructure.■

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Access to electric grid services in Africa