Renewable Energy for Development

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Special Theme Issue: Rural Energy and Climate Mitigation

Low-cost Energy Efficient Housing in South Africa

By Glenn Hodes with Thlami Nkambule and Christelle Beyers, IIEC

The "Housing For A Healthier Future in South Africa" project aims to demonstrate the role of low-cost energy efficient housing in generating household savings, improving indoor health, and contributing to reductions in greenhouse gas emissions. Four pilot sites have been chosen and a comprehensive package of training and institutional support has been designed.

President Mandela launched South Africa's ambitious housing programme in 1994 to deliver low-cost housing to poorer households. In the rush to deliver housing, health and environmental aspects are often overlooked. Government-subsidised houses, although a step up from shacks, are often poorly constructed and un-insulated. The "Housing For A Healthier Future in South Africa" project will show that energy efficient housing delivers health and environmental benefits as well as energy and cost savings. The project is one of only five UN Climate Convention Activities Implemented Jointly (AIJ) hosted by South Africa. Funded by the Dutch government, the project is managed by the Africa regional office of the International Institute of Energy Conservation (IIEC).

Project Objectives

The AIJ project pivots around the construction of sixteen low-cost energy-efficient homes in each of four communities across South Africa. These demonstration homes will not be empty shells, but will be inhabited by families who will lead their lives and use energy as they see fit. These homes will bring innovative designs and technologies to the South African housing marketplace, while the project will provide training, education, and capacity building to the target communities. Community acceptance, accessibility, and ultimate demand (i.e. "street appeal") will define the scope of the energy savings and the GHG emissions reduction potential. After monitoring the demonstration and baseline homes over a sixteen-month period, cost-effectiveness and socio-economic benefits will be documented and disseminated. The project contributes to sustainable development goals in a number of ways:

- By developing economically viable, locally appropriate low-cost housing that significantly lowers GHG emissions

Local participation in building of low-cost energy-efficient homes in Kimberley, Kutlwanong township.

- By contributing to technical skills and management training of community builders and community organizations
- By helping the government of South Africa and the provincial authorities to realize an urgent development priority

Project Sites

The four project sites span climatically different regions and socially diverse communities:

- The small city of Kimberly in the Northern Cape;
- Benoni, urban suburb of Johannesburg;

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In this issue:

From the Editor: Rural Energy and Climate Mitigation

Climate mitigation is much in focus now, due in part to the upcoming meeting of the Conference of the Parties (COP-6) to the Climate Convention. In this issue of the newsletter, we have chosen to explore some of the links between rural energy development and climate mitigation, goals that potentially lay in conflict. Local development needs must be prioritised if rural energy systems are to help reduce poverty and improve living conditions. At the same time, industrialised countries looking for carbon emission credits are more likely to choose large-scale, urban energy projects that are more cost-effective and have lower transaction costs on a per-unit basis.

The challenge for project designers and policy-makers is therefore to find creative intersections between sustainable rural energy and climate mitigation. The issues involved are complex and we have not attempted to review them all here. Instead we have tried to provide a snapshot of some of the opportunities and challenges for renewable energy projects, policies, and programmes aimed at stimulating rural development while also providing value-added climate benefits. In the four articles included in this issue, we have attempted to include different sectors – housing, transport, and electricity production, as well as considering some aspects of the overall international policy framework.

The "Housing for a Healthier Future" project in South Africa provides a good example of the multiple benefits of sustainably addressing basic living conditions by making the best use of materials and climatic conditions. The ethanol programme in Columbia shows how a major agricultural resource can stimulate rural development while contributing to sustainable urban transport. The renewable electricity portfolio in India suggests how a diverse array of technologies can be employed to match a tremendous range in scale and user needs. Finally, the renewables policy article provides recommendations as to how international mechanisms like the CDM can support rural sustainable development and strengthen the institutional capacity needed for renewables to become an integral long-term tool for climate mitigation. ■

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Columbia Paving the Way in Renewable Fuels for Transport

By Henry Echeverri-Campuzano, CORPODIB, Columbia

A new renewable fuels programme in Colombia aims to improve environmental standards while making better use of domestic resources, providing an economic stimulus to the rural economy, and reducing CO_2 emissions. The programme will include expanded cultivation of sugar cane and construction of twelve new bio-refineries for production of ethanol and blending with gasoline.

Colombia is a nation of 30 million inhabitants and 1.14 million square kilometers, making it the fourth largest country in South America after Brazil, Argentina and Peru. Much of the country is located in the Torrid Zone, but the mountains of the Andean system criss-cross the country and have created ecological resources that are rich in biodiversity. Colombia's environmental heritage and its geographical proximity to major trading centers make it a strategic country for sustainable economic development through expanded renewable energy sources.

The Corporation for Development of Biotechnology and Clean Technologies (CORPODIB), a governmental/private entity, has developed an ambitious programme for renewable transport fuels. The programme aims to reduce mobile source emissions and conform to Colombian environmental regulations requiring use of oxygenates in gasoline as of 2001. The High Chamber of Congress recently approved an innovative law requiring use of bio-alcohol in all Colombian gasoline after 2003. The environmental benefits of the programme range from local impacts in the form of improved air quality to a global contribution through greenhouse gas (CO_2) reduction.

Sugar cane manual cut at Manuelita cane fields, Cauca valley

Ethanol from Sugar Cane

Colombia's Ecopetrol refineries do not produce enough gasoline to satisfy domestic demand, and the balance is imported as high octane gasoline, incurring additional transportation costs. Ethanol from sugar cane offers an octane enhancer that can meet the quality requirements while also saving costly investments at the Ecopetrol refineries. An immediate goal of the CORPODIB project is therefore to produce sufficient anhydrous ethanol from sugar cane for a 10% blend with gasoline. A 10% ethanol blend would require 730 million litres/year of ethanol, which is roughly equal to current gasoline imports in Colombia.

Currently a half million hectares of sugar cane are cultivated in Colombia, 180 thousand of which lay in the high-yielding Cauca Valley region. It is estimated that the new ethanol programme will require planting of 150 thousand additional hectares, distributed in different regions of the country. It will also require construction of twelve bio-refineries in the first phase of the project. The agro-industrial complexes will be located close to the more suitable regions for sugar cane and around demand centers for gasoline.

Rural Economic Benefits

It is estimated that the programme will generate 150 thousand new jobs, mainly in the agricultural sector. Colombian farmers will provide fuel that was previously imported, resulting in foreign exchange savings of 150 million USD per year. The precarious position of farmers will be greatly improved through the new economic opportunities available. The rural economy will benefit further through expanded domestic markets for agro-industrial products and services with linkages to cane and ethanol markets.

A 10% ethanol fuel does not require any modification in vehicle engines, and the Brazilian experience with ethanol shows that it is possible to go up to 25% blend. Indeed, the project is considering maximising ethanol content in remote areas where there are sources of crude oil to obtain straight run nafta in small refineries for blending with ethanol. This is the case in Putumayo, a southern region close to the border with Ecuador that is included in the government's peace program, under which renewable biofuels are seen as a substitute for illegal crops protected by the guerrillas.

Irrigation of sugar cane plantation at Manuelita cane fields, Cauca valley

Energy Efficient Production

Production units will use efficient technologies to optimally extract energy from the waste streams at the factory and distillery. Vinasse from the alcohol plant, which would otherwise pose contamination threats to surface water, will be transformed to biogas in anaerobic digestors. Along with bagasse, the feedstocks will be employed in a modern cogeneration unit adjacent to the agro-industrial complex. In addition to providing all on-site demands for steam and electricity, an excess of power will be available to sell to the national electric grid.

The production cost of ethanol, according to CORPODIB analyses, should be US$ 1.00/gallon (26 cents/litre). The selling price is estimated at 1.4 to 1.6 USD/gallon (37–42 cents/litre), representing the opportunity cost to substitute a gallon of imported gasoline. The consumer price of gasoline will not increase because taxes from the ethanol portion will be transferred to the alcohol production chain, as compensation for the social benefits of the project and to provide incentives to private investors. Total private investment in the project is expected to reach 400 million USD. The after-tax rate of return for investors in the bio-refineries has been estimated at 20%.

Environmental Benefits

Fleet and engine tests by CORPODIB in Bogotá (2600 meters above sea level) using different blends of ethanol-gasoline, resulted in a reduction in CO and hydrocarbon emissions of 27% and 20%, respectively. In Bogotá this would mean an emissions reduction of 245 thousand tons per year. Overall, the programme would reduce national CO_2 emissions by six million tons, offering an excellent opportunity to obtain financial resources for the project via the CDM mechanism of the Kyoto Protocol.

Conclusions

Production of biofuels such as ethanol from sugar cane, takes advantage of year-round cultivation potential in a tropical country like Colombia. Benefits extend from local to regional to national to global. Local rural economies benefit through new economic opportunities and employment in the agricultural sector. Urban regions benefit through cleaner air and health improvements. The nation benefits through substituting domestic resources for costly imported gasoline. The world benefits from reduced CO_2 emissions. The project in Colombia could be replicated elsewhere, and CORPODIB looks forward to a regional and global dialogue on expanding use of ethanol and other renewable fuels to promote sustainable development. ■

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- Gugulethu, a winter rainfall region outside of Cape Town; and
- Lady Grey, a rural community in the high, remote Witteberge mountain range of the Eastern Cape.

The project managers recognised that a modified approach was necessary to account for the different climatic, socio-economic, and cultural contexts of the four sites. In Lady Grey, for example, the focus was on design since alternative materials and technologies were not easily affordable. The small volume of housing development in the area and high transport costs limited the commercial viability of new companies, products and services. Moreover, a number of small local brick production businesses that provide jobs for the community could have been placed in jeopardy.

Technical Details

The technical focus is on improving thermal performance, thereby reducing energy consumption. The project management team is evaluating options such as insulated ceilings, roof systems, and use of alternative materials such as compressed earth bricks and compound materials (e.g. waste wood). The most common materials for low-cost housing in South Africa are cement and bricks baked in low-grade-coal-fired kilns with high CO_2 emissions. The project hopes to commercially advance alternative materials with lower embedded energy, such as clay bricks made with a mobile production facility and on-site insulation expansion systems. End-use efficiency measures such as CFLs and solar water heating geysers may also be incorporated, depending on affordability.

On the design side, the key is harnessing the sun's natural energy. According to Christelle Beyers of IIEC, "The most crucial no-cost technique is to orientate the house to face north and place the biggest windows on the northern side. The sun warms the house during the heat of the day, and this heat can be retained in the cooler evenings." Initial monitoring at the Kutlwanong project site confirms these results. Indoor temperatures of 21°C have been recorded at 1:00 am during cool winter evenings, obviating the need for space heating. Energy consumption in passive solar houses constructed by PEER Africa is 70 percent less than typical housing. Other design modifications include insulated ceilings and a roof overhang for shade in summer and heat retention in winter.

Informal settlements in Kimberley before the building of Eco-Homes

Environmental and Health Benefits

Energy efficiency brings health, productivity, safety, comfort and savings to the homeowner, as well as local and global environmental benefits. In Lady Grey, for instance, the winter months can be severely cold. Families generally heat their homes with coal or wood and shrubs collected on the mountain slopes. Local sources of wood are seriously depleted, and a reduced need for indoor space heating would help protect local tree species. Elimination of indoor burning of coal, wood, and paraffin translates into substantial health benefits. In the winter months, as much as 75% of South Africa's ambient particulate concentrations are attributable to household coal burning.[1] These particulate emissions, along with carbon monoxide and other toxins from burning of fuels in poorly ventilated areas, are linked to acute respiratory ailments and accidental paraffin poisoning that annually claim the lives of dozens of infants each winter. Reduced indoor fuel use also results in fewer accidental burns and fires.

Capacity Building

Achieving the full benefits of energy efficient housing requires community awareness about energy consumption and proper operation of equipment. The consumer must be empowered to make informed choices and to negotiate with provincial governments and building contractors. The IIEC Eco Home Advisors programme is linked to the AIJ project, and places trained members of the community within the housing delivery organisation. The Advisor is knowledgeable in energy efficiency and passive solar design. Another aspect of capacity building lies in the new jobs and skills created in energy efficient construction and design in the communities. Communities will also be involved in monitoring of household energy statistics.

Cost-Effective GHG Reductions

The GHG benefits from energy-efficient housing are cost-effective from both a local and a national perspective. Low-income families in South Africa spend up to 40 percent of their monthly disposable income on energy for cooking and heating. Poor thermal performance, the high cost of electricity from pre-paid meters, and inefficient use of coal, wood, and paraffin all point to low-cost energy efficiency measures as a tool in poverty reduction. A variety of construction measures – such as adequate window shading and roof overhangs – can deliver energy savings at no additional cost. Other low-cost measures – such as compact fluorescent lighting, insulation and solar water heaters – can pay back initial investments within five years.[2]

From the perspective of a national climate change strategy, housing projects

Completed Eco-homes in Kimberley

are attractive in that they improve the livelihoods of the most disadvantaged population while delivering significant GHG emission reductions at modest cost. The residential sector in South Africa is responsible for 25.4 million tonnes of CO_2.[3] Under the Kyoto Protocol, investors might fund the incremental costs for energy efficient low-cost housing. A CDM project with a critical mass of low-cost efficiency measures for 1000 homes could generate 15,000 tonnes of CO_2 reductions over their lifetime, at a cost of $19 per tonne.[4] Another study found CO_2 savings of 776,800 kg annually for 2,300 houses.[5] An explicit objective of this project is to obtain more reliable empirical data on the cost/benefit ratio of energy efficient housing interventions as a climate protection measure. ■

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[1] Yvonne Scorgie, University of the Witwatersrand, 22 August 2000.
[2] USAID/South Africa (August 2000). *Environmentally Sound Energy Efficient Low-Cost Housing.*
[3] Professor Dieter Holm, University of the Witwatersrand, 22 August 2000,. Figures based on 1990 data.
[4] Calculation assumes 25-year project lifetime and a baseline of subsidized low-income houses.
[5] "IIEC-Africa and PEER Africa (1997). *Housing as if People Mattered – The Story of Kutlwanong,* 30.

Renewable Energy and Climate Mitigation in India

By Kalipada Chatterjee, Vivek Kumor, and Abhijit Chatterjee, Development Alternatives

Sustainable low-carbon energy scenarios for the coming century emphasise the untapped potential of renewable resources. Rural areas of the developing world can benefit from this transition. The increased availability of reliable and efficient energy services stimulates new development alternatives. A number of renewable energy initiatives are under way in India that can contribute to rural development while also addressing climate mitigation.

750 kW Wind farm in Tamil Nadu

The last fifty years have seen a tremendous shift in India's energy consumption from non-commercial to commercial sources. Commercial energy consumption has increased ten-fold and installed electric generating capacity has increased more than fifty-fold during this period. As of 1994, the installed capacity of 76,000 MW was dominated by thermal (71%) and hydro (26%) with the remainder supplied mainly by nuclear power. Current power shortages have fuelled calls for continued expansion in supply so as not to constrain India's economic growth. At the same time, the growth in commercial energy consumption has been mainly in urban centres. Over 70% of India's one billion residents live in rural areas with little or no access to electricity.

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Renewables to Support Rural Development and Climate Mitigation

By Michael Lazarus, Sivan Kartha and Steve Bernow, SEI-Boston

International efforts for climate mitigation are stirring interest in renewable energy not seen since the oil crises of the 1970s. If the Kyoto Protocol is ratified, industrialised countries investing in renewable projects in developing countries can receive emissions reduction credits through the Clean Development Mechanism (CDM). These credits would enable industrialised countries to exceed their own emissions targets and reduce costs of compliance. Some view easy access to inexpensive emission credits from CDM projects as the key to making the Kyoto Protocol economically and politically tolerable.

Whether or not the Kyoto Protocol is ratified in its present form, it is likely that an international market for carbon emission credits will emerge in the coming decade, offering new opportunities for renewable energy projects and markets. Renewables have special significance for rural areas in developing countries compared to other climate options since renewables can be applied at scales appropriate to sustainable rural development. In recent years, pilot CDM programs (AIJ–Activities Implemented Jointly) have established 21 new renewable energy projects. The carbon credits from these AIJ projects along with those from a major natural gas project are shown in Figure 1. If grandfathered into the CDM, these projects would generate 6.4 million tonnes of carbon credits (MtC) for use during the first budget period of the Kyoto Protocol (2008–2012).

What does all this activity mean for the future of renewable energy? Will emerging markets for carbon credits provide the key that finally unlocks the promise of renewable energy for promoting sustainable development? Whether the CDM will boost renewables in developing countries depends on three major factors: carbon credit prices, competition from other eligible sources, and the rules for carbon credits. Renewables are still relatively expensive and face institutional barriers. Small financial incentives will probably not be sufficient to change investment patterns (see Box 1). Furthermore, depending on how the system is administered, free-riders could give a boost to non-renewable projects (see Box 2 and Figure 2).

Negotiations on the rules for carbon credits have been dominated by a few players (larger Annex 1 parties) and have focused on quickly creating a market for low-cost credits. Less attention has been given to how CDM can promote long-term climate stabilization and sustainable development. Moreover, there has been little input from developing countries and project host communities. A critical opportunity to transfer renewable energy technologies may be lost without additional pressure in climate negotiations to:

1) Expand the dialogue to host country stakeholders, especially communities that are the intended hosts and beneficiaries of CDM projects.
2) Reduce likelihood of free-riders through project reviews.
3) Limit the use of land use and forest based sinks, which have complex and still poorly understood carbon, ecological and social impacts.
4) Support programmatic measures, policy changes, and capacity building measures. Presently CDM focuses on "projects" with quantifiable emissions reductions, excluding activities needed to sustain long-term climate strategies.
5) Limit transaction costs (e.g. through better bundling or packaging of projects) for dispersed and small renewable projects. High transaction costs have not deterred pilot programs. The small size of pilot projects will work to their detriment once carbon credits put cash in investors' pockets and justify larger investments.
6) Operationalise the sustainable development provisions of the CDM by improving accountability, transpar-

Box 1: Financial incentive from carbon trading price

Consider the financial incentive provided by carbon credits in the case of solar PV home systems. At a $10/tC trading price – the level expected by some during the next decade – CDM credits would provide about $1 in annual revenue for a 40Wp system that typically costs $500-1000. If carbon traded at $100/tC, credits could provide $10 per year, giving a small boost in revenues for small businesses supplying solar systems on a fee-for-service or lease basis.

Box 2: The problem of free-riders under the CDM

A recent SEI study analysed the "free-rider" problem. Free-riders are credited projects that would have been undertaken anyway and do not provide "additional" emission reductions as required by the CDM. The study found (see Figure 2) that under lax CDM rules, the volume of free-riders from new power supply projects alone – largely hydro, natural gas, and nuclear – could satisfy over 20 percent of the total emissions reduction requirement (600 MtC out of an estimated 2600 MtC) for Annex 1 countries during the first budget period of the Kyoto Protocol. Free-rider credits threaten the environmental integrity of the Protocol and weaken markets for legitimate projects. Also remarkable is how small the "additional" renewable electricity generation activity (7 MtC) is at $10/tC price.

ency and community participation. International competition between prospective hosts might lead to a "race to the bottom", whereby hosts can only find buyers for the cheapest CDM opportunities, which are likely neglect sustainable development priorities.

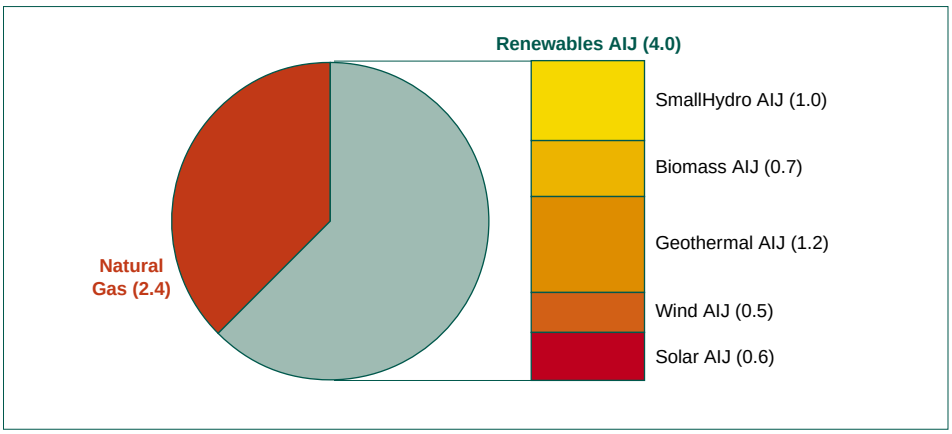
7) Set up national climate change offices and clearinghouses that pay special attention to rural energy needs (urban areas will tend to attract projects more easily) and streamline application of program rules and requirements.

8) Consider portfolio standards for renewable energy projects, particularly in rural areas. For instance, Annex 1 countries could be required to have 5% of their CDM portfolio in credits for rural renewable projects.

9) Get serious about technology transfer. Even if the Kyoto Protocol is not ratified, the Climate Convention already requires that industrialised countries promote and finance transfer of low GHG technologies, suggesting strong support for renewable energy.

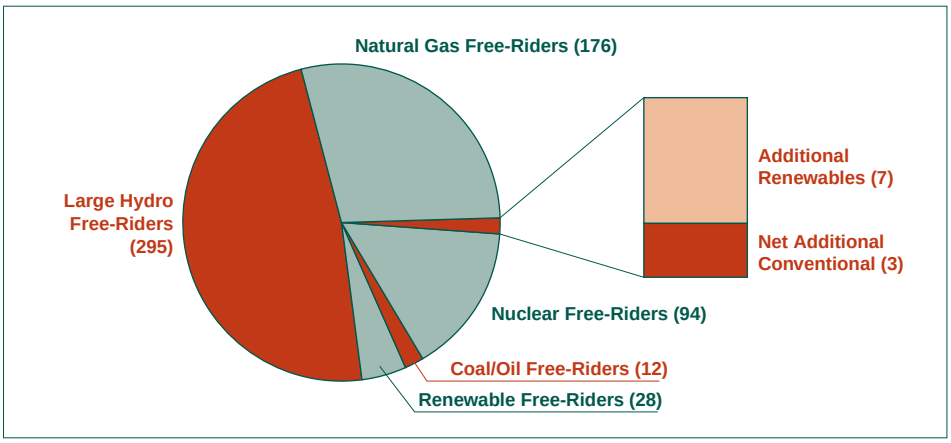
In conclusion, the international climate regime, particularly the CDM, can promote rural renewables, *if designed to do so*. The long-term need for renewable technologies, and the near-term need for rural energy services, must be explicitly recognized in the Protocol, in a way that provides incentives for developers. ■

Figure 1: Crediting of existing AIJ Projects (MtC)



Source: UNFCCC, Sept 2000. http://www.unfccc.de/program/aij/aijproj.html.

Figure 2: Projected CDM Project Credits under a Loose Regime (MtC)



Source: SEI report – see References

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A Role for Renewables

The challenge is to find decentralised and/or renewable applications that can support sustainable development while reducing India's dependence on fossil fuels and addressing climate concerns. The scale of renewables makes them more competitive in rural areas where grid extension is expensive, while matching local development needs and linking better to load centres, thereby addressing distribution problems. As low-carbon sources with growing international appeal, they will attract new sources of investment and become more cost-competitive as markets expand. India's large domestic market and high level of technical expertise offers special benefits and opportunities for renewables.

Wind, solar, and bio-energy options have seen the most interest and/or expansion. Installed wind power is 600 MW, placing India among the top three countries in the world in harnessing wind resources. Wind energy in Tamil Nadu state has saved an estimated 250 thousand tonnes of coal and 790 thousand litres of furnace oil, with significant associated CO_2 reductions.

India is currently the world's second largest manufacturer of crystalline silicon modules for solar photovoltaic cells, with an annual production level of 7 MW. The main applications have been for solar lanterns and solar pumps. Other popular solar energy applications include solar thermal water heating systems for commercial establishments.

Bio-energy takes advantage of domestic resources and technologies at many

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The Stockholm Environment Institute (SEI) is an international research institute focusing on local, regional and global issues related to environment and development.

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Correction: In the June 2000 issue, the correct e-mail address for Dr Atiqur Rahman is: r_ateeq@mailcity.com

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different scales. At one end is advanced bagasse cogeneration, for which the government launched a programme to tap the 3500 MW cogeneration potential of India's cane sugar industry – the largest in the world. At the other end of the scale are small-scale biomass gasifiers, to substitute for diesel fuel in village power installations, providing health, environmental, and employment benefits for rural communities.

Institutional Support

Government agencies and international organisations have supported research, development and demonstration projects for wind, biomass, and other renewables. The Ministry of Non-Conventional Energy Sources (MNES) carries out an extensive wind monitoring and mapping programme to identify better sites and assess resource potential. The Global Environment Facility supported the wind programme implemented in Tamil Nadu. The Indian Renewable Energy Development Agency has supported wind, biomass, solar, and other renewables.

The government has promoted legislative and administrative frameworks to support renewables, led by the Ministry of Non-Conventional Energy Sources (MNES) since 1985. Regulatory reform includes efforts to enable independent power producers to sell to the electricity grid at a remunerative price. The energy sector has been opened up for private foreign investment, with new legislation allowing 100% foreign-owned private companies to set up power projects in India with a five-year tax holiday.

Climate Change Mitigation Strategies for India

The Asia Least-cost Greenhouse Gas (GHG) Abatement Strategy (ALGAS) study by the Asian Development Bank showed that, as in many countries, the energy sector was the main source of GHGs in India. With over 70% of commercial energy coming from fossil fuels in India, it is clear that major structural changes in India's energy sector are needed to achieve climate mitigation goals. The abatement strategy suggested by the ALGAS study emphasised energy efficiency measures, renewable technologies.

Climate Change Centre

Development Alternatives has set up a Climate Change Centre to act as a knowledge base on climate change mitigation and raise awareness of key stakeholders. The Centre organises workshops and seminars on impacts, measures, and international mechanisms (e.g. AIJ, JI, CDM). The Centre promotes renewable energy projects through advisory services, project identification workshops, and facilitation of business sector participation.

The Centre carries out research on climate change policies and programmes. It carried out a study on "Measuring Progress towards Sustainable Development in Indian Climate Change Mitigation Projects" and prepared a policy recommendation paper for the Government. The Centre develops training modules and gives courses on "Incorporating Sustainable Development Concerns in Climate Change Mitigation Projects in India."

Conclusion

India's low per capita GHG emissions raises legitimate concerns about constraining energy consumption in India in the coming decades in order to meet climate mitigation goals. Yet it is also recognised that renewables offer special opportunities to satisfy energy needs while addressing rural development and climate mitigation. The need of the hour is thus for joint efforts between developed (Annex-1) and developing countries to reduce GHG emissions without compromising development priorities. ■

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