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conventional models like grid extension have failed them or the local utility's electricity supply has proved to be unreliable, smaller users are increasingly acting on their own. In Uganda, for example, over 12% of peri-urban and 9% of rural households are now electrified by small diesel gensets, and the numbers are rising rapidly. This is despite costs per kWh of US$1.5–2.5, over 15 times the US$ 0.1 charged by the state utility for electricity. Similar movements and willingness to pay are reported from Kenya, Tanzania and Zimbabwe. More comprehensive information is needed on the demand for energy services that is revealed by such activities in order to match planning to on-the-ground realities.

Second, in order to meet huge and growing needs, policies that foster productive diversification must be given the highest priority in energy sector planning. In particular, policies that create the right environment for rapid investment and business-led market growth must replace the traditional donor-led small-project model (unless this adds real value to policy formulation). Good projects will of course continue to have an important role in testing and developing the technical, economic and social aspects of new energy systems. But all too many projects don't achieve such goals.

A high priority, therefore, is to seek out good-practice policies and instruments across the world and adapt them to each country's particular conditions. Energy sector reform provides an excellent opportunity, since it has to be accompanied by laws and regulations to control the new private sector. These new rules can be framed to give the best balance between supporting new energy markets and advancing public development and social equity objectives. They can define clear longer-term social and environmental goals as benchmark signals to energy producers and consumers, encourage energy efficiency and renewable energy technologies (e.g. taxes and incentives, or insuring fair returns for independent power producers), and promoting social innovations which favour sustainable energy (e.g. village energy cooperatives).

Energy Efficiency and Renewables

Meanwhile, there is a considerable scope for governments and donors to support the development of energy efficiency, renewables and other dispersed energy systems. New delivery and financing structures need to be tested, developed, adapted and implemented. Many alternative models are already in use but no clear winners have yet emerged. Good technical and business management training is needed – especially for equipment producers, distributors and service technicians – backed by demonstration of good-practice technologies and financially self-supporting delivery and service networks. Energy efficiency and energy equipment standards exist in some countries, but generally need updating and wider dissemination. In some regions there is an urgent need to harmonise standards: in much of West Africa, for example, countries use incompatible designs for liquid gas bottles – severely hampering cross-border trade and hindering bulk manufacture that would reduce costs.

Where projects continue to be the main approach for putting new energy technologies on the ground, there are excellent opportunities for bundling them together to reduce costs and extend outreach. For example, combining an "uneconomic" off-grid rural electrification scheme with a profitable peri-urban project could give an attractive overall scheme.

New Policies and Institutions

The biggest challenge of all, though, is the weakness of Africa's energy policy making and planning capacities. Strong institutions will be essential for tackling the daunting agenda outlined above – nothing short of creating new policy, legal, fiscal and administrative frameworks which can unlock and mobilise the tremendous potential of emerging national and regional energy sectors to contribute to development. This is the single most important area where donor assistance is needed to support and encourage the efforts of national governments. This message is itself not new. But unless this fundamental problem is tackled systematically and in a sustained manner there will be little chance of achieving a sustainable energy future in Africa.

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Independent Rural Power Producers and Sustainable Development in India

by Ashok Khosla, President, Development Alternatives

Independent Rural Power Producers can play an important role in sustainable development strategies by finding village-level solutions that fulfill the need for electricity services. DESI Power in India has developed an innovative approach for applying technological and institutional expertise in rural electrification. A recent grant to DESI Power under the auspices of the UN Climate Change Convention highlights the international significance of these efforts.

To fulfill its fundamental goals of full employment and universal literacy, India needs to create more than 200 million jobs and educate 500 million people over the next few decades. To do this without causing a catastrophic collapse of its cities, the country must focus on improving the socio-economic infrastructure of its villages and small towns. Widespread introduction of village-level enterprises and better lighting in each home (and school) are critical tools in this fight against poverty and illiteracy. These efforts require electricity, as do so many basic human needs such as water, agriculture, communications, and entertainment. Across and within societies, a close correlation has been observed between availability of electricity and key indicators of socioeconomic development, such as falling birth rates. Reliable and affordable electricity services are often a prerequisite for development.

Electricity and Sustainable Development

The current reliance in India and other countries on centralised power, cannot

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solve the problem in the foreseeable future. After 50 years of massive investments in infrastructure, half the people of India still do not have reliable access to electricity. Many of these people live in villages where it is too costly to connect to the national grid. Many others live in villages that have been "connected" but receive no electricity. Still others simply cannot afford to pay for electricity. In any case, much of the power produced is hijacked by the cities and large industries long before it can reach homes or small enterprises in rural India.

Large-scale, centralised energy systems suffer from other handicaps as well. They require large investments, long gestation periods and heavy management systems. They often displace people, destroy land and nature, and are particularly vulnerable to corruption. While large-scale power systems certainly have a place in the nation's development strategy, they clearly cannot be the only route for delivering power to the vast majority of the population, as evidenced clearly by the results of past policies.

The Barriers to Sustainable Power Generation

Unfortunately, even today, there are few technologies that can produce electricity competitively from renewable fuels in small-scale units, for several reasons. First, significant subsidies are given to fossil fuels (by undervaluing their environmental costs) and to grid-based electricity (by undercharging its economic costs). What technology can possibly compete with virtually free electricity?

Second, barriers to alternative energy technologies are built into the legal framework under which electrical utilities operate. The Electricity Act of India assigns responsibility for power distribution to State Electricity Boards. As highly inefficient monopolies, their natural tendency is to block competition, and most prohibit independent producers from selling to the grid or to third parties. They also impose minimum charges on their grid connections, discouraging customers from using other sources of power. Without continuous loads or outside customers, it is difficult to achieve economies of scale for independent producers.

Third, small, decentralised producers face major obstacles in raising funds. Financial agencies are not familiar with them and smaller credit transactions are costly to appraise and manage. For any commercial plant, the financial arrangements are crucial in determining the profitability and return on investment – and therefore the viability of a venture.

A fourth reason has its roots in the vested interests of the status quo – the fact that so little effort has been devoted to R&D for alternative power systems and sources. If one-tenth as much money had gone into R&D for solar, wind, biomass, and other renewable energy systems as has gone into conventional fossil fuels and nuclear energy, the countryside would surely look quite different – and much the better for it.

For all these reasons, decentralised renewable systems have not made much meaningful headway. Only recently does there appear to be some recognition that investment and planning must begin now if renewables are to assume their expected major role in the energy systems of the next millennium. With oil giants BP and Shell making billion dollar commitments to commercialising renewables, perhaps more scientists and policy makers will wake up to the possibilities.

A new design for Biomass Gasifiers

Despite these problems, a few renewable energy technologies are breaking in to the Indian electricity generation scene, such as wind, biogas (methane from fermentation of biomass) and producer gas (carbon monoxide and hydrogen from partial combustion of biomass). Biomass gasification is a promising technology for village-scale applications. The technology is well-known, and was used extensively in Europe as well as India during the second world war when oil and gas became scarce. The gas produced by a biomass gasifier is fed into an internal combustion engine to drive an electrical generator, substituting 80% or more of the required diesel fuel.

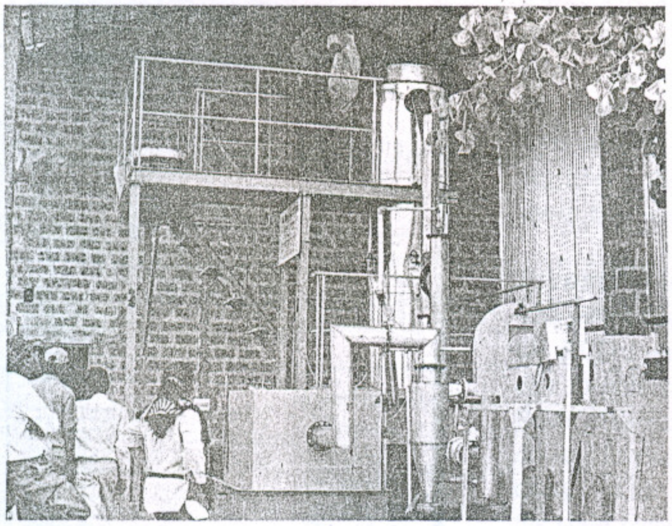
Most gasifiers in the past have been of limited utility because of tar and other impurities in the gas, which tend to reduce the life of the engine. After several years of intensive research, scientists at the Indian Institute of Science (IISc) developed an innovative gasifier design that produces virtually 100% pure combustible gas. The design features a unique geometry, a specialized combustion chamber temperature profile, and a novel sequence of filters, making it one of the most advanced gasifiers available anywhere. The IISc gasifier is manufactured commercially by NETPRO a Bangalore-based engineering company to which the Institute licensed the know-how. The gasifiers can be supplied in sizes ranging from 20 kW to 1 MW.

DESI Power chooses the IISc gasifier

This IISc-designed gasifier was chosen for a commercial demonstration phase by DESI Power as part of its program on Independent Rural Power Producers (IRPPs). IISc is closely associated with the implementation and monitoring of the first few units, both to help debug technical problems and to get feedback from actual performance of the gasifiers in the field for further refinement of the design. DESI Power Pvt Ltd is a not-for-profit collaboration between DASAG India and TARA, the commercial wing of Development Alternatives that is dedicated to the promotion of renewable energy.

DESI Power sets up IRPPs at the village level as joint ventures with local communities and entrepreneurs, using a series of innovative arrangements. The first set of innovations is in the technologies chosen, such as improved gasifiers, co-generation applications, domestic appliances. The second set consists of innovations in arranging financing for the IRPPs. The third set of innovations lies in the institutional framework, which is designed to support the local IRPPs (or clusters of IRPPs). The IRPPs are independently registered as companies, not only to raise investment capital at minimum possible cost, but also to involve the local community in the management and operation of the plants.

DESI Power provides roughly 25% of the financing in the form of equity, while the local partner provides another 25%. The remaining 50% of the financing is raised from the market – preferably from "green" funding sources willing to accept below-market rates of return, and other-



India – DESI Power Biomass Gasification Unit

wise from regular commercial sources. Three factors are critical in determining the financial performance of this type of village-scale biomass gasifier: the cost of capital, the load factor and the cost of the fuel. These factors were carefully studied in a demonstration plant at Orchha in Madhya Pradesh.

The DESI Power Unit at Orchha

The first DESI Power plant was installed in 1996 at Orchha, near Jhansi, a five hour train ride south of Delhi. This plant has now been operating for more than three years. It is located at and supplies power to TARAgram, a campus where TARA carries out research, demonstration, training and production activities using appropriate technology. Although TARAgram has acquired a grid connection, the bulk of its electricity requirements are still met by the DESI Power plant.

As for all DESI Power stations, a careful site analysis and feasibility report was prepared for the Orchha plant, including an assessment of electricity demand, availability of renewable fuels and existence of interested partners for setting up an IRPP. The study team investigated current energy sources purchasing power of households small business opportunities in the region, accessibility of local investment capital and availability of skilled labour. For local biomass sources, the study team conducted surveys on availability and calorific value of agrowastes, industrial wastes, and common weeds.

A survey of the region around TARAgram showed that two weeds – ipomea and lantana camera – were abundantly available in the region. Ipomea was so pervasive and so prolific that the local people call it "besharam" or shameless. This weed, which has a substantial woody part, contains considerable calorific value, but is not used by the local inhabitants. It is no good for cooking since it burns with an obnoxious smell. It is not eaten by animals and has no use as a fibre. Lantana, on the other hand, is commonly used as a fuel for cooking, and is also good for making handicrafts and furniture.

On the basis of these studies, an 80 kW power station was ordered in December 1995. The DESI Power Orchha unit, located at TARAgram, went into operation in April 1996. The capital cost of the station was Rs. 22 Lakhs. Initially, the sole client was TARA. Ipomea was used as the fuel.

Management of the Biomass Resource

An 80 kW plant needs almost one tonne of biomass fuel every day. Managing biomass resources properly is crucial for reliable plant operation. The woody part of the weed needs to be harvested and then chopped into smaller pieces. The biomass in this form is still green and needs to be dried to reduce moisture content before it can be fed into the gasifier. Adequate covered storage capacity is needed for rainy days and supply holdups. The supply of ipomea must be sustained over the years at reasonably stable levels and prices.

Different methods for procuring the ipomea had varying degrees of success due to different perceptions of the economic value of the resource. Initially, the owners/operators of the Orchha unit tried to manage the process of procuring fuel internally. It soon became clear that a market-oriented approach was preferable, and a price was offered at which they were willing to purchase ipomea. The prices offered were designed to add up to a minimum daily wage and/or to the prevailing rates for transportation. The actual prices negotiated had to be higher.

More than ten local families have created new livelihoods through harvesting, chopping and transporting the weed and delivering it to the power station, where it is sun-dried before being fed into the gasifier. However, it is estimated that the cost of fuel is adding some 20% more than it should to the final cost of electricity produced. Biomass costs must be contained to keep DESI Power partners competitive.

After three years of experience in procuring ipomea, it appears that regeneration of the plant biomass per acre does fall off significantly after the first cutting and sufficient extra acreage of ipomea must be accessible to ensure fuel sustainability when planning a unit. The current indications are that the quantity of biomass accessible to the plant in its first year should be at least 50% greater than the long-run annual requirements.

The Economics of an IRPP

The plant can be satisfactorily operated and maintained by three personnel – one operator and two assistants – per shift. The plant is generally operated in two shifts, so the minimum number of staff for plant operations is six. Local people with fairly minimal education can be trained and employed for the tasks. Further employment of over 100 persons was created through the factories that purchase electricity from the Orchha plant.

Over the past three years, the gasifier has logged about 5,000 hours of operation, running nearly 10-12 hours per day during normal operation. The percentage of diesel replaced by gas depends on the plant load factor. It has been recorded as high as 85%, with the average at about 75 percent. Competitive pricing of electricity will require DESI Power stations to maintain an average of well above 80%.

Plant load factor is a critical parameter to which the economics of power generation is extremely sensitive. The plant load factor is important not only for spreading out the fixed costs, but for raising the diesel replacement rate, reducing the use of costly diesel fuel. The breakeven plant load factor for the Orchha plant is between 50% and 60%. Even with 40% load factor and high biomass

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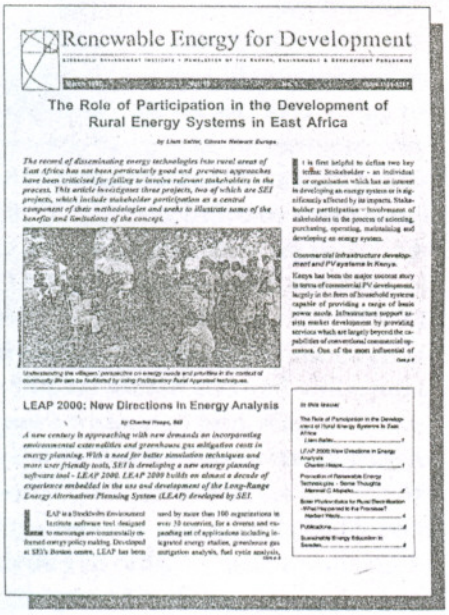

Renewable Energy for Development

The Role of Participation in the Development of Rural Energy Systems in East Africa

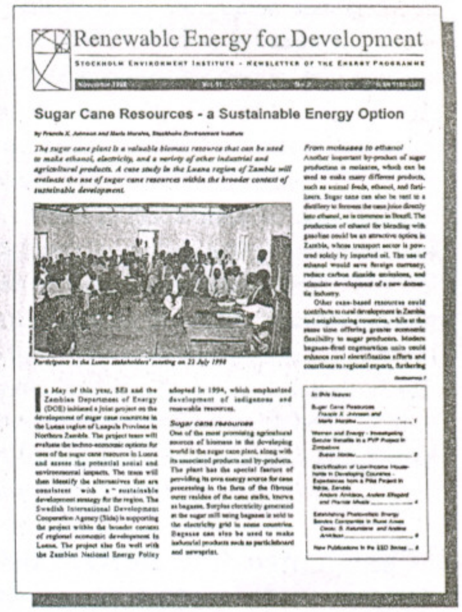
LEAP 2000: New Directions in Energy Analysis

March 1997

pendent Rural Power Producers provides a specific set of examples of how the intersection of advanced technology with innovative institutions brings sustainable and replicable results. The EU/UNDP study on sub-Saharan Africa is aimed at framing the overall problem, but nevertheless illustrates that local entrepreneurs are a major element of the solution. Small businesses, cooperatives, and households across Africa are building the capacity to respond locally to the challenge of improved access to energy services. But, as the report and the article stress, their efforts are only effective when national and regional policies send the right signals about new ideas and investments.

Investing in human capital

The path of subject material followed in the RED over the years – from technology to policy to local institutions – reflects changes in perceptions about the driving forces behind improved access to energy. It has become clear that finding the right technology is only the starting point in the process of implementing affordable and sustainable energy systems. Progressive and market-oriented policies at the national and regional level can provide the right incentives to adopt these technologies, but they cannot guarantee their long-term success. It is only the local partners and the institutional framework to support these partners that can induce fundamental changes in the prevailing status quo. It is after all the local population that best understands its own needs for energy services and the means to achieve them. What they need is an


Renewable Energy for Development

Sugar Cane Resources - a Sustainable Energy Option

November 1998

institutional framework that looks for the successful intersections in the application of technological, financial, and human capital. It is this institutional framework that forms the basis for the work of the Energy Programme at SEI.

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cost, the cost of electricity has been Rs.4.0 to Rs 4.5 per kWH, which is still competitive with electricity from the grid.

Lessons learned and Future Plans

The Orchha plant has shown that the cost of electricity can be highly competitive with conventional systems, provided that investment capital is obtained on terms similar to those available to larger Independent Power Producers. The two most sensitive determinants of production cost have been confirmed as the cost of biomass fuel and the plant load factor. Efforts are being made to raise the Plant Load Factor at Orchha by adding new clients and industries with energy-intensive applications, reducing the high fluctuations in some of the loads staggering certain activities.

The co-generated heat from the exhaust of the diesel engines is used, adding value and improving its economics. Other applications for the heat from the gasifier and the diesel engines are being investigated to further increase energy utilisation and thereby improve the overall economic performance. The extensive testing and performance monitoring at Orchha has provided detailed operational data and has also led to significant modifications to make the technology more robust, safe and suitable for field applications.

DESI Power obtains Climate Change Funds

The importance of IRPPs in climate change mitigation efforts was underscored by the agreement signed on 23 July 1999 between the Governments of India and the Netherlands. In this agreement, DESI Power became the first power utility in India to obtain financing under the AIJ programme of the UN Climate Change Convention. The Dutch Ministry of Development Cooperation will provide investment capital in the form of a grant to DESI Power to set up six Independent Rural Power Producers (IRPPs). The goal is to demonstrate the commercial viability of local generation and distribution of electricity using renewable energy. The six stations are slated to be in full operation by the end of 2000. The local partners in these projects range from village panchayats to entrepreneurs and small industries.

Under the Kyoto Protocol, AIJ will in the future be replaced by the "Clean Development Mechanism," which is likely to become a major source of capital investment and technology acquisition in the South. Hence, the DESI Power projects serve as a valuable model for the design of effective procedures by which developing countries can benefit from the new opportunities arising from international agreements on climate change. At the same time, rural populations will benefit from improved and sustainable access to electricity and the international community will benefit through cost-effective climate mitigation strategies.

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